ILCA
SYSTEMS STUDY 5

The Borana Plateau of Southern Ethiopia:

Synthesis of pastoral research, development and change, 1980–91

1994

INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA

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by

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Executive highlights

The Borana Plateau of southern Ethiopia: Synthesis of pastoral research, development and change, 1980–91 summarises results from work conducted in the southern Ethiopian rangelands between 1980 and 1991. The global objectives of this inter-disciplinary project were to describe the evolving production system of the Borana pastoralists and prescribe best-bet component interventions and policies that might promote growth in the livestock sector, alleviate poverty among pastoral producers and encourage ecologically sustainable patterns of resource use. A large effort was also devoted to contrasting our research results with other findings in the pastoral literature, largely from eastern and southern Africa. This comprehensive system study is intended to serve two main audiences: (1) professionals within Ethiopia who deal with range research and development, who need detailed interpretation of local data but who also have poor access to the international literature and (2) an international audience concerned with more general implications of the work for pastoral research and development in sub-Saharan Africa.

Borana society is in crisis today, mostly due to human over-population. Scholars of pastoral development will recognise many aspects of system change that have been observed elsewhere in Africa. Despite daunting challenges, we believe that a combination of policies, procedures and technical options could help manage the system to reverse the downward trend in human welfare. Such efforts, however, will require a high degree of creativity and commitment on the part of the Borana people, the Ethiopian Government and development agencies. Problems need to be addressed in new ways if major impact is to be achieved.

These highlights are structured as responses to 13 major questions that decision makers are likely to have.

1. Why focus on the Borana pastoral system?

The original reason for focusing on the Borana pastoral systems was that the semi-arid southern rangelands are valuable to Ethiopia as a source of livestock for use by smallholders in the highlands and for export to generate foreign exchange. The region also had the highest ecological potential among major range-development areas and the semi-sedentary Boran were regarded as relatively easy to study and work with. Development of infrastructure in the south started in the 1960s and it was thought that this would facilitate the impact of research results on development.

2. Does Ethiopia still have a stake in the rangelands?

Yes. Although the highlands are justifiably the major focus of agricultural development efforts in Ethiopia, the rangelands cannot be ignored in a comprehensive national strategy. High rates of population growth throughout the country dictate that commerce should be allowed to flow freely and thus permit comparative production advantages of different agro-ecological zones to be expressed. The rangelands will increasingly serve as an important source of animals for highland small-holders and for export. The Boran are now in dire need of grain from the highlands, at favourable terms of trade, to reduce risks of famine and lessen the need to expand cereal cultivation onto fragile upland range soils in the rangelands. A loop of mutual assistance can now be completed, achieving the vision set for Ethiopia by planners over 20 years ago. What is required are integrated policies and improved access to inputs that allow producers and traders to create mutually beneficial networks themselves.

3. The Boran have persisted for a long time. Why bother to develop the southern rangelands now?

Unless efforts are now made to improve human welfare among the Boran, future commercial linkages with the rest of the nation and the social welfare of urban centres in the rangelands will be in jeopardy. Increased risk of famine, increasing poverty and the undermining of traditional cultural values may all erode the traditional social order of the Borana production system. If the traditional social order is not maintained, there are acute dangers of increased regional insecurity and less efficient operation of the deep wells. Requiring large amounts of coordinated labour, the deep wells are virtually the only supply of water in dry seasons and their efficient operation underpins the viability of the entire livestock production system. Ecological sustainability, on the other hand, is threatened by the spectre of increased cereal cultivation on upland soils and by woody encroachment and soil erosion, which can be attributed to heavy cattle grazing.

4. What is the outcome of development in the southern rangelands thus far?

Starting mostly in the 1970s, there have been considerable efforts to develop infrastructure and provide veterinary services to the Boran. The intent was to stimulate livestock commercialisation. This involved the typical, but often erroneous, assumptions of pastoral behaviour that have characterised African pastoral development in general.

It was prominently assumed, for example, that if the Boran were given access to markets they would readily sell cattle and improve their lives by increasing their cash income. Sales of immature cattle were to form the basis of a stratified livestock industry. Today, however, instead of happy, prosperous pastoralists we find a situation in which 200 000 people are on food relief and half of the region's cattle died during the 1990–91 drought. Rates of cattle offtake remain low. Without economic development, food relief is likely to become a permanent fixture, regardless of drought. Woody vegetation has encroached on 40% of the land area and 19% of the area has suffered significant soil erosion. What went wrong?

First, we contend that interventions to boost livestock production actually worked. New ponds increased access to underutilised productive lands and veterinary campaigns lessened risks to animal production. Herd size likely grew, but then so did the human population. Improvements in animal production were probably largely absorbed by a growing subsistence population, rather than being marketed. The traditional Boran probably had little desire to routinely enter the market-place because they did not need to. They produced most of their own food as milk, traded for a bit of grain and used cash sparingly to buy discretionary items such as coffee, shoes or sugar. Their cattle had greater perceived utility as accumulated assets than as a cash crop. People with larger herds have fewer economic risks, are socially influential in the community and even have landmarks and encampments named after them. This is what people aspire to here.

It is also likely that a traditional Boran household waited until it had an acute need for cash before selling an animal. The main season for selling cattle was thus the warm dry season, when milk supply is lowest and the people needed to buy food. The terms of trade would often be unfavourable to the Boran during this season, but this was of only marginal relevance because the people commonly hoped to avoid the sale all together. They thus behaved more like optimistic gamblers, hoping that good rains or some other favourable circumstance would help them obtain the food they needed to carry them over to the next rainy period and allow them to avoid the sale. The people could endure considerable misery in waiting out a dry season.

If a household were forced to sell cattle, it would tend to sell an older, mature male rather than younger animals. This is because the higher gross proceeds from the sale of a large animal would be enough to buy both the commodities needed and replacement calves. It would thus meet both the immediate need for cash and promote herd growth. Net proceeds are not very relevant where costs of production are almost nil and concern over how fast the animal grew would not have been prominent compared with efforts just to keep it alive. A poor household would typically have to sell more animals than would a wealthy household to buy food throughout the year. This is because poor households have more people per milk cow than do wealthy households and hence have too little milk to support them. Fewer cattle also implies less diversity in age and sex classes. Thus, a poor household would tend to sell an immature animal more commonly than would a wealthier household because of lack of choice. Selling an immature animal to buy food also offers less likelihood of money being left over to buy replacement stock and thus less opportunity for herd-building and a greater likelihood of continued poverty.

Some views in this scenario above may be controversial but together they help explain (1) the traditional economic rationale; (2) why range development projects have commonly failed to meet expectations; (3) why droughts can decimate cattle herds and (4) why pastoralists are commonly victimised by poorer seasonal terms of trade of livestock for grain.

In sum, the traditional Borana household did not need much money but aspired to having a large cattle herd. It preferred to sell older animals rather than immatures and probably was concerned only with low-input means to keep animals alive. In addition to the problem that the goals of livestock commercialisation conflicted with the traditional production rationale, livestock prices within Ethiopia were regulated and kept low until 1991 and there were chronic difficulties in coordinating external market linkages from the southern rangelands. Little wonder, then, that development expectations were not fulfilled. This is not a society that would respond to widespread marketing initiatives or want to sell immatures as part of a stratified cattle production industry. This also suggests that efforts to provide early warning of droughts to encourage destocking may not work very well. What appears to be commonly misunderstood is the role of cattle as a primary asset, not as a cash crop, and what this implies for human economic behaviour.

Lack of development impact has not been due to scarcity of technology or inappropriate behaviour on the part of the Boran. Expectations were unrealistic because Western-trained planners had an inadequate understanding of social values and a production rationale that differed from their own.

This is not to say that development efforts have been fruitless but that impact has been more indirect than direct. Roads and markets, less used in the past, will soon become the critical lifeline for the Boran because they can no longer feed themselves using traditional methods. The small towns that have grown up as a result of improvements in infrastructure provide crucial market outlets and have led to widespread dissemination of new ideas among the pastoral population. We thus postulate that the response of the pastoral population to infrastructure is highly dependent on timing. The willingness of the Boran to receive innovations is dictated by population pressure; change occurs when the people have little choice. The stage is now set to accommodate a major economic shift in Borana society.

5. Is the traditional system changing?

Yes, and very quickly. If cattle prices are competitive with those offered on the Kenyan black market and trade links within Ethiopia are made more efficient, the good news for planners is that rates of cattle offtake for Ethiopian markets should increase dramatically. More immature cattle will be sold. The original vision for increased marketing by pastoralists can be fulfilled. The bad news, however, is that this increased involvement in the market economy will largely result from the increasing poverty and risk of famine that is undermining Borana society. A larger segment of the society is becoming poor and acting in accordance with the schema of behaviour of the poor as reported above. Today, 51% of the households may be considered poor; these households control about 10% of the regional cattle herd. Around 18% may be wealthy and control 65% of the regional cattle herd. Traditionally, the poor would petition the wealthy to redistribute cattle at dozens of annual clan meetings. Such meetings are still held but needs are beginning to dwarf possibilities for redistribution.

The long-term trend that drives increased commercialisation among the Boran is the declining ratio of cattle to people. The human population is increasing at a net rate of 2.5% per year, with a 50% increase in population possible within 14 years. Apparently, relatively few people are killed by drought; even births are reported during drought. In contrast, land availability imposes a ceiling on cattle numbers and large numbers of cattle die during droughts. The net result is a downward "ratchet" effect: the steady decline in the ratio of cattle to people is periodically exacerbated by drought. More people are thus becoming poorer in cattle assets.

A decline in the number of cows per person reduces per capita milk production and forces people to buy grain or grow crops. A decline in the number of male cattle per person limits, among other things, the ability of the people to rebuild their herds after drought by exchanging males for cows. More households are likely to be squeezed out of the system during drought because of the intensified competition of more people for a finite base of resources. Furthermore, this base is becoming even smaller due to ecological degradation and loss of traditional grazing reserves to encroachment by the growing population.

People squeezed out of the system will increasingly become destitute farmers or peri-urban sellers of milk, chickens and firewood. Peri-urban dairy marketing results, in part, from these processes. For example, there are women living near towns who must sell a cup of milk from their single cow every day to buy a survival ration of grain for the family; this would not be possible except for the favourable terms of trade (both on a cash and per unit energy-yield basis).

Most Boran will be unable to fully compensate for increasing poverty by becoming agro-pastoralists. This is not because of lack of rainfall but because less than 12% of the land (i.e. valley bottoms and swales) may be cultivated sustainably. It is postulated that the people seek to grow grain and diversify herds to include more small ruminants to avoid selling cattle at a rate that would deplete their assets. Small ruminants are more of a cash crop than are cattle and would be a substitute sale item.

The declining economic status of the Boran may result in famine if markets do not offer grain at favourable terms of trade. It may also result in expansion of cultivation onto shallow upland soils, increased felling of trees to sell as firewood and charcoal and possible dilution of the Boran cattle breed. The last results from the Boran trading male Boran cattle for reportedly inferior cows from the southern highlands in an attempt to replace the large number of Boran cows killed during drought.

These negative trends may have emerged because the pastoral sector has been too successful in terms of human reproduction. Now the Boran need links to the rest of Ethiopia to enable them to work their way out of crisis. The free flow of commerce is no longer a luxury for the Boran: it is now a necessity.

6. What can be done to alleviate this situation?

Overview: Despite the daunting nature of the task, the major premise of this research is that the entire system can be managed to (1) promote growth in the livestock sector; (2) alleviate poverty and (3) reduce risks to the environment. This requires an integrated set of policy measures, procedures, participatory development tactics and selective use of technology and management innovations. A focus on technological impact alone is not very useful. Even if there were, for example, a "magic forage," planting it would do little to change the fundamental causes of instability and poverty in the system. Development impact is also increasingly dependent on linkages from the rangelands to the outside world, including markets, fuel, veterinary inputs, school teachers and accessible banking for pastoralists. If such dependence is viewed as inappropriate, we must dramatically lower our expectations for impact and let the Boran fend for themselves.

Attacking the problems requires a systems approach that recognises that livestock development has social, economic, biological and ecological dimensions. The time when one agency or a few technologies could improve the lot of the Boran is over. Agencies and government ministries must achieve a common vision of the problem at hand and collaborate on policy refinements. Technical innovations should first be extended with a priority for the peri-urban sector, which is compatible with the modest logistical capabilities of extension and would better meet the needs of a very poor, and growing, segment of pastoral society.

The rate of human population growth is not excessive and is consistent with that of other semi-settled pastoral groups. We suggest, however, that the root cause of system problems is that too few Boran are able or willing to emigrate from the system to balance the net reproduction rate. This suggests that more must be done to educate the Boran in order to make inroads on their cultural isolation and give them a choice of life-style. If attempts to develop human potential over the past 20 years had been similar to those directed towards stimulating cattle offtake, the need for crisis management today might have been lessened. Lack of emigration also suggests that economic underdevelopment of the urban sector is an important constraint with ramifications for the stability and sustainability of rural production systems in general.

Over the short to medium term, efforts need to focus sequentially on (1) improving food security; (2) reducing risks to animal production and asset accumulation; (3) enhancing livestock production and herd turnover and (4) reducing risks to the environment. Assuming that the first goal can be achieved, attainment of the second goal is the key to everything else. Attempts to reduce risks for the environment will not be fruitful unless human welfare has been improved.

Policies, procedures and technology for food security: Food security is ultimately tied to the human population density. For example, one way to improve the situation in the study area would be to reduce the human population by 50% (i.e. by 39 000) and then provide jobs outside the pastoral sector for the 2000 people reaching working age each year. Since the low level of economic development will permit this approach, food security must be dealt with in a step-wise manner. Over the short to medium term, relief organisations must be prepared to stay in Borana. Inter-regional commerce must be allowed to open up to facilitate trade of range livestock for surplus maize from the southern highlands. This involves complex national issues such as increasing cereal production in the highlands and solving regional transport and security problems. Markets for small ruminants should be expanded, since the Boran view sheep as more of a cash crop than are cattle and hence sheep offer better opportunities for increasing incomes rapidly. In the longer term the Government should promote the economic growth of urban centres in the rangelands to provide more local market demand for animal products and future employment opportunities for pastoralists. The future of the Boran is closely linked to the future of such towns as Yabelo, Negele, Moyale and Mega.

Using information provided in the Borana System Study, land-use planners can designate agro-ecological zones and sites within zones suitable for sustainable cereal cultivation in the rangelands. Extension could promote technical and management measures to increase maize yields in these locations and reduce the need of pastoralists to cultivate on more fragile sites elsewhere. Suitable locations include valley bottoms in higher rainfall areas but these may comprise a relatively small percentage of the region.

This is not an endorsement of widespread cultivation in the rangelands, since cultivation may cause soil erosion on upland soils under a variable rainfall regime. Rather, it is a call to increase cereal production selectively to reduce some local risks of famine, particularly for people with poor market access. The only way to control the spread of cultivation over the short term is to forge a regulatory partnership between development agencies and the Boran. Increased maize production on appropriate sites is recommended only as an emergency food-production measure over the short to medium term. We believe that widespread emergence of agropastoralism would be detrimental to the long-term ecological sustainability of the system. Cultivation can ultimately be discouraged through favourable marketing interventions, increasing options for investment other than in cattle and spurring human emigration in an ecosystem management approach.

Interventions to increase milk production from cows should focus on health measures, in particular the use of acaricides to reduce tick damage to cow udders. The problem, however, is that acaricides must be imported. Lack of acaricide use points to the fact that the absence of sustained extension of existing technology is a greater problem than generation of new technology. Despite the rangelands having been viewed as an important source of foreign exchange for the nation, range development programmes are commonly unable to extend technologies because of a lack of access to foreign exchange, because extension is poorly funded or because international procurement is excessively bureaucratic. As with other interventions, the Boran should pay for technological inputs and extension using local currency generated from livestock sales. This will provide a good test of the people's priorities.

Primary attention to topics such as terms of trade of livestock for grain and selected improvement of cultivation is in recognition that the biggest problem in the system over the short term is securing more food energy for people. It is clear that plants extended merely as forages will not be high on the Boran's list of priorities. The best way to introduce new forages is through sustainable cropping systems using dual-purpose legumes, such as cowpea, which produce both food for people and feed for livestock.

Policies, procedures and technology for risk management: There are about six drought-grazing reserves that have been traditionally used as fall-back areas for cattle herds during the early stages of drought. These are now reportedly being routinely encroached upon by people and animals. This is occurring because of over-population and probably contributes markedly to the apparently increased instability of the cattle population in response to drought. These fall-back areas need to be re-established by relocating any residents and their carrying capacity increased through water distribution and forage improvements.

Management plans specific to grazing territories (*madda*) under resource stress should also be implemented. *Madda* are highly variable in resource endowments, which requires site-specific resource-use strategies. Reclamation might include bush control, prescribed burning and site restoration using local methods and native forage species. Practices such as regulated charcoal making can generate funds from site reclamation: a profit of about US$ 3200.00 per hectare could be realised from making charcoal from dense stands of otherwise useless *Acacia drepanolobium*. The difficulty in implementing such projects lies, however, in regulation and the fear that charcoal production would spread uncontrolled. While this is a valid concern, it has been found elsewhere in Ethiopia that pastoralists in fixed territories can effectively regulate harvest of wood products in some situations. It might thus be worthwhile conducting pilot projects to see if the Boran can regulate some profitable aspects of resource use themselves. Development agencies might serve as marketing conduits in this process. The Boran have ample knowledge of which plants are useful for the production system and which are not.

Specific grazing territories that would benefit from improvements in carrying capacity should be identified according to their importance to the resource diversity and stability of the community at large. This could be assessed in consultation with local leaders.

Given that the system is over-populated, we believe that the crucial risk management intervention is one that allows the Boran to hold some of their cattle assets in a non-livestock form. The ability to manipulate the asset function of cattle is vital to efforts to adjust stocking rates and relocate households from sensitive areas. This activity embodies "efficient opportunism" and involves storing a portion of the value of male cattle as simple savings accounts in local banks. There is evidence that some Boran may be doing this already.

During the high-density phase of the cattle population, when about 300 000 head of cattle occupy the study area, roughly 25% of the herd is comprised of mature males. About 67% and 25% of these males may be held by wealthy and middle-class Boran, respectively. Mature males serve a valuable traditional economic role but at high stocking rates they also compete with milk cows and other productive stock for limited forage and water. This leads to social stress in the community. The males probably also contribute to sudden system crashes during drought in which many households lose all their cattle. Relieving pressure on the system by banking part of the male component each year as cash achieves many system-management goals simultaneously. The tendency, regardless, will be for the Boran to gradually increase the percentage of milk cows in their herds to cope with declining per capita milk production. This will come at the expense of traditional investment potential. Banking livestock capital is offered as a means to help them achieve traditional goals, possibly at a lower risk, despite population pressure.

Constraints to implementing the banking innovation are numerous but are probably less formidable than those involved in extending technical interventions described thus far. Constraints include possible distrust and lack of knowledge of banking among the Boran, cultural mores which work against selling cattle, difficulties of illiterate people gaining access to the banking system and aspects of national currency management such as inflation which might erode wealth stored in non-livestock forms. Local constraints of banking access could be overcome but this would require creativity and incentives. We envision a portfolio-management approach that recognises the maximum benefit from a mix of assets held as livestock or cash in sequences of years in which production risks vary according to stocking rate and rainfall. Banking livestock capital is proposed as the keystone intervention for managing the system out of famine, poverty and increasing risk of environmental degradation.

Policies, procedures and technology for improved animal production: The notion that animal production is uniformly poor in rangeland systems is not supported here. Indeed, under near-average rainfall and low stocking rates, cattle productivity can be extremely high. At high stocking rates, however, risk of forage competition becomes paramount and animals are more likely to be in poor condition, give lower milk yields and die.

Because the stocking rate of cattle changes somewhat cyclically in response to drought (see below), cattle productivity also varies in a cyclic fashion in an inter-drought sequence of five to 10 years. This may be relatively predictable. Using various risk-mitigation measures described above, particularly banking livestock capital, would provide a major stimulus to cattle production per head as a result of destocking during years of the high-density phase of the cattle population when stocking rates exceed on the order of 20 head/km^2. This is because livestock production and mortality are density dependent, with stocking rate mediating effects of annual rainfall on the population. Any measures that increase animal sales to improve human welfare are also valuable; this includes sales of animals to fund water-development activities and construction of grain stores. These activities also build on traditional values of the community.

Calf mortality in near-average rainfall years is the main production factor that requires technical attention. High calf mortality is attributable mainly to poor calf nutrition due to milk restriction in poorer households and to high incidence of diseases resulting from lower management inputs per calf in wealthier households. Shortage of water is also a problem, one that could be addressed by building cement cisterns in certain situations. Attempts to reduce calf mortality fit the cultural rationale of the people, are more consistent with effective use of small quantities of local resources and need an intervention that the Boran can extend among themselves.

The main intervention to reduce calf mortality is making hay from native grasses to improve dry-season calf feeding. The Boran do not traditionally make hay but pilot trials suggest they can make large quantities of hay of suitable quality after the long rains. Feeding hay rather than the traditional cut-and-carry grass could increase the crude-protein content of calf diets by 60% and the digestibility of the diet by 45% during the dry seasons, both on a dry-matter basis. Grass hay can be supplemented with high-protein native legumes such as acacia fruits and leaves and with cowpea (*Vigna unguiculata*) hay where this crop is grown.

Performance of calves and small ruminants might also be improved by providing better veterinary services at the "farm gate." Veterinary services have, however, been very difficult to sustain. New efforts to extend health services and calf feeding packages should initially be focused on peri-urban areas, with the Boran paying for services where possible.

In addition to reducing mortality rates, improved calf feeding could increase milk production by prolonging lactations and might also allow peri-urban households to take more milk from the calf and sell it. Improvements in cattle recruitment would only be sustainable over the longer term if offtake is accelerated through commercial links or banking livestock capital. Policy and technical issues are thus inter-linked.

Implications for poverty alleviation and ecological sustainability: In conjunction with attempts to spur human emigration, the policy and technical interventions described thus far should act in tandem to reduce chronic insecurities that now exist in the system. Banking livestock capital is the key to poverty alleviation and facilitating range management over the short to medium term. Opening markets, increasing milk production, encouraging pockets of sustainable cereal production and facilitating human emigration should all act to reduce the threats of widespread cultivation to the environment, but cumulative impacts of different innovations would be felt over different time frames.

7. Why is banking livestock capital proposed as the keystone intervention?

Banking livestock capital is the only intervention that would have large and simultaneous effects throughout the system. It would improve food security and risk management, alleviate poverty and reduce threats of environmental degradation. It would also help reduce the danger of genetic dilution of the Boran cattle breed by helping stabilise the cattle population, thus reducing the need for pastoralists to trade for highland cows during drought recovery. Banking livestock capital could be a nutritional intervention for cows, an ecological intervention for the plant community and an economic intervention for people. It is thus a classic "system intervention" because it requires an inter-disciplinary knowledge of system function to know when to implement it and why. While pilot projects might attempt to extend this intervention concept soon, additional social and economic research is required to thoroughly assess its implications.

Banking livestock capital may not have been a viable innovation as recently as 10 years ago. However, we believe that it is now viable because of the increased risks to households of holding all of their assets as livestock. This is because of a declining resource base and implications this has for increased system instability.

8. Could banking livestock capital even assist small towns?

Yes. The Boran and the small towns in the rangelands are increasingly interdependent. To the extent that economic development of small towns is constrained by lending capital, banked livestock wealth may have important implications for development of small-scale industries in the urban sector. Conservative calculations suggest that if every wealthy and middle-class household in the study area banked from one to three male cattle each year this would generate about US$ 1.7 million annually from the sale of 14 500 head. This represents only a modest percentage of the total male inventory. Animals would, however, have to be traded out of the system for the initiative to help stabilise cattle population dynamics and contribute to creating a sustainable yield scenario.

9. How should interventions be implemented?

Interventions should be primarily directed to deal with two population phenomena: (1) the long-term trend (see above) and (2) inter-drought cycles, usually lasting 10 years or less, which consist of a drought-recovery phase followed by a phase of high stocking density. Changes in cattle stocking rates affect many ecological, agricultural, social and economic dynamics in the system. The high-density phase, with more than 20 head of cattle per square kilometre, is essentially a different system, with different constraints, than that in the drought-recovery phase.

The long-term trend: In 1990, the long-term trend may have been an average system state in which the ratio of cattle to people was about 4.5:1. In 1959 the average ratio is thought to have been near 7.4:1. In 2006, barring a large change in net human population growth, the ratio should be 3.3:1.

The negative effects of this long-term trend in cattle-to-people ratio could be lessened using policies and procedures that increase commerce and allow more Boran to emigrate. For an example involving technical perspectives, the long-term trend militates against such interventions as improved dairy technology to process milk surpluses and aspects of system extensification. The long-term trend is better confronted by focusing on the likes of facilitation of dairy marketing and intensification of some aspects of range management.

The inter-drought cycle, drought-recovery phase and high-density phase: In 1993 we are in the second year of the drought-recovery phase following the 1991 drought. There is a 75% probability, based on rainfall records, that the high-density phase will be reached by 1997, allowing for the effects of one dry year or less on the growth of the cattle herd. Once the high-density phase is reached, however, there is a 50% chance of a population crash during the first three years due to the combined effects of the high stocking rate and the risk of one or more years of below-average rainfall. It is thus suggested that the impact of drought on the cattle population is now as much a function of high stocking rates as it is of below-average rainfall. Without adequate drought-grazing reserves, a modest dip in rainfall will now kill far more cattle than it would have 30 years ago.

The drought-recovery phase should be characterised by more maize cultivation, peri-urban sales of milk and small ruminants, opportunistic production values of the Boran, high rates of cattle production and the honouring of reciprocal rights of grazing among communities. The high-density phase will be more a time of risk management, negative density-dependent effects on livestock production, grazing-induced bush establishment, increased rates of cattle sales and conservative production values of the Boran.

In the drought-recovery phase of 1992–96, innovations should be employed that complement immediate food-procurement strategies of the Boran (e.g. obtaining maize or selling sheep and dairy products) or that are dependent on low stocking rates for their success (e.g. site reclamation). During the high-density phase, with its high stocking rates and higher risks of asset losses, efforts should encourage banking of livestock capital, sales of cattle to fund water development and promotion of improved calf feeding and grazing management.

In sum, the development strategy has to be opportunistic. There is, however, a reasonable degree of predictability of system dynamics that could guide planning for system management. Another important implication of this schema is that windows of development opportunity are not static; they may be gradually opening, gradually closing or opening and closing cyclically. At one extreme, some innovations would be adopted, dropped and re-adopted in a cyclic pattern.

10. What are the constraints on system transformation?

In past decades it has been common to blame pastoralists, or harsh rangeland environments, in Africa for the apparent failure of range development projects. However, this research indicates that the main constraints actually lie outside the pastoral sector. Planners and researchers commonly do not understand how the pastoral way of life differs from Western concepts such as ranching. They have also lacked appreciation of the complexity of pastoral strategies and how constraints change over time in response to internal and external pressures. Bottom-up approaches to development have been discounted in favour of exotic technologies and Western ideas. Extension is under-funded and personnel is limited and poorly trained. Access to existing technology is limited. The ability of agencies to monitor and regulate resource use is poor and this leads to blanket prohibition of certain practices that might be useful in some situations. True partnerships among pastoralists and development agencies are not traditional and may be difficult to create. Underdevelopment of the nation contributes to major uncertainties in urban employment, commerce and extension. Bureaucratic decision-making is inimical to the opportunistic nature of range ecosystem management. Lack of coordination among government and development agencies obstructs coordinated policy and technical implementation.

The Boran are open minded and can produce animals very well; they just need some stronger links to the outside world. In contrast to many other African producers, the Boran can create large amounts of capital quickly if it can be better harnessed in a rapidly changing world. In one sense, this is all good news. This is because it discounts the notion that this pastoral system is resistant to constructive change from within.

11. What is the source of this systems approach? Does it have wider applicability?

The dynamic view of system interactions requires a different way of thinking. It has been inspired by knowledge of (1) population ecology and (2) predictable relationships among people, animals and the land. A large dose of participatory Farming Systems Research was also mixed in. Clues from producers and traders gave important insights as to how the system changes from year to year and decade to decade. The approach has no strong roots in traditional agricultural investigation.

This philosophy recognises that the Borana system is at a particular point of change along a general continuum. This point has been passed by other African pastoral groups decades or even generations ago. The Borana system may be unusual in that the linkages between the pastoral and non-pastoral sectors are still restricted. This must change if the system is to avoid internal collapse. There are probably other pastoral groups in remote areas of Africa that have yet to reach this stage of change. Systems at different points along a continuum of change require different intervention concepts. The systems perspective is thus applicable beyond the southern rangelands.

When commodity and systems perspectives are run in parallel, the combined answers help tell you what to do, when to do it and why. Neither perspective alone can do as much. Although it has its own scientific merit in terms of inter-disciplinary integration, the systems perspective has an added advantage in that it assists formulation of local strategies that will have an impact on people. We contend that this framework can be easily modified to suit a variety of animal-production circumstances, including smallholders.

12. This all looks expensive. How can this approach be employed elsewhere at low cost?

The systems approach is expensive but systems studies do not need to be repeated often. The key is that researchers and development people learn to think in terms of interacting system components while designing projects. This may require more inter-disciplinary training. Ideally, research should focus on extracting more systems principles from existing work and testing hypotheses concerning specific interactions. Using a systems approach to assess intervention strategies to be used by development people requires more attention to conceptualisation of the system of interest and perhaps examination of important system interactions using producer-participatory approaches along the lines of Rapid Rural Appraisal.

In sum, it is important to know where a system is at any point in time and what the future trends might be, based on probabilities. The practical outcome concerns how population pressures or outside influences might help or hinder uptake and impact of innovations.

13. What are some other research and development implications?

- Future research priorities involve sociology, economics and ecology in the context of risk management. Routine system monitoring is needed to test hypotheses embedded in the theory of local system dynamics, survey felt needs of the pastoralists, observe shifts in resource use and performance of markets and examine the fate of emigrants. Monitoring could be quantitative or qualitative, depending on research budgets. The theory of local system dynamics also has large implications for monitoring range trends. Given near-average rainfall, herbaceous dynamics may tend to be cyclic in response to cattle stocking rates rather than linear. Establishment of woody seedlings may also be more episodic than continuous, with eruptions of woody seedlings occurring more during high rainfall years in the high-density phase of the cattle population.
- The cattle population tends to exhibit equilibrial characteristics. This is not to say that the system does not change from year to year: it is very dynamic within certain limits. It tends towards equilibrial features because cattle stocking rates reach levels that negatively affect the population. Relatively high rainfall and a dominance of perennial vegetation increase the likelihood of periodically intense plant–herbivore interactions. Stocking rate is a crucial filter that affects the response of the population to variation in rainfall. Both equilibrial and non-equilibrial systems may exist in East Africa, with non-equilibrial ones occurring more when systems are less bounded by resource limitations and/or are subject to very low and erratic levels of rainfall. The equilibrial tendencies of the Borana system periodically generate pressure in the system and motivates producers to consider new ways of doing things. Equilibrial dynamics have probably been promoted in the southern rangelands by infrastructure development and population growth.
- The cattle population appears to have substantially modified the environment, causing grazing-induced woody encroachment and soil erosion. However, the extent of impact in relation to a pristine original condition of the study area has not been quantified. Many impacts observable today may have occurred in previous generations. The relatively high rainfall suggests that the region could naturally support a high density of woody plants and thus may have been densely wooded prior to the arrival of man hundreds of years ago. We may therefore now be witnessing the disappearance of a mixed savannah that has been traditionally maintained by people. Woody encroachment has probably been exacerbated recently by human population growth, which encourages sedentarisation, and by a Government policy that prohibited range burning from 1974 to 1991. Although the ultimate effects of encroachment by woody plants are probably detrimental to cattle grazing, intermediate stages may have a variety of positive, neutral and negative effects. We believe that, under proper management, many areas encroached by woody plants could be reclaimed. Cereal cultivation on upland soils may, however, pose a greater future threat to the environment than cattle grazing.
- Transfer of nutrients by cattle from grazing areas to encampments has been implicated in some aspects of environmental change here. It has also been hypothesised that leaf fall from woody vegetation is an important contributor to the replenishment of soil nutrients on overgrazed sites. These questions require further investigation.
- Preliminary information on native plants and wildlife gathered by during the System Study provides a baseline from which to begin to

address biodiversity issues. Biodiversity research is, however, a low priority until the human crisis can be alleviated.

- Borana leaders are aware of problems associated with the high human population and high cattle stocking rates and of links between heavy grazing and environmental degradation. They make political proclamations intended to protect their natural resources. The extent to which the traditional leadership can effectively control resource use today is, however, unclear.
- The critical measure of system sustainability is per capita production of milk and male animals as assets. Trends in both now appear to be in precipitous decline because the human population continues to grow while the cattle population is increasingly limited by land availability. Until this situation is dealt with, other aspects of improving social or ecological sustainability must be a lower priority for development.
- Human population dynamics and their effects on the system are poorly understood. The observed increase in the net population growth rate may be due to increased availability of relief grain and health inputs. It may be due also to less adherence to traditional social norms that have regulated reproductive behaviour in the past and/or to a temporary decline in the effectiveness of reproduction rules that are dictated in the *Gada* generation system. For example, fewer people may be affected by certain *Gada* rules today than in the past because of recent shifts in the age composition of the society.
- As with other pastoral systems, the Borana system is more efficient than commercial ranching in terms of food-energy yield per person and per unit area. This is largely because of the high stocking rates and inclusion of milk as an output. The high stocking rates of pastoral systems can, however, pose greater risks for the environment and for system stability than does ranching. As elsewhere, the ranching concept has failed in Borana. Ranch lands are in the process of being transferred back to the Boran. There are several reasons for this failure here, but the key factor is that commercial ranching is fundamentally inimical to the Borana production rationale.
- It is hypothesised that rapid growth in the regional cattle herd (i.e. from less than 10 to over 25 head/km^2 during just a few years in the drought-recovery phase) leads to a sequence of nutritional constraints on cattle in successive years (i.e. from minerals to crude protein to energy). This would undermine the general rule of thumb that shortage of crude protein in dry periods is the most common nutritional constraint in the semi-arid zone at all times. Mineral and protein supplements may be more effective at lower stocking rates than at high stocking rates. At higher stocking rates, when competition for forage among cattle limits energy intake, the best intervention is destocking that is compensated along the lines of banking livestock capital.
- Boran cattle show considerable compensatory growth in recovering from early restriction of milk intake as calves. Under experimental conditions, reducing the amount of milk consumed by calves by 170 litres had no long-term effect of the productivity of the animals. Under ranch conditions, adult cattle also are able to compensate for weight lost because of restricted water intake during dry seasons. However, high stocking rates probably periodically hinder compensatory growth in calves and adults. Feeding calves forages to compensate for milk deprivation and to accelerate growth over the long term is not useful because weight advantages can be easily lost and are thus risky. Feeding to reduce calf mortality is much more viable. Ideally, small- scale water development should accompany improved feeding systems for calves, because seasonal lack of water limits dry-matter intake. Studies of the allocation of extra water available from the use of cement cisterns suggest that the major impact of increased availability of water for households is on the calves, not people.
- Besides a primary focus on dual-purpose legumes to provide food for people, forage improvements should focus on the best native grasses and woody species. Some of East Africa's best native forages are found in the southern rangelands. The pre-occupation of past development efforts with exotic forages is unwarranted and resulted from ignorance of the possibilities of using native plants. Trials with herbaceous exotics also have been disappointing; it appears that low rainfall and/or cool temperatures are major constraints to establishment and growth of *Stylosanthes hamata* cv Verano in particular. Despite their often low and variable productivity, native species are valuable because of their proven persistence in an often difficult environment and because valuable species are already recognised as such by the Boran.
- The dynamics of the Borana system can be most comprehensively described in the

context of three states: (1) drought, (2) the drought-recovery phase and (3) the high-density phase. From 1980 to 1991 there were roughly four years of drought, four years of drought recovery and three years of the high-density phase.

- The 1983–84 drought contributed to the death of 45% of the milk cows, 90% of the calves and 22% of the mature male cattle in five encampments. This testifies to the risk-mitigation role of hardy, mobile males during drought. More-productive cows may also be more vulnerable to starvation than are poorly productive cows. Drought may thus undermine attempts to upgrade the genetic base of the regional herd. The main value of camels to peri-urban households during drought appeared to be their ability to maintain long lactations. This allowed households to sell milk to buy grain at favourable terms of trade. Cow milk was also sold but in smaller quantities. Dairy products were in very limited supply during the drought and were the only livestock product for which terms of trade for grain did not decline precipitously.
- In the near future, management of drought effects will still rely largely on provision of relief grain. It is envisioned that proper system management would reduce the negative effects of drought that result from high stocking rates and human over-population. Important measures over the short to medium-term could, however, include strategic restoration of drought-grazing reserves, provision of public-works jobs during drought, opening of market linkages between the highlands and lowlands and creation of grain stores both on a household and a regional basis. Banking livestock capital would also be expected to improve the commonly poor terms of trade between livestock and grain during drought. Considering recent patterns of prices and annual terms of trade, if the value of animals were banked during the inter-drought cycle and cash were withdrawn to buy grain during drought, households would on average liquidate only one-third of the animal assets otherwise needed to purchase grain to endure a two- or three-year drought.
- Male camels are important for hauling grain, construction materials and other goods from the market to distant encampments. Given their browsing habits, camels and goats are ecologically more compatible with cattle than are sheep, since both cattle and sheep are grazing animals and would compete for the same feed supplies. There is no evidence to link woody encroachment with camels or goats. Diversification of herds to include more camels and small ruminants is probably most dependent on improving access to camel markets and on veterinary extension; these interventions could be pursued.
- These observations suggest that agro-pastoralism, herd diversification and peri-urban dairy marketing have evolved in East Africa because of extreme pressure on the traditional livestock system as a result of human population growth. They do not, therefore, necessarily represent improvements in human welfare or an enhanced system state. Rather, they represent indigenous mechanisms for avoiding starvation and/or asset depletion. The development goal for the Borana system should be sustainable, extensive pastoralism, not agropastoralism.
- Borana society is economically diverse and clearly stratified into wealthy, middle-class and poor components. There is also a rural sector and a peri-urban sector (i.e. within 30 km of towns) which are believed to behave differently from each other in social and economic terms. The concept of an overall average household thus has little meaning and does not offer much utility as a research tool.
- Two independent surveys showed that 20 to 25% of household heads were women, particularly in the poor and middle-class strata. It is hypothesised that a higher percentage of households heads are women in the peri-urban sector. There is no information on whether a larger percentage of households are now headed by women than in the past or if the roles of women in the society are changing.
- Women reported that they worked long hours all year but direct observation suggested that about 30% of their time in the warm dry season consists of activities associated with "leisure." An extension trial indicated that women apparently had enough "free" time at the end of the long rains to make up to 300 kg of grass hay. Whether or not production innovations are adopted probably depends largely on social values and whether the women are willing to give up some of their leisure time.
- The perverse supply hypothesis might be valid here for poorer households who are forced to sell cattle. That is to say that the Boran will seek to sell livestock in markets with higher prices but that the primary reason they do so is to minimise the number of animals sold. This hypothesis needs to be tested at the household level.
- Although all households will be forced to sell more cattle, informants report that true

livestock commercialisation in the southern rangelands will emerge from a new class of individuals who have some education, wealth and ties to the traditional sector. Some of these people may have learned the livestock trade while working as government agents. Increased competition and possible conflict between commercial and subsistence herds may occur. One irony is that, in the attempt to gradually guide the traditional pastoral system towards enhanced productivity, sustainability and social welfare, the Government may have to intervene to protect the subsistence population from intense competition with commercial producers.

- The Boran are innovative and have pioneered some of their own resource management concepts such as planned grazing allocations and fodder banks (*kalo*). Persistence of traditional leadership structures should facilitate introduction of appropriate interventions in this system.
- In the southern rangelands, bottom-up approaches to development of innovations have been more effective than top-down approaches. This is because the producer's behaviour, values and daily life are more complex than, or counter-intuitive to, that imagined by researchers. Top-down concepts such as the pond scoop, the improved butter churn, pasture improvements using exotic forages, speeding-up calf growth through supplementary feeding or drought fodder banks based on *Atriplex* and *Opuntia* spp will not have an impact here for various reasons. Bottom-up concepts such as hay-making, using native legumes, intensified aspects of range management, cement cisterns, banking livestock capital and reducing calf mortality are far more likely to have an impact.
- In this project, the interaction between researchers and development agents proved very fruitful in helping design research that had an impact on development. Development agents provided grass-roots links with the community that provided a better bridge to researchers. This permitted a true systems-research process to evolve.

Primary contributors and collaborators

Assefa Eshete

The late Assefa Eshete, Ethiopian, had a primary role as a photo-interpreter and ecologist with the aerial survey team at ILCA until 1991. Here he contributed results from aerial surveys conducted during the mid-1980s. He also had a leading role in the production of a comprehensive ecological map of the study area.

Marco Bassi

An Italian national, Dr Bassi is a social anthropologist who was affiliated with the Institute of Ethiopian Studies at Addis Ababa University and the Instituto Universitario Orientale, Naples, while conducting his doctoral research in the southern rangelands during 1989–90. Here he contributed observations on social aspects of resource allocation among the Boran.

Belete Dessalegn

Belete Dessalegn, Ethiopian, served as an animal scientist with ILCA until 1989. His work in the southern rangelands focussed on productivity and feeding ecology of small ruminants and camels.

Jean Claude Billé

Dr Billé, French, was a senior ecologist at ILCA until 1986. Dr Billé contributed material on grazing-induced vegetation dynamics, patterns of environmental degradation, and pastoral land use in the southern rangelands. He now resides in France.

D. Layne Coppock

Dr Coppock, American, was a range and animal scientist at ILCA until 1991, and served as research coordinator for the southern rangelands site from 1987–91. Author of the final project synthesis, Dr Coppock's primary research focus was on testing development-intervention concepts and deriving an interdisciplinary systems perspective for the southern rangelands. He is currently on the faculty of the Department of Range Science at Utah State University.

Michel Corra

Dr Michel, Ethiopian, was an ecologist and member of the aerial survey team at ILCA until 1991. He contributed material on aerial survey results and plant community ecology.

Noel J. Cossins

An Australian national, Mr Cossins was Team Leader for the Ethiopian Rangelands Programme at ILCA from 1981–86. He assembled the original research team, focussed work in the southern rangelands, and helped forge initial links between ILCA and CARE-Ethiopia. He contributed material on baseline descriptions of the pastoral system and production intervention concepts. He resides in Australia.

Tim J. Donaldson

Mr Donaldson, British, received his master's degree at Reading University in 1986 with research requirements fulfilled from his study of effects of the 1983–84 drought on Borana households and their livestock. He also conducted work in which he described water resources. He has recently been employed with the Natural Resources Institute in the United Kingdom.

Geoffrey W. Dyce

Mr Dyce based his 1987 master's thesis on livestock marketing data collected by ILCA and the Third Livestock Development Project (TLDP) in the southern rangelands during the early 1980s, and produced a synthesis of supply-side features. An Australian national, he received his degree from Reading University.

Ephraim Bekele

As a member of the Dairy Technology Unit at ILCA, Ephraim Bekele, Ethiopian, provided some of the first comprehensive descriptions of Borana milk processing practices during 1987. He has also been a senior staff member affiliated with the ILCA administration in Addis Ababa.

Claudia Fütterknecht

An Austrian national, Dr Fütterknecht has been coordinator of the Borana Rangelands Project for CARE-Ethiopia from 1989–93. A social anthropologist, she contributed observations on famine relief and implementation of development interventions in the southern rangelands.

Girma Bisrat

Girma Bisrat, Ethiopian, is a range professional and former General Manager of TLDP. He contributed observations concerning range development in

Ethiopia. He is currently coordinator of the Peasant Agricultural Development Project (PADEP) and is based in Addis Ababa.

Ron Hacker

A consultant range ecologist to the Third and Fourth Livestock Development Projects (TLDP/FLDP), Dr Hacker, Australian, made many useful observations on range ecology and bush encroachment. He has also been involved in the development of ecological monitoring approaches in the southern rangelands during 1988–90.

Jean Hanson

As Head of the Gene Bank at ILCA, Dr Hanson supervised much of the laboratory work on germination studies for seeds of indigenous trees. A British national, Dr Hanson has been with ILCA in Addis Ababa since 1986.

Richard Hogg

Dr Hogg, British, has been a consultant social anthropologist to TLDP/FLDP and the Southeast Rangelands Development Project (SERP). He has primarily focussed on organising more effective participatory development strategies for pastoralists.

Roger J. Hodgson

Mr Hodgson, British, served as coordinator of the Borana Rangelands Project for CARE-Ethiopia from 1985–89. He was responsible for initiation of participatory approaches that accelerated identification of development problems and possible solutions in the pastoral system. An agroforester, his technical interests focussed on forage improvements. He has recently worked with Action-Aid in Nepal.

Sarah J. Holden

A British national, Ms Holden obtained a master's degree from Reading University with the research requirement fulfilled from her study of dairy marketing among Borana women in 1987. She has recently worked as an economist with the Overseas Development Administration in Indonesia.

Ephraim Kabaija

A Ugandan national, Dr Kabaija conducted studies on mineral nutrition of Boran cattle while a postdoctoral associate with the Nutrition Unit at ILCA during 1987–88.

C. S. Kamara

From Sierra Leone, Dr Kamara carried out the first detailed soil analyses in the southern rangelands during 1987, when he was a research associate with the Plant Sciences Division at ILCA.

Gordon King

Dr King has had a key role in supervising several Ethiopian postgraduate students in the southern rangelands. Research topics for these students varied from range ecology to forage agronomy. An Australian national, Dr King is on the faculty of the Department of Wool and Animal Science at the University of New South Wales.

Menwyelet Atsedu

A former staff member of TLDP, Menwyelet Atsedu, Ethiopian, obtained his master's degree from Colorado State University and fulfilled the research requirement with his studies of the ecology and management of indigenous forage resources by the Boran during 1988–90. He is currently pursuing a PhD degree at Colorado State.

Wangoi Migongo-Bake

Dr Migongo-Bake, Kenyan, was a postdoctoral associate at ILCA during 1985–86. Her research focus was forage agronomy.

Kevin Milligan

The late Mr Milligan conducted the first comprehensive analysis of an aerial survey of the southern rangelands for ILCA in 1982.

Mulugeta Assefa

A former staff member of TLDP, Mulugeta Assefa, Ethiopian, obtained his master's degree from Colorado State University with the research requirement fulfilled from his studies of effects of family wealth on the productivity and management of Boran cattle, and implications for production interventions as assessed through cost/benefit modeling of herd performance. This work was conducted during 1988–90. He now resides in the United States.

Negussie Tilahun

While a field research assistant at ILCA, Negussie Tilahun, Ethiopian, conducted some of the first economic surveys of Borana households and livestock markets in the study area during the early 1980s.

Mark J. Nicholson

A British national, Dr Nicholson primarily focussed on studies of water restriction of Boran cattle and the implications for production at Abernosa ranch in the Ethiopian Rift Valley. He also investigated calf growth and milk offtake patterns in the southern rangelands. His principal assignment at ILCA from 1984–87 was as a doctoral candidate affiliated with Cambridge University, UK, with the water-restriction work comprising the research requirements for his degree.

Charles B. O'Connor

An Irish national, Dr O'Connor has supervised the laboratory work dealing with technical aspects of milk processing as practised by the Boran. He is currently Head of the Dairy Technology Unit of ILCA at Debre Zeit station in Ethiopia.

Frank O'Mahony

The late Dr O'Mahony, an Irish national, was a dairy technologist at ILCA who initiated field studies of milk processing in Borana households in 1986.

Jess D. Reed

Dr Reed, American, contributed to work on nutritional evaluation of indigenous forages in the southern rangelands conducted while he was a scientist in the Nutrition Unit at ILCA in Addis Ababa from 1984–89. He is currently on the faculty of the Department of Animal Science at the University of Wisconsin.

Solomon Dessalegn

Solomon Dessalegn, Ethiopian, has worked towards his master's degree at the University of New South Wales. His research has focussed on the use of fire, mechanical or chemical control techniques in the management of woody vegetation in the southern rangelands.

Solomon Desta

As senior economist with TLDP, Solomon Desta, Ethiopian, has been instrumental in TLDP management. For this report he contributed results from a livestock census conducted in 1987 in the southern rangelands that he designed and supervised, as well as results from other unpublished government surveys from the 1980s. He also shares many of his important insights regarding livestock development in Ethiopia. He has recently been project manager for the Southeast Rangelands Project (SERP) in the Ogaden.

Solomon Kebede

A former staff member of the Ethiopian Ministry of Land Use Planning, Solomon Kebede, Ethiopian, conducted research towards his master's degree at the University of New South Wales. He studied aspects of ecological competition between herbaceous and woody vegetation on a government ranch in southern Ethiopia during 1987.

Sandro Sovani

An Italian national, Dr Sovani contributed to an analysis of the effects of nutritional interventions on affecting time to puberty in Boran heifers. This work was conducted while he was a research associate with the Animal Reproduction and Health Section at ILCA in Addis Ababa during 1988–90.

Tamene Yigezu

Tamene Yigezu, Ethiopian, obtained his master's degree at the University of New South Wales in 1990 and fulfilled the research requirement with a study of the population ecology of two *Acacia* species in the southern rangelands. He has recently served as sub-project manager for the Southern Rangelands Development Unit (SORDU) in Yabelo.

Tarik Kassaye

Tarik Kassaye, Ethiopian, obtained her master's degree in food science at McGill University in 1990 and fulfilled the research requirement with a technical study of traditional milk processing as practised by the Boran, conducted in 1988–90. During this time she was a research assistant with the Dairy Technology Unit at ILCA.

John C. Tothill

The former head of the Plant Science Division at ILCA during 1985–1990, Dr Tothill, Australian, helped supervise Ethiopian postgraduates in range ecology and forage agronomy in the southern rangelands. He now resides in Australia.

Martin Upton

Professor Martin Upton, a British national on the faculty of Reading University, served as a consultant to ILCA at various times during the mid-1980s. He contributed work concerning evaluation of production interventions using modeling approaches as well as exploring issues in resource management and development policy in southern Ethiopia.

Patrick Webb

A British national and research staff member of the International Food Policy Research Institute (IFPRI) in Washington, D C, Dr Webb was the field director of a study of household responses to the 1983–84 drought in agricultural systems throughout Ethiopia. The study was conducted during 1988–90 and included a site in the southern rangelands. A geographer by training, he currently works with IFPRI and is based in the United States.

Richard Wilding

Dr Wilding served as a consultant to ILCA at various times during the mid-1980s. His work focussed on uses of indigenous plants by Borana households and historical aspects of the Boran in southern Ethiopia. At the time of his collaboration with ILCA, Dr Wilding was a staff historian with the National Museum system of Kenya.

Andrea Woodward

An American national, Dr Woodward obtained her doctorate at Cornell University in 1988 with research requirements fulfilled from a study that focussed, in part, on use of browse forages by small ruminants and camels in the southern rangelands. She has recently worked as a biologist with the College of Forestry at the University of Washington.

Yohannes Alemseged

A former staff member of the Ethiopian Ministry of Agriculture, Yohannes Alemseged, Ethiopian, obtained his master's degree from the University of New South Wales in 1989 with the research requirement fulfilled from his study of various forage legumes as intercrops with maize conducted in the southern rangelands during 1987. He is currently pursuing his PhD degree in Australia.

Chapter 1

Review of rangelands and rangeland development in Ethiopia

Summary

The Ethiopian lowlands occur below 1500-m elevation and comprise 61% of the national land area. Climate in the lowlands includes arid (64%), semi-arid (21%) and subhumid (15%) zones largely defined by four rainfall and temperature regimes. These zones vary markedly in terms of number of plant growing days per year, forage production, common plant associations, livestock and human carrying capacities and incidence of important livestock diseases.

Ethiopia today has about 42 million people and over 70 million head of livestock. The lowlands are home to 12% of the human population (or five million people) and 26% of the livestock (or 21 million head). Land use by the 29 ethnic groups of the lowlands is dominated by various forms of pastoralism and agropastoralism. Livestock depend upon rangelands consisting of native vegetation, with crop residues increasing in importance as livestock feed as annual rainfall increases. Calculated for the lowlands overall, roughly six people/km^2 are dependent on 11 Tropical Livestock Units (TLUs), which are composed of cattle (49%), goats (16%), equines (16%), camels (12%) and sheep (7%). In contrast, the highlands support 72 people/km^2 dependent on 44 TLUs/km^2 which are dominated by cattle (76%), equines (14%), sheep (8%) and goats (2%). Thus, although the lowlands comprise over 50% more land area than the highlands, the lowlands have only 40% as many TLUs at one-quarter the density.

Although the lowlands have a lower abundance of animals than the highlands, the lowlands still play a crucial role in the national livestock economy. Livestock production is an important component of the national economy; in the mid-1980s livestock production comprised 33% of the gross value of annual agricultural output and 15% of gross domestic product. Besides supporting rural and urban lowlanders with milk, meat, employment and investment opportunities, lowland breeds of cattle and sheep made up over 90% of legal exports of live animals. In the mid-1980s, export revenues for live animals came in a distant second after coffee and comprised 12% of gross annual export revenue overall. However, about 450 000 head of lowland livestock may be traded on the international black market each year and official statistics often do not reflect this volume. This situation resulted from black market prices being 150% higher than regulated, domestic livestock prices during the 1980s. Lowland cattle may also provide around 20% of the draft animals for the highlands, particularly to the east, and smaller numbers are supplied for finishing on crop residues and cross-breeding in smallholder dairy programmes. The lowlands are thus an important source of livestock supply to the nation. This situation results, in part, because there are three times as many TLUs per person in the lowlands than in the highlands. This per capita "surplus" in the lowlands, however, may be declining because of rapid growth in the human population (i.e. 2.1% per annum, with a doubling time of 26 years) and environmental limits on growth in livestock populations.

Although some development projects were targeted for lowland livestock systems in the 1950s, large-scale development efforts did not occur regularly until after 1965. These projects were generally intended to foster greater integration among lowland and highland production systems. The Third Livestock Development Project (TLDP), originally budgeted at US$ 44 million, has been the dominant force in development of the pastoral livestock sector since 1975. The TLDP has provided infrastructural improvements (roads, markets, water) and support services (veterinary and facilitation of inter-regional trade) to around one million pastoralists residing in 27% of the lowlands to the north, south and east of the country. The primary goal was to stimulate livestock commercialisation. These regions were targeted because of proximity to national markets and infrastructure, the quality of indigenous livestock breeds and their higher ecological potential compared to other lowland areas. Despite chronic problems with regional security and the national economy, the TLDP has made a notable contribution, particularly in terms of infrastructure. As one of three sub-projects of TLDP, the Southern Rangelands Development Unit (SORDU) has been most successful in implementing programmes in the Borana pastoral system. In large measure this has been due to the enhanced security situation in the south during the 1980s compared with lowland development regions in the north and east.

More recent development initiatives have included the Pilot Project at SORDU in conjunction

with the Fourth Livestock Development Project (FLDP) which was initiated in 1988 and the Southeast Rangelands Project (SERP) in the Ogaden, initiated in 1990. These projects were designed to incorporate participatory approaches to pastoral development in addition to provision of infrastructure and support services. Despite advances in pastoral-development concepts since 1975, impact of pastoral-development activities has been routinely constrained by shortages of operating funds and trained manpower and periods of insecurity.

Research and development organisations collaborated in the lowlands during 1982–90 to better understand the pastoral systems and design appropriate production interventions. These efforts included TLDP, ILCA, CARE-Ethiopia, the Institute of Agricultural Research and the Relief and Rehabilitation Commission (RRC) working in the SORDU sub-project area since 1985. Ultimately, the most effective approach involved research following the lead of insightful development agents who implemented a more participatory approach for identifying felt needs and production problems as perceived by the pastoralists. This evolved process appears to be a departure from traditional models of farming systems research and extension in which researchers take sole responsibility for problem identification.

1.1 Introduction

The Ethiopian lowlands support a great diversity of livestock production systems. These systems are fundamentally defined by interactions of rainfall and topography. This chapter reviews the Ethiopian lowlands in a national and regional context, including abiotic features, vegetation, populations of people and livestock and contributions of lowlands livestock to the national economy.

Commercialisation of the livestock sector has been a prominent development strategy for Ethiopia. A series of livestock development projects that date from 1965 are highlighted in terms of their history, objectives, successes and problems. In aggregate, these projects have attempted to foster more integration among highland and lowland production systems as elements of livestock demand and supply, respectively. Special attention is given to the Southern Rangelands Development Unit (SORDU), which has been the primary development agent in the Borana pastoral system. Finally, a synopsis is presented that outlines experiences resulting from collaboration of research and development organisations in SORDU during 1985–90.

1.2 The lowlands and pastoralism in a national perspective

Calculated across 39 countries of tropical Africa, Ethiopia has 17% of the ruminant Tropical Livestock Units (TLUs, where 1 TLU = 250 kg live weight (Jahnke, 1982)) and about 60% of the equines (Jahnke, 1982: pp 13–14). Ethiopia thus has the largest national totals of these animals in tropical Africa. This is related to Ethiopia's large area (1 224 000 km^2), high ecological diversity, large human population and historical and cultural factors.

Ethiopia can be divided into highlands (39%) and lowlands (61%) using 1500-m elevation as a crude threshold. While the highlands typically have higher annual rainfall than the lowlands, this is not always the case. The highlands are characterised by relatively low mean temperatures during growing periods (Jahnke, 1982: p 16). The highlands have climates that vary from semi-arid to humid (i.e. sufficient moisture for 90 to over 270 growing days per year) and contain nearly all of the important areas for cereal cultivation and mixed crop–livestock enterprise (Westphal, 1975). The lowlands, in contrast, are dominated by arid to semi-arid climates (i.e. up to 180 growing days and 700 mm of precipitation per year). The lowlands are home to a diverse array of pastoral people who depend to a high degree on livestock for their sustenance. These livestock, in turn, depend nearly exclusively on native vegetation for forage, and net primary production is highly variable over time and space. The lowland regions that support wildlife and extensive livestock operations on native vegetation can also be referred to as rangelands (Pratt and Gwynne, 1977: p 1).

The uncertainties of rainfall and primary production in the rangelands have promoted animal-based life-styles that enable people to be mobile and opportunistic. Pastoralists typically rely on milk for food and also use animals to store and generate wealth. Animals are consequently important in social value systems. Pastoral social systems also commonly emphasise decentralised leadership that promotes flexibility in resource use (Jahnke, 1982; Coppock et al, 1985). Ethiopia's lowlanders are derived from 29 Nilotic and Cushitic ethnic groups. It has been estimated that 93% of these people are pastoralists or agropastoralists, with the remainder being hunter-gatherers or pure cultivators (UNDP/RRC, 1984).

It was recently reported (FLDP, nd: p 22) that Ethiopia had about 29 million cattle, 24 million sheep and 18 million goats in 1987–88. Jahnke (1982: p 14) estimated 6.8 million equines from FAO data for

Ethiopia in 1979. Distribution of animals differs sharply with elevation. The highlands have 80% of the cattle and 75% of the sheep but only 27% of the goats (FLDP, nd: p 22). Assuming two-thirds of the equines occur in the highlands (with a TLU equivalent of 0.6 each), this translates into a total of 44 TLUs/km^2 in the highlands with 76% cattle, 14% equines, 8% sheep, and 2% goats. For the lowlands about one million camels need to be figured in (Jahnke, 1982: p 13), which brings the lowland total to 11 TLUs/km^2 with 49% cattle, 16% goats, 16% equines, 12% camels and 7% sheep. Thus, despite being over 50% larger in area than the highlands, the lowlands have only about 40% as many TLUs at one-quarter the density. Lowland livestock, however, are more diverse in terms of species composition.

The subsistence character of the livestock contribution to rural economies of Ethiopia is illustrated by ratios of animals to people. Considering that the human population is currently 42 million, with 12% in the lowlands and 95% in rural areas (EMA, 1988), the rural highlands support some 72 people/km^2 on average, with 1.6 people/TLU. In contrast, the lowlands support about six people/km^2 with 1.8 TLU/person. Other estimates have ranged from 1 TLU/person in the highlands to 5 TLU/person in the lowlands (FLDP, nd: p 22). These ratios differ markedly from those of developed commercial systems. For example, successful commercial beef operations in Kenya may require a herd size of 70 head/person employed (Pratt and Gwynne, 1977: p 201). Even pastoral systems may require at least 5 TLU/person for subsistence (Pratt and Gwynne, 1977: p 38), which challenges the commonly held view that the lowlands have a large, marketable surplus of animals (FLDP, nd: p 22).

Despite the low level of commercialisation, livestock production in Ethiopia overall contributed about 33% of the gross value of annual agricultural output and 15% of gross domestic product during the mid-1980s (IBRD, 1987). The per capita consumption of animal protein is relatively high for Africa and averages up to 13 kg/person annually, with 51% consisting of beef (IBRD, 1987). Improved livestock marketing is viewed as an important national development strategy to increase both rural incomes and foreign exchange. A rising domestic demand is expected to compete more in the future with demand for live animal exports (FLDP, nd: pp 1, 10). During the mid-1980s coffee contributed about 60% of gross annual export revenue for Ethiopia, followed by hides and skins (12%). Revenue from live animals was far behind at 1% (IBRD, 1987). The recent volatility in coffee markets has probably increased the relative importance of livestock products in Ethiopia's exports, but room for improvement exists in absolute terms. It is anticipated, for example, that expansion of live animal and carcass exports to Yemen, Saudi Arabia and the United Arab Emirates now offers one of the best opportunities for increased trade; the major competitor in this market has traditionally been Somalia (FLDP, nd: pp 2–4). Australia has also recently become a competitor (Solomon Desta, TLDP economist, personal communication).

Although the lowlands have fewer animals than the highlands, the lowlands still play an important role in the national livestock economy. Overall, the Ethiopian highlands are considered as livestock-deficit areas with the lowlands as the major source of supply (FLDP, nd: p 29). Twenty per cent of the highland draught cattle are thought to come from the lowlands (Girma Bisrat, PADEP Coordinator, personal communication). Lowland breeds of cattle (e.g. unimproved Boran; Plate 1.1) and sheep (e.g. Somali blackheaded) are often regarded as superior to indigenous highland breeds in terms of size, durability, productivity and/or consumer preferences in the Middle East (Alberro, 1986; Girma Bisrat, PADEP Coordinator, personal communication; Solomon Desta, TLDP Economist, personal communication). As a consequence, lowland stock may comprise over 90% of export animals (Girma Bisrat, PADEP Coordinator, citing unpublished data from the Ethiopian Livestock Marketing and Development Corporation). Boran cattle have also played an important role in cross-breeding programmes with Friesians to provide dairy cattle for smallholders in the Rift Valley and highlands (Kiwuwa et al, 1983). Finally, lowland animals contribute to a very large flow of income from illegal exports, since all of Ethiopia's international borders occur in lowland areas. This trade may involve on the order of 150 000 cattle and 300 000 small ruminants per annum, and is encouraged by external prices averaging up to 150% higher than those within Ethiopia in recent years (FLDP, nd: p 33).

Livestock in the lowlands provide subsistence employment and investment opportunities for around five million people and a source of meat, milk and fibre for residents of some two dozen major towns and cities within and adjacent to lowland areas (Girma Bisrat, PADEP Coordinator, personal communication). It has been estimated that the human population in the lowlands will grow at an average of 2.1% per year with a doubling time of 26 years (EMA, 1988). Although this is lower than the 3 to 4% growth rates of the highlands (EMA, 1988), it will still produce marked pressure on the less-productive resource base. As will be discussed, economic interaction between the highlands and

Plate 1.1. *Indigenous Boran cattle of the southern rangelands.*

Photograph: JEPSS

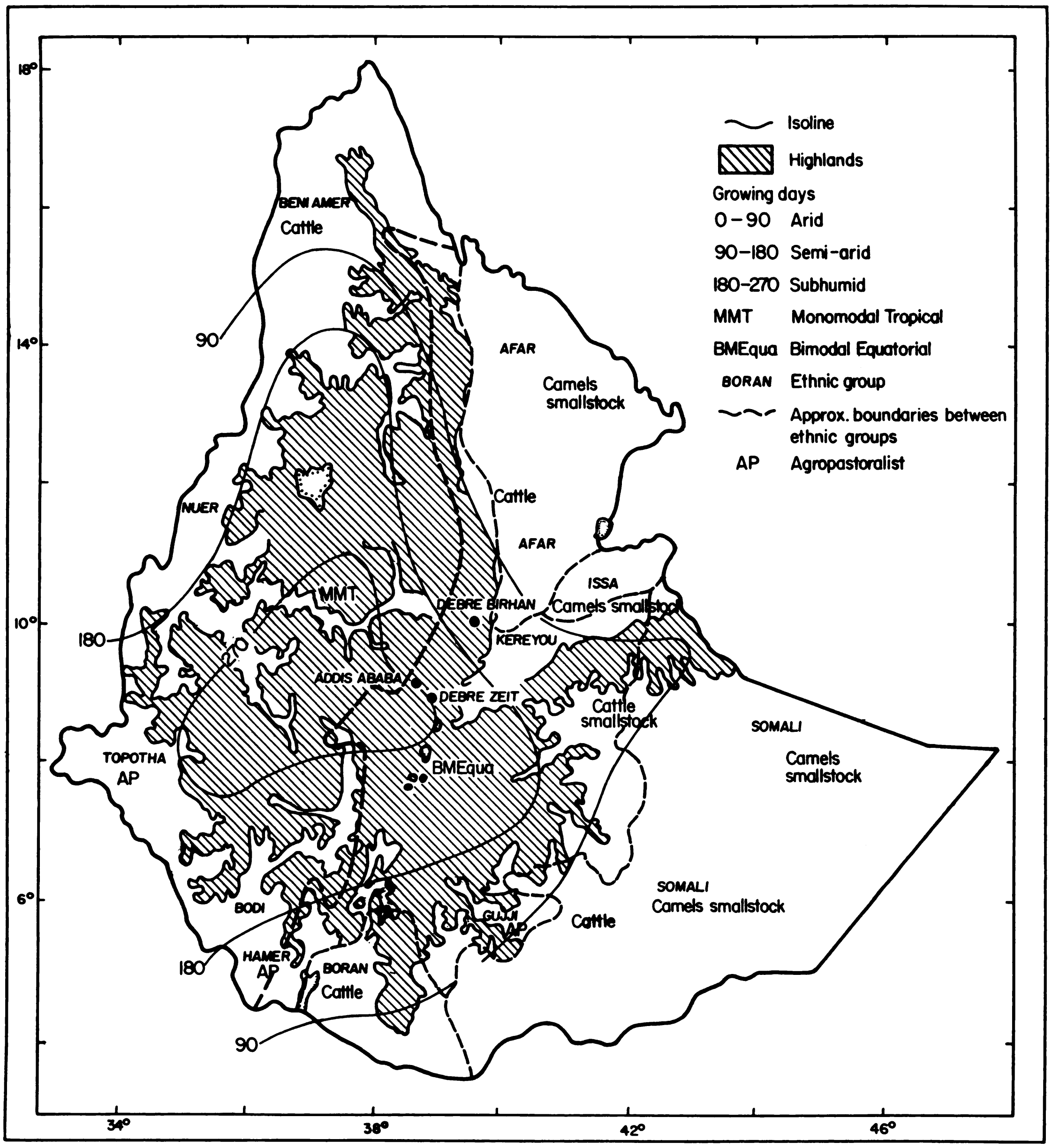
lowlands will probably have to be intensified in response to population pressure. One objective for national development should be to strengthen interregional linkages to help buffer populations from local droughts and other perturbations. The lowlands can thus be expected to play a larger role in the national economy in the future. As elsewhere in Africa, however, livestock development in the lowlands will often occur in situations where human populations are rapidly increasing, prime grazing lands are being lost to cultivation, traditional leadership and cultural value systems are being diminished and where land in general may be increasingly under threat of degradation (Swift, 1977; RRC, 1985; Moris, 1988).

1.3 Climate and zonation of the lowlands

The lowlands of Ethiopia form a wide apron surrounding the highland massif. Part of the lowlands is the Great Rift Valley, which divides the west-central highlands from the north-eastern, eastern and southern lowlands. A map depicting highlands and lowlands and climate regimes is provided in Figure 1.1. The Great Rift Valley is demarcated in this map by territories of the southern Afar, Issa and Kereyou to the north-east and Bodi to the south-west. The climate regimes are defined in terms of interactions between temperature and precipitation that largely define plant growing periods and variation in human exploitation patterns. This review closely follows Westphal (1975: pp 18–27), Workineh Degefu (1987) and EMA (1988).

The main factor influencing air temperature in Ethiopia is elevation. As elevation increases air temperature falls. The lowlands below 1500-m elevation are thus the warmest parts of the country, with annual mean temperatures ranging from 20 to 25°C. Because the highland massif occupies such a large and central position in Ethiopia, gradients in altitude and air temperature can be visualised as a series of concentric belts radiating outwards from the geometric midpoint of the highlands. The warmest lowlands occur to the "outside" of the 25°C isotherm (EMA, 1988). In the north this isotherm travels in a south-easterly direction parallel to, and about 100 km inland from the Red Sea. It then descends into the Danakil Plain, cuts briefly north, and proceeds east parallel to the Gulf of Aden. Next it sweeps south, bisecting the Ogaden region, curls through the south-east portions of the Bale and Borana Administrative Regions, approximately coincident with 1000-m elevation. The 25°C isotherm occurs much closer to the highland

Figure 1.1. *National agro-ecological zones and ethnic and agricultural regions of the lowlands in Ethiopia.*



Source: Cossins and Upton (1985).

escarpment in the west than in the east (EMA, 1988). In contrast, the 20°C isotherm is coincident with 1500-m elevation all along the perimeter of the highland escarpment.

Superimposed over this crude temperature pattern is a more diverse assortment of rainfall regimes. Westphal (1975: pp 22–23) lists six for the country overall. Detailed rainfall maps can be found in Workineh Degefu (1987) and EMA (1988). For the lowlands the basic dichotomy involves unimodal and bimodal systems. Four dominant systems are briefly described below.

In terms of extent of land affected, the most important unimodal system is to the extreme north and north-east (Afar territory in Figure 1.1), where the maximum (70 to 80%) of the annual precipitation of 200 to 600 mm occurs in December through February. This rainfall is partly cyclonic and partly orthographic in origin. Rainfall increases to the south towards the highland escarpment.

Another unimodal system, referred to as the "Sudan" type, has most of the annual delivery of 800 to 1200 mm occurring during June through August. This occurs in the lowlands along the border with

Sudan (Nuer and Topotha territories in Figure 1.1). This system also varies in terms of a latitudinal rainfall gradient with heavier and more reliable rainfall in the south.

The most prominent bimodal system occurs in the Ogaden and Borana regions (Figure 1.1) and dominates much of the Horn of Africa. The total annual rainfall under this regime ranges from 250 (Ogaden) to 700 mm (northern Borana Plateau), with 50 to 60% occurring in March through May and 25 to 35% in September through November. The rainy periods coincide with equinoxes when low pressure over southern Sudan attracts moist winds from the Indian Ocean. A cool, foggy period, a result of the gradual warming of air as it passes inland, may occur from June through August. Rainfall is lowest in the central Ogaden and increases towards the west (Bale), south and south-east (Borana Plateau).

Another bimodal regime occurs in the extreme south-west (Hamer and Bodi territories in Figure 1.1). This has lower and more variable annual rainfall (300–600 mm) than the Borana Plateau. Most (55–65%) of the rainfall occurs from March to May and from December to February. This system is influenced by the climate of the Lake Turkana basin in Kenya.

The regional variation in temperature and rainfall in the lowlands provides a basis for understanding climatic variability. This, in turn, yields important differences in vegetation and primary production that influence human ecology and agricultural development potential. For example, very arid climates tend to occur under unimodal rainfall and warmer temperatures, while the semi-arid climates occur under bimodal rainfall and cooler temperatures closer to the highland massif. Westphal (1975: pp 25–27) describes in detail eight climate types for all of Ethiopia. Here a simpler categorisation (Pratt Gwynne, 1977; Jahnke, 1982) is used to partition the lowlands into three agro-ecological zones.

1.3.1 Arid zone

The arid zone has up to 90 growing days per year. It includes the lowest areas such as *Dalol* in Afar territory near Djibouti, which has the lowest elevation in the country at 100 m below sea level. The arid zone makes up nearly 64% of the lowlands, including territories of the Beni Amer, Afar and Issa to the north and north-east and the Somali in the eastern half of the Ogaden. The arid zone is composed of the warmest regions (including the 25°C isotherm) in combination with either lower annual rainfall (mostly unimodal, but some bimodal systems up to 400 mm/year) and often thin, weakly developed Xerosols and poorly differentiated sandy substrates or volcanics that contribute edaphic sources of moisture stress. Range plant communities have low production potential. Total dry-matter (DM) production is commonly <1 t DM/ha/year. On undegraded sites the carrying capacity can range from 4 to 16 TLU/km^2, given the wide variability in annual rainfall (Pratt and Gwynne, 1977: p 112) (The validity of the carrying-capacity concept is discussed further in Chapter 8: *Synthesis and conclusions*). Vegetation types include dwarf shrub grassland, shrub grassland and dry thorn bushland. Plant species include herbaceous perennials and annuals (*Aristida, Eragrostis, Cenchrus* and *Chrysopogon* spp) and small to medium-sized woody plants (*Indigofera, Sericocomopsis, Acacia* and *Commiphora* spp). Livestock composition is diverse but tends to emphasise browsing species (camels and goats) that forage from woody vegetation. Human lifestyles are nomadic, involving frequent movements of households as well as animals. Social systems tend to be decentralised in terms of traditional leadership (Donaldson, 1982). Cultivation is very risky and often confined to early maturing drought-tolerant grain crops (e.g. sorghum or millet) planted in depressions or flood plains.

1.3.2 Semi-arid zone

The semi-arid zone has from 90 to 180 growing days per year. This zone clings to the periphery of the highland massif below 1500 m elevation, except in the west where it occurs below 1000 m. It also includes higher elevations in the Rift Valley (near the Kereyou territory in Figure 1.1), the Nuer region to the north-west, the Gujji and Borana territories to the south and the western portion of the Ogaden. The semi-arid zone makes up about 21% of the lowlands. Annual temperatures tend to be cooler than in the arid zone (more representative of the 20°C isotherm) and rainfall (400 to 700 mm/year) is bimodal except in the Nuer region, which is under a unimodal regime. Soils include Xerosols and volcanics. Range plant communities have much higher potential productivity than those of the arid zone, with total DM production of 1 to 3 t DM/ha/year (Cossins and Upton, 1988a). Carrying capacities are higher and less variable than in the arid zone. Means range from 14 to 28 TLU/km^2, with variation ranging from 11 to 33 TLU/km^2 overall (Pratt and Gwynne, 1977: p 112). Plant communities commonly consist of perennial savannahs and dry woodlands with grasses such as *Themeda, Cenchrus, Chloris* and *Chrysopogon* spp. Overstories are typically dominated by *Acacia* and *Commiphora* spp, with *Brachystegia* and *Combretum* spp when conditions are more moist. Under higher rainfall the tendency is for woody plants to increase at the expense of grasses, but this can often be slowed by regular use of fire. Management can thus have an important role in shifting vegetation composition between conditions of woody and herbaceous dominance. The greater stability and productivity of the grass layer relative to the arid zone promotes more grazing cattle and sheep, although browsing goats and camels can thrive in wooded or bushed areas. People here tend to be semi-nomadic, with households sedentary in most years and livestock being mobile if necessary. Compared with the arid zone, livestock diseases appear to be a more serious production problem in general (Sileshi Zewdie, SORDU veterinarian, personal communication). Agropastoralism may also emerge on favourable water-collecting land- scapes and maize is an important food staple.

1.3.3 Subhumid zone

The subhumid zone has from 180 to 270 growing days per year. This zone occurs near 1500-m elevation (particularly to the west) and has a longer growing season than the drier zones due to higher annual rainfall (800 to 1300 mm) and lower temperatures. Subhumid regions also extend into pockets of the highland massif and in total may comprise 15% of the lowlands. Native vegetation types commonly consist of moist perennial savannahs and woodlands. Taller grasses such as *Hyparrhenia* spp are more frequent than in drier zones, with an overstory dominated by *Brachystegia*, *Terminalia* and *Combretum* spp with some *Acacia* spp. Cultivation of cereals (especially maize) is important and tends to be limited more by soil fertility than by moisture (Jahnke, 1982). Sedentary, mixed crop–livestock operations are more the norm. Land availability is usually not a major limiting factor (Jahnke, 1982). Biomass yield of forage is on the order of 6 t DM/ha/year and livestock nutrition tends to be limited by forage quality rather than forage quantity. Carrying capacities average around 66 TLU/km^2 with low annual variation because of the greater predictability of rainfall. Livestock, however, tend to be relatively less important in the rural economy than in the drier zones, largely because of diseases such as trypanosomiasis. Common livestock are cattle, sheep and goats. Camels are not typically kept where annual rainfall is over 900 mm (Wilson, 1984).

For in-depth reviews of climate, vegetation and land-use practices in the lowlands of Ethiopia and East Africa the reader is referred to Lind and Morrison (1974), Westphal (1975), Pratt and Gwynne (1977), Jahnke (1982), Workineh Degefu (1987) and EMA (1988).

1.4 Rangeland development

1.4.1 Overview of livestock development projects

Ethiopia has long collaborated with the World Bank, African Development Bank (ADB), African Development Fund (ADF), International Development Association (IDA) and other lending institutions in economic development programmes. This has included assistance with a series of livestock development projects that continues today. Lenders have commonly provided over two-thirds of the operating funds for any given project, with the remainder contributed by the Ethiopian Government. In most instances projects have been intended to improve economic linkages between highland and lowland systems. Historical background on poorly documented projects was solicited from Solomon Desta (TLDP (Third Livestock Development Project) economist, personal communication).

The First Livestock Development Project (1958–63) was narrowly focused and created the Dairy Development Agency (DDA) in the highlands. The Second Livestock Development Project (SLDP) was initiated by the Livestock and Meat Board (LMB) and budgeted at 14.7 million Ethiopian Birr (EB). The SLDP ran from 1973–81. The SLDP was only loosely affiliated with the Ministry of Agriculture (MoA). It was directed by the LMB because the project emphasised development of a marketing and infrastructure network to promote sales and processing of livestock. This was supposed to initiate commercial links between the lowlands and highlands. Only half of the original budget was eventually used because of administrative problems and Ethiopia's conflict with Somalia, which interrupted projects. The SLDP did succeed, however, in building a number of primary and terminal markets and slaughterhouses and 600 km of roads.

After the SLDP was initiated the LMB funded studies of several pastoral areas that were thought to offer potential for supplying animals for the newly created infrastructure. The consultancy firm AGROTEC/CRG/SEDES Associates (see AGROTEC/CRG/SEDES Associates, 1974a-l) was chosen to study the southern Borana rangelands because this was considered the most important region. Other consulting firms and experts supplied by the United States Agency for International Development (USAID) conducted surveys in two other rangelands to the east (LMB, 1974a) and north-east (LMB, 1974b). These studies included surveys of population demography, vegetation, water resources, pastoral socio-economics and animal husbandry. The final reports were used to generate proposals to finance a range project called the Third Livestock Development Project (TLDP), headquartered in Addis Ababa. Budgeted at EB 88 million, the TLDP was initiated in 1975 with the primary objective of developing infrastructure and natural resources to support livestock production and marketing. The three target regions totalled 203 000 km^2. Details of the TLDP are reported in Section 1.4.2: *History of lowlands development and the TLDP.*

The TLDP has traditionally operated as a semi-autonomous entity outside of the MoA. The general manager of TLDP has reported directly to the Vice Minister for Animal and Fisheries Resources Development Main Department (AFRDMD), who in turn has been charged with overseeing all aspects of livestock development as one of four vice ministers in the MoA. The TLDP received a couple of extensions to enable full use of the original funds, allowing it to operate through 1987. The TLDP continues to function at the time of writing this, however, with the Ethiopian Government funding much of the core administrative activity. Additional funds have also come into TLDP from the Fourth Livestock Development Project (FLDP), operational since 1988. The FLDP is very diverse and has focused on forage development, livestock epidemiology and livestock marketing in mixed farming systems of the highlands (FLDP, 1987). A small portion of FLDP funds, however, were allocated to the Pilot Project, which operates with TLDP staff. The Pilot Project has been based in the southern rangelands since 1988 and has focused on institution building and development of extension and monitoring capabilities for better outreach to the Borana pastoral community (Hogg, 1990a).

It was originally intended that the TLDP would gradually be phased out by the mid-1980s, but as of 1992 the TLDP remains as the only corps of national range professionals in Ethiopia. It has subsequently become the management entity for the South-east Rangelands Project (SERP), initiated in fiscal 1990–91 with funding from ADF. SERP will operate in what have been the Eastern Hararghe Administrative Region and Ogaden Autonomous Region. It is intended to be a hybrid of previous range development projects, combining the infrastructural development emphasis of TLDP with the outreach approaches of the Pilot Project (ADF, 1989).

When the TLDP is phased out there will be no permanent organisation to represent rangeland interests within the MoA. It is possible that either a new range department would be created within the MoA, or that range development would fall under another semi-autonomous authority (Solomon Desta, TLDP economist, personal communication). The problems of merging rangeland development interests within the farming-oriented MoA lies in important distinctions between lowland and highland projects in terms of staff skills, staff management and implementation of development activities (Tafesse Mesfin, TLDP General Manager, personal communication).

A number of other rural development projects are currently operating in Ethiopia. These include smallholder dairying in the highlands and highland reclamation. A concise review of these and other projects is provided in FLDP (nd: pp 20–21).

1.4.2 History of lowlands development and the TLDP

Interactions among highlanders and lowlanders in Ethiopia historically have been characterised by a mix of trade and warfare (Luther, 1961; Kaplan et al, 1971; Wilding, 1985a). The establishment of contemporary trade routes between the highlands and lowlands is commonly attributed to Emperor Menelik. Following his victory over Italian forces at Adowa in 1896, he sent his armies to consolidate a grip over the lowlands by 1908. Modern roads followed such military routes in many cases (Ethiopian Road Transport Authority, unpublished data). Gravel roads were constructed by Italian companies during 1943–53 for five arteries from Addis Ababa to the lowlands. During 1960–70 some of these roads were rehabilitated and asphalted by the Ethiopian Transport Construction Authority. These included roads from Addis Ababa to Negele, Moyale, Jijiga and Assab.

One of the first attempts at infrastructural development for livestock production in the lowlands was initiated in 1965 by the Ethiopian Government and USAID. Tilaye Bekele (1987: p 16) mentions, however, that some stock ponds were built in the southern rangelands by the Ethiopian Government in the 1950s. The joint Ethiopian-USAID project was referred to as the Pilot Rangeland Development Project (PRDP) and the Ethiopian side of the project was conducted through what was then the Range Development Unit in the Livestock Department of the MoA. The intervention concept focused on development of large ponds to improve access of livestock to some 1600 km^2 of *Themeda* and *Acacia* spp savannah within 50 km of the town of Yabelo on the Borana Plateau, about 570 km south of Addis Ababa. Traditionally Borana pastoralists and their cattle had relied on ephemeral, rain-fed ponds in wet seasons and deep wells in dry seasons (see Section 2.4.1.7: *Water resources*). Pond development in the PRDP was intended to relieve pressure on wet-season grazing and improve efficiency of range use overall. About 20 large ponds were constructed using heavy machinery that removed some 200 000 m^3 of soil. Some of these ponds became perennial rather than ephemeral, however, and resulted in a large exodus of people and stock from the central Borana Plateau that had become degraded over several hundred years of use (Billé and Assefa Eshete, 1983b). Over the next 25 years, pastoralists settled and became permanent residents in several areas that had been opened up. The implications of this for the local ecology and pastoral development are reviewed, respectively, in Section 3.3.2: *Long-term vegetation change* and Section 7.1.3: *Review of dynamics and past interventions.*

The preliminary results of the PRDP were considered encouraging and led the MoA to formulate a more comprehensive strategy on pastoral development. This, in conjunction with activities of the LMB reported in Section 1.4.1 (*Overview of livestock development projects*), led to the selection of the Southern Rangelands Development Unit (SORDU), North-east Rangeland Development Unit (NERDU) and the Jijiga Rangeland Development Unit (JIRDU) as the basis of the proposal for the TLDP in 1974. These target areas were considered superior because of their proximity to highland markets, their generally higher stocking potential and because they possessed the highest quality animal breeds in the largest numbers. They also offered good proximity to export markets and meat packing plants. The NERDU area was close to the port of Assab; the JIRDU area had rail access to Djibouti and the SORDU area was bisected by a tarmac road conceived as part of a transcontinental highway system. NERDU was close to the Kombolcha meat packing plant near Dessie; JIRDU was near a plant in Dire Dawa and SORDU was about 200 km south of the Melge–Wondo plant near Shashamene.

Despite the excellent grazing potential of the lowlands to the west and south-west, these could not be considered for the TLDP because of remoteness and prevalence of trypanosomiasis (UNDP/RRC, 1984). The three TLDP sub-projects thus incorporated 27% of the lowlands in total, home to nearly one million pastoralists herding some three million TLUs in 1974. The overall purpose of each sub-project was to develop infrastructure (roads, market facilities, veterinary clinics) and natural resources (water and forage) to stimulate animal production and offtake and to increase incomes and welfare of pastoral producers (UNDP/RRC, 1984). The sub-projects are described below.

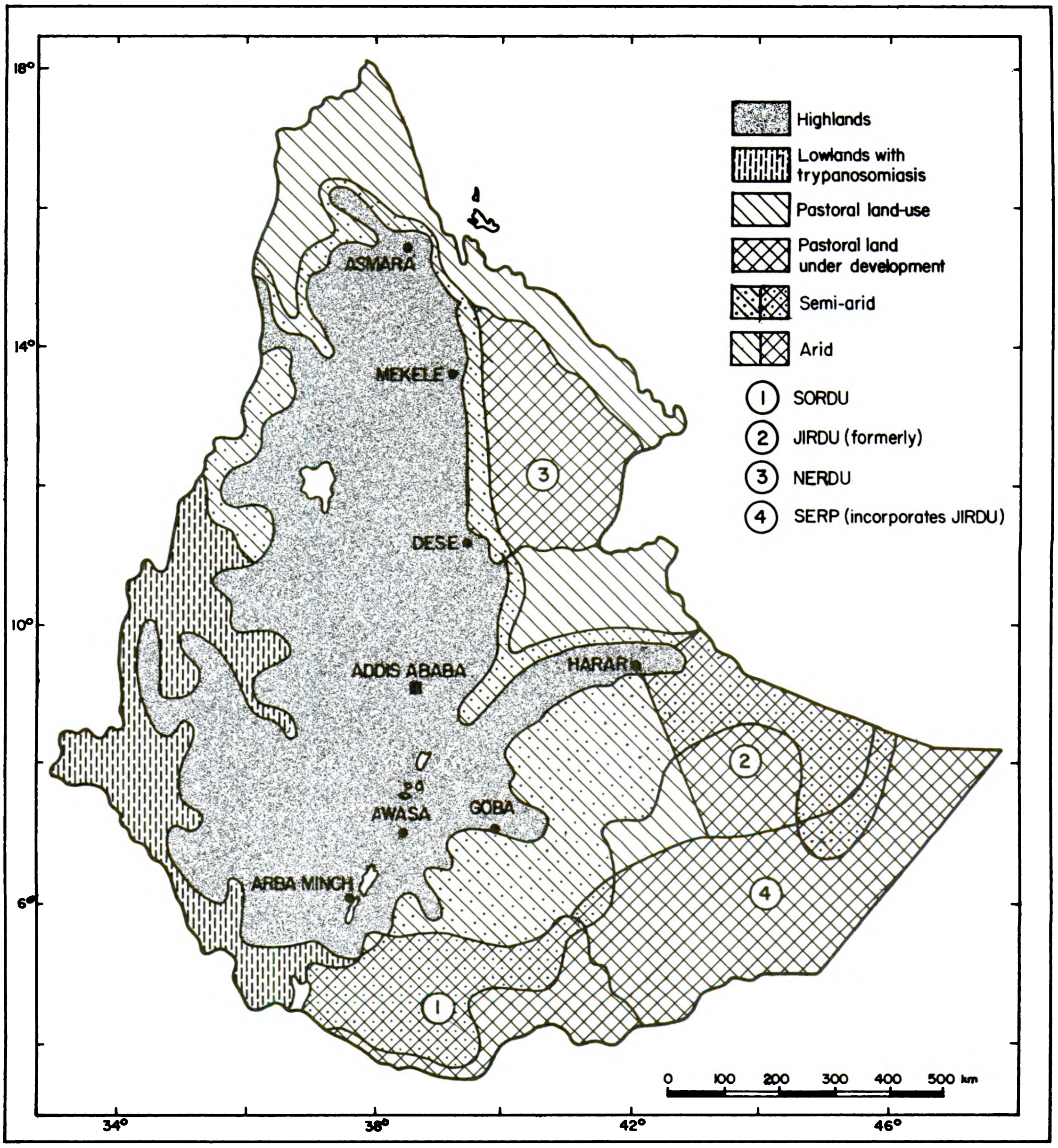
1.4.2.1 JIRDU

Headquartered in Jijiga, this sub-project has been responsible for about 33 000 km^2 of semi-arid (60%) and arid (40%) land in the eastern half of Ethiopia (Figure 1.2). In 1974 the human population was estimated at about 500 000, with the majority being semi-nomadic Somali-speaking pastoralists. The livestock population was estimated at 600 000 cattle (57% of TLU), 1.3 million small ruminants (12%) and 200 000 camels (31%) for a total of over one million TLU (LMB, 1974a). This represented an average of 32 TLU/km^2 in wet seasons and a ratio of TLU to humans of 2.1:1. Livestock numbers change dramatically depending on season, however. During the rainy season the population may be almost twice that in the dry season. Rainfall and forage production tend to decrease to the south and south-east but local forage conditions are greatly influenced by landscape. Of particular importance are the large valleys that extend west into the highlands near Harar. These collect soil moisture and offer higher forage production than the rest of the JIRDU area. These valleys have been traditionally used as dry-season grazing reserves for livestock which spend the rest of the year on the dry tablelands. The cattle population is dominated by a short-horned *Bos indicus* breed regarded as a good dual-purpose animal well adapted to difficult conditions. It also has a commendable export value to the Middle East (Girma Bisrat, PADEP Coordinator, personal communication). The cattle are concentrated more to the north in the large valleys, while the smallstock and camels are more abundant to the south and south-east. Except for areas traditionally prioritised for cattle, access to sub-surface water using traditional means is very difficult. Market access to Jijiga and Harar is fair, but it is thought that the vast majority of animal offtake is illegally sold to Somalia (Girma Bisrat, PADEP Coordinator, personal communication).

1.4.2.2 NERDU

Headquartered in Weldia, this sub-project has been responsible for about 75 000 km^2 of arid (85%) and semi-arid (15%) land in north-central Ethiopia (Figure 1.2). In 1974 the human population was estimated at 225 000, the majority of whom were nomadic Afar pastoralists. The livestock population was estimated at 734 000 cattle (62% of TLU), 1.2 million small ruminants (10%) and 206 000 camels (28%) for a total of over 1.18 million TLU (LMB, 1974b). This was equivalent to 16 TLU/km^2 and a ratio of TLU to humans of 5.3:1. Severe drought in 1973–74 probably had reduced livestock numbers substantially compared to previous years (LMB, 1974b). The less-predictable nature of rainfall and

Figure 1.2. *Lowland typology and development regions in Ethiopia.*



Source: TLDP (unpublished data) and EMA (1988).

forage production mitigate against reliable animal production and offtake in NERDU, despite good access to large markets in the region (UNDP/RRC, 1984). Herbaceous forage production and dominance of cattle typically increase with greater proximity to the highland escarpment. Sites in the Teru Depression and basins of the Awash and Mille rivers have traditionally been dry-season retreats for livestock. The main development objectives for NERDU were similar to those for the other sub-projects except for a great emphasis on rehabilitation of drought-stricken pastoralists. This rehabilitation was intended to include irrigation schemes as an alternative life-style for those who had lost access to dry-season grazing because of irrigated cultivation of cash crops along the Awash river (LMB, 1974b).

1.4.2.3 SORDU

Headquartered in Yabelo, this sub-project has been responsible for about 95 000 km^2 of semi-arid (70%) and arid (30%) land in southern Ethiopia (Figure 1.2). In 1974 the human population was estimated at 500 000, dominated by the Boran (to the west) and Somali (to the east) whose life-styles vary from semi-nomadic to semi-settled. The livestock population was estimated at 1.3 million cattle (74% of TLUs), three million small ruminants (17%) and 94 000 camels (9%) for a total of over 1.75 million TLU (AGROTEC/CRG/SEDES Associates, 1974f, g). This equated to 11 TLU/km^2 and a ratio of TLUs to humans of 3.5:1. SORDU was considered to have the highest ecological potential for livestock production of the three sub-project areas because of higher rainfall and lower temperatures (Billé, 1983). The more productive environment and reliance on wells for dry-season water also influenced the Borana people to be more sedentary and socially organised, which was expected to improve prospects for animal offtake. In addition, the Boran breed of cattle was considered of high value for domestic use and export (Alberro, 1986; Girma Bisrat, PADEP Coordinator, personal communication).

At its height in the early 1980s, the TLDP supported a permanent staff of over 1000 and a temporary staff of about 4000 (Girma Bisrat, PADEP Coordinator, personal communication). SORDU had the largest staff due to concentration of activities in the south and the absence of civil unrest there. Thus, SORDU used 44% of the TLDP budget (Girma Bisrat, PADEP Coordinator, personal communication). Until the change of government in June 1991, the region around NERDU had been a focal point of armed conflict. Administrative and natural resources at JIRDU have been strained in the last few years because of 250 000 refugees who have fled Somalia (A. Moussa, UNHCR Senior Programme Officer, personal communication).

1.4.2.4 Infrastructural improvements

Although JIRDU, NERDU and SORDU shared common development goals, local variation in resource constraints required that different strategies be emphasised. Table 1.1 illustrates some of the achievements of the three sub-projects from 1976 to 1986 and a few details are presented below.

Water

The SORDU area in particular was assessed to have problems regarding access to surface water by livestock. Although the NERDU area is more arid, animals there can drink from perennial rivers originating in the highlands. This helps explain, for example, why 78% of the 122 ponds constructed were in the SORDU area, followed by JIRDU (15%) and NERDU (7%). In the JIRDU area the presence of accessible sub-surface water in the foothills near Harar led to promotion of shallow wells in addition to ponds. The pond programme in JIRDU was constrained by soils that had high rates of seepage (Menwyelet Atsedu, Colorado State University, personal communication). Until 1986, additional efforts to develop water in the JIRDU area focused on promotion of cisterns (*birka*) to collect run-off water. Other water development in the SORDU area has involved maintenance and re-excavation of the traditional deep wells on the western half of the Borana Plateau (see Section 2.4.1.7: *Water resources* and Section 7.3.1.1: *Water development activities*).

Forage

The NERDU area had the greatest constraints in forage supply, and it was intended to take advantage of the river system and landscape to promote water spreading (irrigation) to increase forage production (Girma Bisrat, PADEP Coordinator, personal communication). JIRDU also faced significant forage constraints. Most of the key forage supplies occurred in the large valleys, but this was under threat from encroachment by farmers, especially in the Fafen Valley north of Jijiga. In contrast, SORDU was not perceived to have a major problem with forage supply.

Livestock disease control

Out of 23 million vaccinations over 10 years, only 8% were given by NERDU (Table 1.1), primarily because NERDU had fewer problems with livestock diseases than the other areas; and the lowest density of easily accessible cattle (Girma Bisrat, PADEP Coordinator, personal communication). Cattle was the species targeted most often in vaccination campaigns.

Roads

More attention was paid to road construction in SORDU than in the other areas because it had fewer roads. Of 3952 km constructed, 75% were in SORDU area followed by JIRDU (15%) and NERDU (10%).

Cattle marketing networks

In recognition of the more productive forage base in the southern rangelands, three ranches were established under the administration of SORDU. It was intended that cattle would be purchased in a lean condition from the pastoralists in the warm dry season (December through March), fattened during the ensuing long rains (April to May) and sold at a profit in June or July to highlands organisations. Part of the profit was to be shared with the pastoralists

Table 1.1. *Infrastructure development and service statistics for the JIRDU, NERDU and SORDU sub-project sites of the Third Livestock Development Project from 1976–1986.*[1]

Development component	Sub-project		
	JIRDU	NERDU	SORDU
Water development			
– ponds (number)	18	9	95
– cisterns (number)	2	3	—
– shallow wells (number)	95	—	—
– deep wells (number)	1	—	5
Forage development			
– water spreading (ha)	—	800	—
– drought fodder reserves[2] (ha)	—	—	—
Veterinary service[3]			
– vaccination total (millions)	9.2	1.9	12.0
Road development[4]			
– trade roads (km)	105	55	1137
– access track (km)	515	311	1829
Holding ranches			
– established (number)	—	—	3
– marketed cattle (number)	—	—	3706
Smallholder fattening programme			
– purchased cattle (number)	5197	—	3804
– distributed cattle (number)	4956	—	3706
Training[5]			
– veterinary scouts (number)	134	20	164
– range wardens (number)	50	20	76
– dip/crush attendants (number)	—	20	—
Trials and studies			
Meteorology stations (number)	11	8	10

1 Where JIRDU = Jijiga Rangelands Development Unit; NERDU = North-east Rangelands Development Unit; and SORDU = Southern Rangelands Development Unit.

2 Drought-resistant genera such as *Atriplex* spineless *Opuntia* and various *Acacias* have been examined in joint trials with FAO and the Ethiopian Ministry of Agriculture (MoA). These have not been implemented through extension, however. Other forage screening trials involving *Leuceana* spp have been conducted in joint trials with the MoA at SORDU and JIRDU. *Leuceana* is envisioned as an intervention for years of average rainfall on water-collecting landscapes. See Section 7.3.1.3: *Forage improvements*.

3 Vaccination totals are largely dominated by cattle. See text.

4 Where trade roads are 6 m wide and covered with transported materials when local materials were unsuitable and includes drainage structures. Access track is 4 m wide with passing bays every 300 m; these have no drainage structures and only local surfacing materials were employed.

5 Veterinary scouts are males selected from the pastoral community and trained up to 45 days in topics such as identification of major disease symptoms. They are also responsible for organizing the local people to participate in vaccination campaigns. Range wardens were men selected from the community and trained up to 21 days, mainly to guard newly constructed ponds.

Source: Girma Bisrat et al (TLDP, unpublished data).

in a cooperative venture (GRM, nd). In addition, a smallholder fattening programme was intended to supply animals directly to highland cooperatives for finishing in a stratified marketing structure. The JIRDU area has been the largest supplier of cattle (57%) for the smallholder fattening programme, with SORDU supplying the remainder of the 8662 head distributed (Table 1.1).

Human resources

A total of 484 individuals were trained to provide field support for veterinary service (66%) and range management (30%). SORDU has led these efforts with 49% of trainees, followed by JIRDU (39%) and NERDU (12%). Staff established an average of nine weather stations in each region as part of the national meteorological network with assistance from ILCA (Table 1.1). The National Metereological Agency trained field staff to collect weather data.

Only SORDU has achieved or exceeded targets for most aspects of its development programme. Civil disturbances in the JIRDU and NERDU areas have undermined development efforts. Some of the project components listed in Table 1.1 have been sustainable but others have not. This is discussed further in Section 1.4.5: *Development of the southern rangelands as coordinated by SORDU* and Chapter 8: *Synthesis and conclusions.*

1.4.3 The SERP and the Pilot Project

The SERP (introduced in Section 1.4.1: *Overview of livestock development projects*) will almost double the lowlands area under development in Ethiopia (Figure 1.2). In the new organisational format JIRDU was brought under the auspices of the SERP in 1991. SORDU and NERDU will continue much as before, except that SORDU should include the Pilot Project at least through 1992 (Solomon Desta, TLDP economist, personal communication). The TLDP staff may administer all of these components until 1996–97 when the first phase of the SERP expires.

Although a small component of FLDP in terms of funding, the Pilot Project at SORDU is an important addition in terms of philosophy and strategy of pastoral development. Material reviewed here is only a brief synopsis, largely drawn from Hogg (1990a; 1990b; 1990c).

The Pilot Project was initiated in 1988 to establish viable and sustainable service cooperatives (SCs) among Borana pastoralists. It was intended to continue until 1992 but extension to 1995 may be needed to give enough time for adequate impact and evaluation (Hogg, 1990c). The Pilot Project is attempting to work in about one-third of the SORDU area (or 34 000 km^2), with a human population of 150 000. The target area is largely around the town of Yabelo and south to the village of Dubluk, with a large portion to the far west near the Kenya border (see Figure 2.10). The Pilot Project involves a fundamental change for SORDU. The administration at SORDU used to plan and conduct infrastructural improvements and veterinary campaigns largely in isolation from the pastoralists. In the Pilot Project, however, SORDU is to become more of an enabling institution that facilitates implementation of community projects that the pastoralists have prioritised for themselves. The Boran are also expected to pay for much of the cost of the new activities on a contractual basis. This is intended to make the interaction more sustainable by reducing dependency on external funding and should provide better indicators of whether projects are really desired by the community (Hogg, 1990c). It is important to note that formation of SCs in the lowlands has traditionally been the domain of the MoA, while SORDU was in charge of the development of pastoral and range resources (see below). Defining precisely the duties of these agencies has emerged as a more critical problem as development issues become more complex and interconnected (see Chapter 8: *Synthesis and conclusions*).

The SC concept that has evolved in the Pilot Project is a modified version of SCs that were implemented throughout rural Ethiopia during 1975–90 (Hogg, 1989; Hogg, 1990c). The original SCs were based on socialist agrarian strategies. The rural organisational structure during 1975–90 consisted of a system of Peasant/Pastoral Associations (PAs) which served administrative functions. Some of these functions were unpopular and included tax collection, filling government quotas for crops and livestock at below market prices, raising funds for building schools or clinics and recruiting young men for the army. Service cooperatives also served to inculcate political or administrative indoctrination. Membership in PAs was mandatory. Despite the pervasive influence of PAs in daily life, they did not exert much influence over traditional legal and social mechanisms for problem solving among the Boran (Hogg, 1990c; Takele Tilahun, TLDP/ILCA post-graduate researcher, unpublished data). However, the PAs may have had some positive aspects with regard to augmenting traditional influence over resource allocation in the face of rising population pressure (see Section: 7.3.1.4: *Site reclamation*).

The PAs formed the foundation upon which cooperatives were created. Unlike PAs, cooperatives were intended to provide economic services and membership was more optional.

Cooperatives were to be formed from one or more PAs, depending on population density and resources, and were to use contributed labour and capital to create regional and national networks for the production and distribution of basic commodities. There were two main kinds of cooperatives: (1) SCs that focused more on the organisation needed to procure basic goods for the inhabitants of often remote locations; and (2) producer cooperatives (PCs) that focused more on organising the production of a single commodity or a group of related commodities.

The cooperatives were designed and implemented using a top-down approach. The core activity of the SCs was to obtain basic goods from government warehouse networks at subsidised prices. Theoretically, only cooperatives could gain access to these subsidised goods. The members of the SC would also constitute a legally recognised entity that could apply to the national banking system for low-interest group loans for local development projects. One problem in the lowlands was that pastoralists were not considered able to form the permanent residential groups upon which SCs were to be based. Thus pastoral SCs would not be legally recognised and could not apply for loans. In sum, SCs and PCs were considered to be somewhat complementary and were supposed to be important conduits that avoided problems of corrupt middlemen and deficiencies in free markets. Such deficiencies theoretically included inability to efficiently network producers and consumers in remote areas.

The PAs, PCs and SCs throughout the country largely began to collapse with the demise of central authority in 1990. Government bureaucracy, poor local management and shortages of desired goods effectively suffocated cooperatives in the highlands and it has been asserted that cooperatives never really emerged to a significant degree in the lowlands (Hogg, 1990c). Good examples of how unresponsive the cooperative system really was in meeting modest demands for grain and hand tools in the southern rangelands are reported in Hodgson (1990: pp 83–117).

The Boran were organised into PAs in the 1975–76 *Zemecha* or Students' Campaign. Membership in a PA was based on residence in a particular *madda*, which is a watering and grazing entity in the traditional Borana system (see Section 2.4.1.7: *Water resources*). One problem that emerged was that herdowners were expected to pay taxes to the original PA in which they were registered even though they may have moved elsewhere in their search for better grazing or water (Hogg, 1990c). The first SC in the southern lowlands was formed from several PAs and was established by the local branch of the MoA near Teltele in 1977–78. By 1987 there were 112 PAs and 17 SCs in the southern rangelands, with average memberships of 336 and 534 household heads, respectively (Hogg, 1990c). The average number of PAs per SC was 3.6. While PAs provided blanket regional coverage, the few SCs were concentrated near urban areas in wetter upper semi-arid and subhumid regions, where membership was skewed towards farmers and agropastoralists. This was largely because the local MoA had insufficient resources to extend very far from their branch offices and because of the natural bias of the MoA to work in farming systems (Hogg, 1990c).

One objective of the Pilot Project is to retain and modify the SC concept as a development tool for the southern rangelands. Despite problems in the past, the SC is still seen as a viable marketing aid in remote areas where commercial traders have not established. Fortunately, previous experience with cooperatives in the lowlands has been minimal but still some of the negative experiences with the PAs will probably be a constraint in getting the people to overcome their suspicions of new development organisations (Hodgson, 1990; Hogg, 1990c). The reason for continuing to use SCs for pastoral development is based on the proposition that improved market access is essential in stimulating monetisation and more commercial use of livestock, which should facilitate economic diversification and relieve some pressure on the grazing environment (see Section 3.4.2: *Environmental change*).

The proposed SCs are quite unlike the old SCs. In an effort to make SCs more meaningful to the people, the Pilot Project has focused on implementing them with attention to the following details (Hogg, 1990c): (1) they are being structured to reflect traditional organisation and leadership; (2) they are being organised to help provide members with goods they really want and not those that used to be forced upon them; and (3) they are being designed to operate in a free-market setting, planned and implemented from the bottom up and are thus less encumbered by bureaucracy. The management and placement of SCs is being carefully rationalised in a pastoral (not farming) context, including a review of those that have existed for some time. Hogg (1990c) emphasised that there is no standard menu for success, as each SC must respond to the local situation in terms of management constraints, the demand for commodities and the costs of meeting demand. This process of institution building is arduous and will take many years. Constraints of an uneducated and skeptical pool of pastoralists are dominant. This strategy should also not be viewed as a "quick fix";

only four new SCs were established in two years (Hogg, 1990c).

For more details of the Pilot Project the reader is referred to Hogg (1990a; 1990c) and FLDP (1987). Various sections in Chapter 7 (*Development intervention concepts*) review examples of pastoral organisation as they pertain to specific development concepts in animal marketing, grain storage and water and land management.

1.4.4 Has national range development been successful?

Considering the atmosphere of regional insecurity, political change and administrative problems that has prevailed for the TLDP during the last 18 years, it is remarkable that TLDP has had as much success as it has. It is important to recognise, however, that the enumeration of total vaccinations or lengths of roads put in does not reveal whether the overall strategy has been effective, i.e. whether animal offtake has increased or the welfare of pastoralists has improved. Unfortunately, these questions cannot be rigorously addressed because hard data are lacking and many factors beyond TLDP performance influence outcomes. Monitoring of project impacts should improve evaluation but this has only recently been added to the TLDP under the Pilot Project (FLDP, 1987).

The impact of TLDP interventions in the SORDU area was assessed by ILCA using detailed interviews of pastoral leaders in 1990. Although this information is based on subjective perceptions, it is argued (see Section 7.1.3: *Review of dynamics and past interventions*) that improvements of infrastructure and veterinary service in the southern rangelands since the 1960s have had fundamental effects on Borana society. These effects are important and widespread, but also often subtle and hard to detect in a superficial manner. Many of the effects may be positive, but more in the sense of providing a cushion for population growth, delaying the onset of poverty for a portion of a rapidly growing population and acting as a catalyst for future social and economic change.

In addition, whether project objectives are viewed as having been met is complicated by assumptions used in the project preparation stage. For example, suppose that animal offtake is increasing (see Section 7.2: *A theory of local system dynamics*). This may indeed raise cash incomes, but it does not mean that the people are better off if essential goods to be purchased are too expensive or in short supply. A similar paradox arises in connection with the types of animals sold. Higher offtake rates of cattle less than two years old may be interpreted to mean that the system is becoming more "modernised" in terms of incorporating Western production ideals. Alternatively, it can suggest that older male cattle are in shorter supply and the human population is becoming poorer and more vulnerable to droughts. The Boran traditionally preferred to sell older and larger male animals because the producer can buy goods they want plus a young replacement animal (Coppock, 1992a; see Section 4.3.4.7: *Marketing attitudes*). Older males have the lowest risk of death during drought of any class of cattle, which makes them an important reserve of wealth during times of stress (see Section 6.3.11: *Livestock dispersal and herd composition*). Such inferences seem radical compared with developed production systems, but this reflects fundamental differences between developed versus traditional African livestock operations (Behnke, 1984; Coppock et al, 1985; Coppock, 1992a). Both are logical when viewed within their own economic context.

A common perception among TLDP senior staff has been that the roads, markets and veterinary campaigns have not stimulated animal offtake *per se* and that veterinary campaigns in particular have contributed to a greater inventory of animals now in a better position to over-utilise the land (Sileshi Zewdie, SORDU veterinarian, and Solomon Dessalegn, former NERDU Manager, personal communication). These opinions are in agreement with mainstream views generated from rangeland development projects elsewhere in sub-Saharan Africa (see Introduction of Ellis and Swift, 1988; de Haan, 1990).

It is concluded in Chapter 8: *Synthesis and conclusions* that while the TLDP has made some important contributions in SORDU that should catalyse future opportunities for pastoral development, this development is highly dependent on other social and economic processes that operate at national scales beyond the domain of the TLDP. Economic development and improved human welfare for the Boran are defined in Section 7.1.2: *Development philosophy for the Boran* and can be condensed as trends toward: (1) a sustainable level of per capita milk production and per capita asset accumulation largely in the form of livestock; (2) improved food security during times of environmental perturbation; and (3) fewer risks of producers being squeezed out of the pastoral system. All of these trends should occur within a framework that also conserves valued aspects of the traditional culture. Given this scenario, it is hypothesised, based on several indicators, that economic development is not occurring in the southern rangelands (see Section 7.2: *A theory of* *local system dynamics*). The Boran appear to be gradually altering some of their attitudes towards cultural and economic changes, but this is not being effectively tapped in a comprehensive development process. An apparently high rate of human population growth, in conjunction with environmental limits on cattle production, suggest that food security, per capita production and other aspects of human welfare will decline. The system is thus overpopulated and education and urban job opportunities are needed to help release pressure and allow remaining residents to have a chance of improving their living standards. Also needed are other investment opportunities that give returns comparable with those from livestock production. Policies are needed to help open regional markets in order to promote efficient interregional trade and reduce the likelihood of local food shortages and famine.

In sum, this is not to say that some technologies or management strategies within the domain of the TLDP are not important but that they make up only a very small part of a multifaceted, long-term development strategy. While all of the lowland areas have unique constraints to economic development and are probably at various points along a continuum of induced change (Kidane Wolde Yohannes, TLDP range scientist, personal communication) it is likely that the development problems observed in SORDU are relevant to the Ethiopian lowlands as a whole.

1.4.5 Development of the southern rangelands as coordinated by SORDU

The focal point of this report is SORDU and the Borana pastoral community that it serves (Plate 1.2 a, b). Besides the sub-project headquarters in Yabelo, SORDU also has sub-offices at Negele to the east in the Borana Administrative Region and Awassa to the north in the Sidama Administrative Region. The base in Awassa helps coordinate linkages in animal marketing between the highlands and lowlands. This section briefly outlines SORDU activities in relation to eight original project components as outlined by Girma Bisrat (1988). Material here also includes comments on objectives and observations on recent achievements.

1.4.5.1 Range management

The objective of this component was to develop a management plan that would promote a sustainable level of resource use. It was hoped to describe various range areas in terms of vegetation composition, net primary production and stocking rates for livestock that would promote an optimal level of productivity in relation to maintenance of a "desirable" vegetation cover. It was also intended to prohibit "undesirable" land-use practices such as indiscriminate burning of range vegetation, wood cutting and cereal cultivation.

There have been two major constraints to implementing of this activity, namely lack of land-use plans for the lowlands and shortages of trained manpower. Land-use plans are primarily needed to identify sustainable farming areas near and within the rangelands. This would permit evolution of pockets of agropastoralism within the Borana system and provide a legal basis for rationalising user conflicts between farmers and pastoralists in contested areas on the periphery of the southern rangelands (see Chapter 8: *Synthesis and conclusions*). SORDU has not been able to deploy enough trained manpower in range management over the past 18 years. Hacker (1988a; 1988b) devised monitoring methods for range trends. There is concern, however, that even if levels of optimal use and cattle density could be identified, there is insufficient means to enforce land-use regulations, especially under increasing population pressure and the short-term need of the people for maximum cattle production (see Chapter 8: *Synthesis and conclusions*). Whether the local administration or SORDU can control even the recent spread of maize cultivation is debatable (Kidane Wolde Yohannes, TLDP range scientist, personal communication).

1.4.5.2 Water development strategy

The traditional pastoral system was based on wet-season grazing with cattle watering at ephemeral ponds and dry-season grazing close to deep wells (see Section 2.4.1.7: *Water resources*). The longer animals could stay on wet-season range the better, because this would help conserve dry-season forage and delay use of the wells. This in turn would conserve ground water and postpone a high commitment of labour (see Section 4.3.2: *The encampment and the role of cooperative labour*).

Studies showed that some vegetation far from wells was not evenly utilised and that new ephemeral ponds could improve access to this forage in wet seasons. Thus, during most of the first decade of SORDU, great emphasis was put on building ephemeral ponds that could theoretically double the length of grazing in "wet-season areas" from two to five months in average rainfall years (Girma Bisrat, PADEP Coordinator, personal communication).

About 95 ponds were constructed in under-utilised sites throughout the region using heavy

Plate 1.2 (a, b). *Borana men and a Borana woman of southern Ethiopia.*

Photograph: JEPSS

machinery, paid for in full by SORDU. The ponds ranged in size from 10 000 to 60 000 m^3. While some ponds functioned as intended and led to a more balanced and diverse pattern of resource use (Hodgson, 1990: p 52; see Section 7.3.1.2: *Grazing management*), others suffered from high infiltration rates or high rates of siltation (Tilaye Bekele, 1987). Consultants prescribed a variety of improved management and siting methods but many of these were difficult to implement. Despite problems, the water development programme remains as one of the most popular activities with the Boran.

Today SORDU focuses more on trying to help the people maintain existing ponds and wells, since opportunities to expand the area under grazing are now very limited. For several years development agents tried to promote animal-drawn scoops (Abiye Astatke et al, 1986) so the people could desilt ponds themselves and conserve fuel and spare parts for heavy machinery. However, the Boran much prefer to collect money and pay for use of heavy machinery rather than use their draft animals to pull scraps (see Section 7.3.1.1: *Water development activities). Selling stock to pay for maintenance* of water points is emerging as a major form of monetisation and participation of beneficiaries in the development of the southern rangelands.

1.4.5.3 Livestock health

The livestock health programme started strongly but has had recent problems sustaining activities. One central and eight satellite clinics were established in towns during the late 1970s to provide health treatments for animals that could be walked in. Cattle were periodically reached in the field through large-scale vaccination campaigns against rinderpest and anthrax carried out up to twice a year. Cattle dips for tick control were established in several locations and field clinics were conducted for small ruminants and camels (Hill, 1982). However, activities have declined markedly since the early 1980s, mostly due to factors beyond the control of TLDP.

By 1990 there were chronic shortages of imported drugs, reportedly because of procurement problems within the MoA. When TLDP was financially independent (until 1987), it handled its own procurement and drugs were imported more reliably. Now with other elements in the MoA controlling procurement for TLDP, it is felt that the animal health service in the lowlands has been compromised. This has been due to bureaucratic problems and attempts to save money by ordering inferior drugs (Sileshi Zewdie, SORDU veterinarian, personal communication). The greatest demand for veterinary drugs in the southern rangelands is reportedly for acaricides and antihelminthics, but these must be imported from Europe (Sileshi Zewdie, SORDU veterinarian, personal communication). Vaccines for rinderpest, blackleg and anthrax are produced at Debre Zeit in the Ethiopian highlands but supplies have been reduced in recent years. Contagious caprine pleuropneumonia (CCP) is a major constraint to goat production in the southern rangelands (Section 5.3.7.1: Sheep and goats) and it is planned to produce this vaccine in Debre Zeit in the near future (Sileshi Zewdie, SORDU veterinarian, personal communication). Locally made antibiotics have also been available for human ailments through the Ministry of Health but it has been reported that Borana pastoralists obtain these from clinics and use them for livestock (Coppock, ILCA, personal observation). Acaricides and vaccines have also been reportedly smuggled from Kenya.

Today, there are severe shortages of vaccines, manpower and transport. SORDU staff are unable to engage in preventative measures, responding only to disease outbreaks and this is when the shortages are felt most acutely (Sileshi Zewdie, SORDU veterinarian, personal communication). It is now envisioned to have the Boran pay for all health services, including vaccination campaigns. This would reduce the frequency of false alarms of disease outbreaks and improve the financial basis of the service (Sileshi Zewdie, SORDU veterinarian, personal communication).

1.4.5.4 Roads

By 1987, nearly 2800 km of trade and access roads had been constructed throughout the SORDU area, with about 30% built by hand labour and the remainder using heavy machinery. Ongoing activities focus on maintenance. This has probably had major impacts on growth of small towns in the region, provided jobs and facilitated grain distribution during drought. This remains as an outstanding achievement that will help catalyse future change (see Section 7.1.3: *Review of dynamics and past interventions*).

1.4.5.5 Ranch development

Early on in the SORDU sub-project, land was set aside in three regions for use as holding and fattening areas for cattle to be sold to highland operations. The ranches were named Sarite (17 000 ha), Dembel Wachu (12 000 ha) and Wollenso (25 000 ha). Animals were bought from local producers and typically sold to the Ministry of State Farms which used them for domestic purposes or export. One justification for SORDU assuming control over these particular ranch sites was that they had inadequate water supplies in the dry season. It was anticipated that, using SORDU's resources, water supplies could be developed on the ranches. However, difficulties were experienced at Dembel Wachu (Billé and Assefa Eshete, 1983a) and Wollenso (Girma Bisrat, 1988) in particular. The five ponds established at Dembel Wachu had seepage problems, while attempts to drill boreholes at Wollenso were constrained by a very deep water table.

The intent was to manage the ranches jointly through a collaboration of local PA members and SORDU staff and introduce concepts of ranch and range management to the Boran. Through a profit-sharing scheme, the project was supposed to provide money from livestock sales to the local community for development projects. It was also intended to eventually turn over the ranches to the local people after a demonstration period of several years.

SORDU directed ranch management, with Sarite having its first intake of cattle in 1979–80, followed by Dembel Wachu in 1980–81 and Wollenso in 1985 (GRM, nd). It was anticipated that the ranches would handle a total throughput of 36 000 head between 1981 and 1987 (6000 head/annum), but the actual number was only about 25% of this (Girma Bisrat, 1988). Low throughput and associated management and marketing problems led to a net loss of over EB 300 000 by June 1988 (GRM, nd). This lack of profitability, as well as a low popularity with the Boran (GRM, nd), led to the ranch concept being abandoned. It was then decided to return the land to pastoral management. Hogg (1988) proposed that Sarite be turned over to the new local SC developed in the Pilot Project (see Section 1.4.3: *The SERP and the Pilot Project*). He suggested that the ranch size should be halved and an SC committee would decide whether the ranch could be used in a different way to produce animals in more of a free-market setting.

In sum, the outcome of the ranch experiment at SORDU has been the same as elsewhere in pastoral Africa, i.e. the Western ranching concept has failed to transform traditional pastoralism (de Haan, 1990). It was also pointed out by GRM (nd) that the ranch strategy in SORDU ran counter to the survival tactics of the Boran, which included a low priority for selling younger stock (Coppock, 1992a; see Section 4.3.4.7: *Marketing attitudes*).

1.4.5.6 Smallholder fattening programme

Links among cooperatives in the highlands and lowlands were expected to form the basis of reciprocal help in the exchange of lowland livestock for highland grain. Young bulls from the rangelands were to be purchased on credit and distributed to highland farmers, who would finish them on grazing and crop residues and sell them for slaughter or use them as draught animals. The primary beneficiaries of this programme were thus highland smallholders (Menwyelet Atsedu, Colorado State University, personal communication). Cash could, however, be used by the Boran to buy grain directly from highland cooperatives, thereby avoiding expensive middlemen and saving the Boran money.

By 1988 the programme involved 21 PAs and 74 cooperatives overall and nearly 5000 cattle were sold to the southern highlands (Girma Bisrat, 1988). Manpower constraints limited the success of the programme, however. More staff were needed to follow up on collection of loan repayments. Lack of sustained effort led to many smallholders defaulting on their loans and many cases ended up in court (Menwyelet Atsedu, Colorado State University, personal communication).

Another major constraint to the programme was shortage of transport. It was intended that cattle trucks from the rangelands would return from the highlands with grain (Girma Bisrat, 1988). The TLDP purchased its own fleet of trucks in the late 1980s. Privatisation of this activity today is hampered by inefficient remnants of government trucking monopolies, which remain a major constraint to interregional trade (Tafesse Mesfin, TLDP General Manager, personal communication). The Pilot Project envisions that trade between the highlands and the lowlands needs to be stimulated by the establishment of large grain stores at SCs on the Borana Plateau (Hogg, 1990c).

1.4.5.7 Training

Project staff have been educated at home and abroad and pastoralists have been trained to provide field support to animal health activities (Table 1.1). One novel approach was to take over 100 Boran on trips to other pastoral and urban areas so they could get a better feel for the diversity of the nation (Girma Bisrat, 1988). Difficulties in training have occurred, however, indicating problems in sustaining field veterinary programmes and the low return rate (about 20% to date) of senior personnel sent overseas for further education since 1987. Those who have returned have also typically become administrators rather than scientists or resource managers (Coppock, ILCA, personal observation).

1.4.5.8 Trials and studies

The programme of trials and studies was, intended to help SORDU collect data to monitor and guide development projects, has always been constrained by a lack of trained manpower. This was one reason why ILCA was brought in to collaborate with SORDU on research in the early 1980s and to help train post-graduates in 1987–90 (see below). It is also why TLDP has spent considerable amounts on consultants. Recent activities of the Trials and Studies Section of SORDU have included collection of weather data, preliminary establishment of a range trend monitoring network, initial trials on bush control with prescribed fire and hand-clearing methods, roadside sowing trials with *Stylosanthes* spp, observation of a few field plots of fodder trees (i.e. *Leuceana leucocephala* cv Cunningham and cv Peruvian established at Dembel Wachu ranch in 1982) with the MoA, and establishment of drought-hardy forages (*Prosopis, Opuntia* and *Atriplex* spp established at Dembel Wachu and other sites in 1987) in collaboration with FAO. All of this work is constrained by shortages of fuel, vehicles and operating funds (Tamene Yigezu, SORDU Manager, personal communication). Details of forage work at SORDU are reviewed in Section 7.3.1.3: *Forage improvements*.

In sum, the success achieved by various project components varies. For some it is still too early to judge impact. TLDP management has routinely evaluated Project activities and dropped even high-profile activities (such as the ranches) that have not been successful (Coppock, ILCA, personal observation). Shortages of educated manpower constrain management and research capability and problems with support services and operating funds commonly impede programme implementation.

1.4.6 Collaboration among research and development institutions in the southern rangelands

The TLDP and ILCA have conducted various joint activities since 1976, when an intensive land-use survey in the Jijiga rangelands was started but abruptly curtailed because of the Somali invasion. This was followed by a joint ecological survey of the north-east rangelands a few years later. Under the umbrella of the general memorandum of agreement between the Government of Ethiopia and ILCA that was signed on 15 May 1975, the first formal Memorandum of Understanding (MoU) between TLDP and ILCA covered the Cooperative Monitoring Project for Ethiopia (CMPE), in effect from 1980–82. This agreement was replaced by the MoU for the Joint Ethiopian Pastoral Systems Study (JEPSS) from 1982–85.

The JEPSS was intended to provide a framework for research and debate on lowland development strategies. It was to focus initially on the Afar and Borana pastoral systems. Field research for the JEPSS in NERDU and JIRDU was abandoned in the early 1980s because of security problems. Some of this early work at NERDU is found in ILCA (1980), Donaldson (1982), Cossins (1983a), Billé (1983) and Negussie Tilahun (1983a; 1983b). Reports concerning JIRDU include Cossins et al (1984a-d) and Cossins and Billé (1984). The JEPSS continued to work in SORDU until 1985.

After the JEPSS ended in 1985, CARE-Ethiopia (a non-governmental development and relief organization) became a major partner in the SORDU area through establishment of the Southern Sidamo Rangelands Project (SSRP). This project was based on a MoU among the MoA/TLDP, the Relief and Rehabilitation Commission (RRC) of the Ethiopian Government, CARE-Ethiopia and ILCA from 1985 to 1988. CARE and ILCA combined staff and resources in field work, while the MoA/TLDP and RRC participated in liaison and strategy. The objectives of the SSRP were to provide tests of research hypotheses generated in the JEPSS for production interventions in the Borana system. For those interventions that appeared promising, preliminary modes of extension were also developed. ILCA focused on research while CARE worked more on extension and development. The main activities initially dealt with improved strategies for calf management, including water and forage intervention. This was later broadened to include many more development activities (Hodgson, 1990).

The SSRP ended in late 1988. While close administrative collaboration also ended between CARE-Ethiopia and ILCA at this time, informal ties between research and extension remained strong. CARE-Ethiopia then joined in another MoU with MoA/TLDP and the RRC starting in 1989 and the main development activities were collated under what was termed the Borana Rangelands Project. In this phase CARE's extension work still had a strong influence on helping shape ILCA's rangeland research (see below). CARE-Ethiopia also participated in institution building with SORDU to help establish a new SC in Dubluk *madda* as part of the Pilot Project (see Section 1.4.3: *The SERP and the Pilot Project*).

After 1988 ILCA staff designed research to complement the grass-roots activities of CARE and helped train postgraduates in a new MoU with FLDP/TLDP and the Institute of Agricultural Research (IAR of the Ethiopian Government) from 1987–90. This MoU formed the basis for the Cooperative Rangelands Pilot Research Training Programme (CRPRTP), intended to address problems of TLDP in training staff capable of conducting research. Master's-level candidates from TLDP were integrated into the field research, with course work performed at universities abroad. This project was funded by FLDP and ended in 1991 with six students completing degrees. Much of this research is documented in this volume.

1.4.7 Interaction between research and development and project impact

In theory, the SSRP was to follow a standard formula: (1) research providing the understanding of the pastoral community using a farming systems research (FSR) approach and (2) developers following with extension (see Harwood, 1979). Research was supposed to have defined interventions for the production system and their entry points.

By 1987, however, the nature of the SSRP began to change as work evolved into a more reciprocal partnership. Extension agents began to have a critical role in reshaping the research agenda. While research had successfully identified some key issues prior to 1985, it turned out that intervention was far more complex than anticipated. This complexity was revealed by the in-depth interaction of extension agents with the community. It is fair to say in retrospect that the researchers never implemented a true FSR approach on their own. The extension agents completed the circle by forming a more effective feedback loop with the Boran. Research was then redesigned on the basis of this improved information (Coppock, 1990a). Extension agents ended up being more important than researchers in implementing the FSR process. Research then followed up by putting some development issues into a more dynamic systems context (see Section 7.2: *A theory of local system dynamics*). Research also has had a key role in dissemination of project information.

In sum, the model that evolved from the original SSRP turned out to be rather unlike that envisioned for FSR in Harwood (1979). It became more like the situation in the United States where extension is supposed to be the "eyes and ears" for research by providing timely feedback and new ideas (G.A. Rasmussen, Extension Specialist, Utah State University, personal communication). Our experience documents the crucial importance of clever extension agents as well as researchers who recognise that technical expertise must be shaped by development values if impact is to be rapidly achieved (see Chapter 8: *Synthesis and conclusions*).

Chapter 2

Introduction to the Borana Plateau: Natural resources and pastoral society

Summary

This chapter reviews secondary information on geology and sociology, as well as original information on climate, soils, wildlife, plant ecology and water resources for the central Borana Plateau. A 15 475 km² study area was selected because it represented an important region for the national livestock economy. Geology of the study area is dominated by quaternary deposits (40%), basement-complex formations (38%) and volcanics (20%). Except for a central mountain range and scattered volcanic cones and craters, the landscape is gently undulating across an elevation of 1000 to 1600 m. Vertisols occur more in valley bottoms while upland soils occur elsewhere. Valley bottoms are relatively scarce on the landscape and occupy about 12% of the study area. Vertisols are higher in nutrient content and water storage capacity than upland soils.

The region is dominated by a semi-arid climate. Annual mean temperatures vary from 19 to 24°C with little seasonal variation and these decrease 1°C with each 200-m increase in elevation. Average annual rainfall for 10 sites during 1980–89 varied from 440 to 1100 mm (with an overall average of 700 mm) and this increased by 64 mm with each 100-m increase in elevation. The average of 700 mm is probably biased on the high side because climate stations tend to be located at higher elevations. Rainfall delivery is bimodal: 59% of annual precipitation occurred from March to May and 27% from September to November. A "dry" year is defined as one in which annual rainfall is <75% of average and these may occur one year in five. The probability that two consecutive years will have average or above-average rainfall, one dry year, or two dry years is thus 0.64, 0.32 and 0.04, respectively.

At least two consecutive dry years constitute a drought. In an average-rainfall year the number of plant growing days ranges from 100 to 140 in the west and north of the study area, respectively. This corresponds to 1.5 to 2.0 t DM/ha/year of herbaceous forage production. For the study area, conservative calculations suggest that annual mean carrying capacity in an average-rainfall year is on the order of 14 Tropical Livestock Units (TLU)/km², or 217 000 head of cattle but this can decrease to 10 TLU/km² (<155 000 head of cattle) in a dry year. Stocking rates for the near-average rainfall years of 1982 to 1983 and 1988 to 1990 suggest that mean animal density is commonly around 16 TLU/km², or 250 000 head.

The region is dominated by savannah vegetation containing mixtures of perennial herbaceous and woody vegetation. Several native species of grasses and woody plants provide excellent forage. Forage nutritive value increases in rainy seasons compared to dry seasons and browse often retains higher nitrogen content in dry seasons compared to grasses. Elevation, with concomitant effects on temperature, precipitation and associated with shifts in soil parent materials, is the most important factor governing distribution of key plant species. In terms of fauna, the study area is home to at least 26 species of large, wild mammals and 45 species of commonly observed birds.

The Borana Plateau is characterised by a general scarcity of surface water. There are over 540 hand-dug wells and these occur in some 40 clusters largely to the west. These wells provide over 95% of the permanent water points and about 84% of the total accessible water in a typical dry season. The wells also provide about half of the annual water requirements for people and livestock, with the remainder provided by ephemeral and permanent ponds. Wells require large inputs of labour and are thus important in the social and economic life of Borana pastoralists. They also form the basis for traditional units of resource allocation termed *madda.* There are about 35 *madda* with an average area of 500 km². Each *madda,* on average, may contain several well clusters serving some 100 encampments, 4000 people and 10 000 cattle.

The Borana Plateau represents part of the remaining core area or cradleland of the southern highlands and rangelands from which the original Oromo culture expanded and conquered half of present-day Ethiopia during the 1500s. The core rangeland area contains historical Oromo shrines still worshipped by the population. The Borana territory has been reportedly shrinking since the early 1900s, largely because of induced habitat change and Somali encroachment from the east. The Borana social structure includes two moieties, five sub-moieties, 20 clans and some 60 lineages based primarily on patterns of male descent. Clans are widely distributed among the *madda* and are the primary mechanism for wealth redistribution. Some

100 clan meetings are held each year whereby the poor petition the wealthy for cattle.

The Boran achieve concensus on important community issues through open, participatory assembly. Concensus and enforcement of social norms is achieved under the umbrella of the "Peace of the Boran", which refers to traditional values and laws. Two peer-group structures for males, the age-set system (*Hariya*) and a generation system (*Gada*) figure in the distribution of social rights and responsibilities and/or regulation of human reproduction. These two systems share many similar attributes and ultimately are complementary in function. All males have a position in each. *Hariya* consists of 10, eight-year blocks of similarly aged individuals between the ages of 12 and 91 who share a collective identity that evolves with ascension into subsequent age sets. The *Gada*, in contrast, consists of seven grades and an increasing number of generation classes that are created every eight years. *Gada* grades can contain males of vastly differing ages. Among other attributes, the *Gada* grades confer political and ceremonial duties and subject members to different rules regarding sexual behaviour.

It has been hypothesised that the *Gada* was created during the 1600s to help the society cope with a population explosion. Computer models have suggested that *Gada* rules on reproduction served to reduce the population 50% by the mid-1800s, and the population may have slowly grown since. The human population in the study area might have been on the order of seven persons/km^2 (108 000) in 1982 and may be growing at a rate of 2.5% per year. Hypotheses to explain this apparent surge in growth include: (1) improved food supply and medical services from outside agencies; (2) declining adherence of the population to traditional *Gada* norms; (3) external interference with the *Gada* system from national political interests; and (4) cyclic, functional aberrations in the effects of *Gada* rules due to demographic shifts.

The *Gumi Gayu* (Assembly of the Multitudes) is chaired by the leadership and occurs once every eight years in the southern rangelands. It is a foundation of Borana life attracting pilgrims from Ethiopia and Kenya. Assemblies of 1966 and 1988 ended with key cultural and political proclamations. The 1988 proclamations indicate a society under resource pressure. These included decrees to better maintain water points, restrict cultivation, establish calf-fodder reserves, protect valuable indigenous trees, reclaim grazing reserves for cattle and prohibit water sales and alcohol abuse.

2.1 Introduction

To understand the sustainable development potential of a pastoral system it is necessary to understand the natural resources upon which it is based. It is also important to understand some social, organisational and demographic aspects of pastoral society whose features are shaped by interactions between people and their natural resources.

The Borana Plateau is probably one of the most studied regions in Africa with many detailed accounts of its geology, hydrology, vegetation and sociology (see AGROTEC/CRG/SEDES Associates, 1974a-l). This chapter will not attempt to summarise all that has been done prior to 1980. Instead, this material highlights key information from the literature and introduces recent findings from research and other empirical observations.

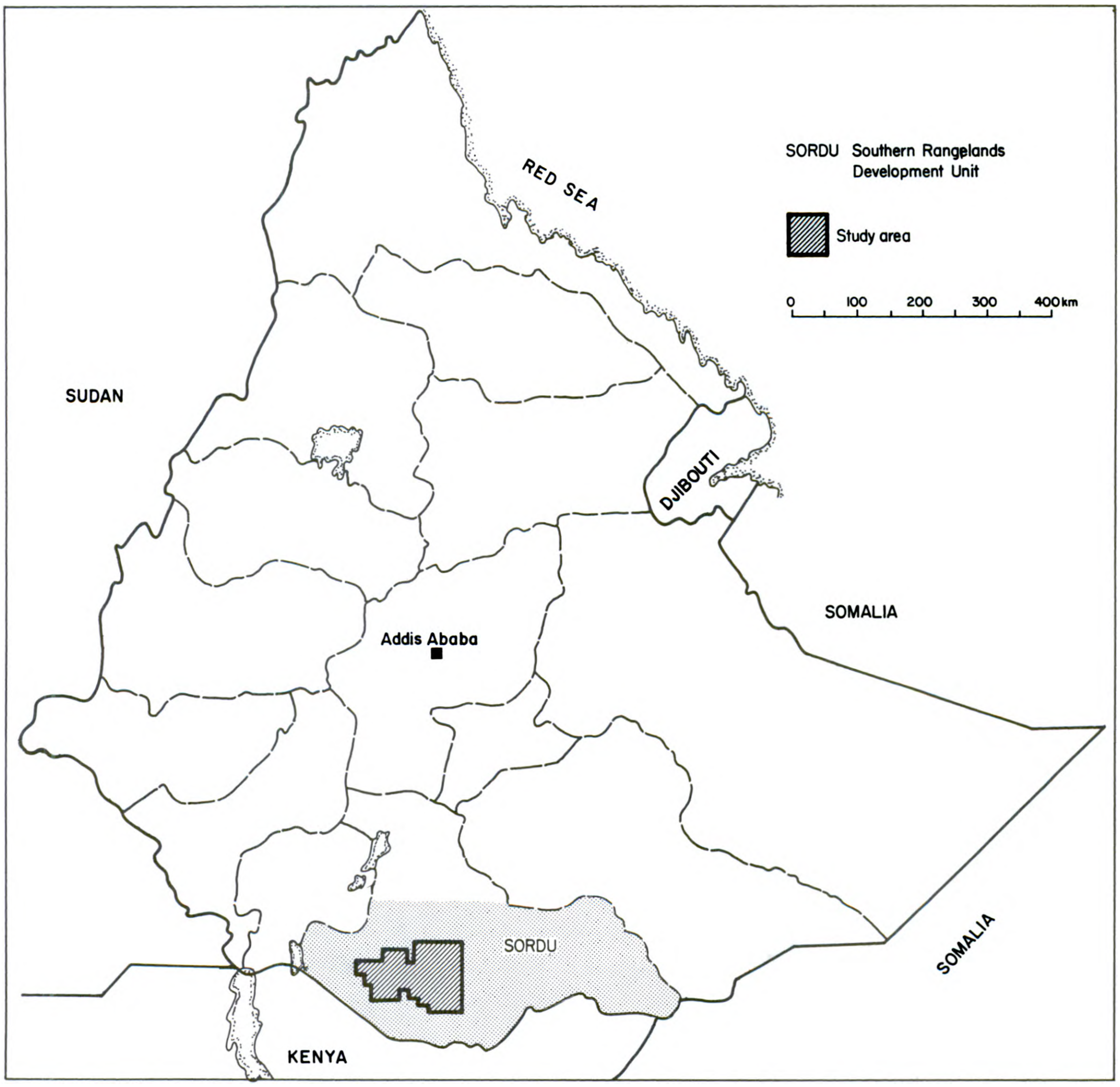
2.2 Study area selection and system delineation

As mentioned in Chapter 1, the southern rangelands were selected for long-term research primarily because the region is important as a source of animals for domestic consumption and export. The infrastructure and high level of security have also facilitated continuity of research and development, at least until 1991 (see Chapter 8: *Synthesis and conclusions*). Much of the study area remains as the development focus of the ongoing Pilot Project (see Section 1.4.3: *The SERP and the Pilot Project*).

Although the Borana Plateau comprises most of the 95 000 km^2 of SORDU, the study area demarcated by the JEPSS programme in the early 1980s was 15 475 km^2 of the west-central portion (Figure 2.1). The "H" shape of the study area resulted from mountain ranges which cut into pastoral lowlands from the north and south. There were several reasons for selecting this study area, the most important being that it circumscribed the heartland of the Borana pastoral system. The Boran dominate the west-central region because they depend on deep wells associated with the geomorphology of the western Borana Plateau (see Section 2.4.1.7: *Water resources*). The area was also selected because it had a reasonable road network and contained government administrative centres.

Ground and aerial surveys of human and livestock populations and extensive vegetation studies were conducted from 1982 to 1986 throughout the 15 475 km^2 study area (Billé et al, 1983; Milligan, 1983; Cossins and Upton, 1985; Assefa Eshete et al, 1987). Most household surveys, however, were performed more commonly in the eastern half of the study area because of

Figure 2.1. *Delineation of the SORDU sub-project region and the ILCA study area in southern Ethiopia.*



Source: Cossins and Upton (1985).

easier logistics (Figure 2.1; see Section 4.3.1: *General household structure and economy in average rainfall years*). Thus, research results from work conducted at the population or landscape level of resolution are more applicable to a sample area of 16% of the entire Borana Plateau while household-level results are applicable to about 1% of the area. As will be shown, the Borana Plateau is extremely diverse in terms of natural resources, ecology and pastoral inhabitants. Because of this diversity, some of the development concepts forwarded later in this report (see Chapter 7: *Development-intervention concepts*) may not be applicable to the Borana Plateau overall.

Reference will be made throughout the rest of this volume to the Borana pastoral system. This will be loosely defined as the people, animals, vegetation and supporting resources that occur within the 15 475 km^2 study area.

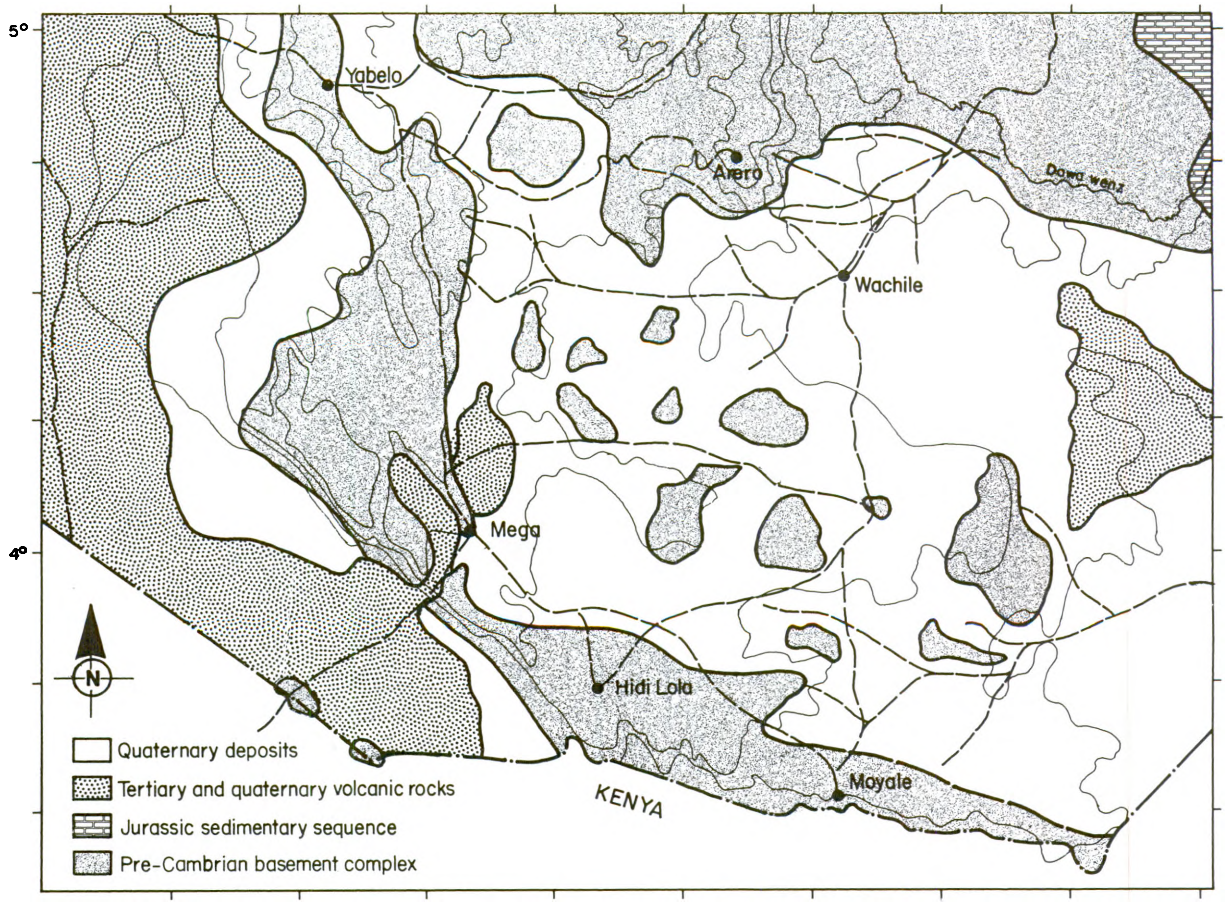
2.3 Methods

This section highlights some of the technical methods used for collection of original data for soils, climate, plant ecology, forage chemical analysis and social surveys reported in this chapter. Methods used to collect secondary information reviewed here can be found in the cited literature.

Eight pits were dug on soils representative of dominant upland and lowland substrates largely in the eastern half of the study area. Pits were analysed to a 2-m depth in 1986 to 1987. Standard methods for the physical and chemical analyses of soils can be found in Kamara and Haque (1987: pp 12–14; 1988: pp 7, 14–15). These include use of Munsell charts for soil colour, analysis of soil pH using a 1:1 water to soil ratio, organic carbon by the Walkley-Black method, nitrogen by *micro-kjeldahl*, available phosphorus by the Bray II method, bulk density by the core method and soil moisture by pressure plate and pressure membrane techniques.

Air temperature and rainfall data were collected by SORDU staff on a daily basis from a network of seven and 10 monitoring stations, respectively, set up during 1979 as part of the national meteorological network with assistance from ILCA. Stations were set up in towns and field sites throughout the central plateau where data collectors could reside and equipment could be supervised. Because towns tend to be in wetter environments at higher elevations, the data are probably biased on the high side for rainfall and on the low side for temperature for the region as a whole. A map of the monitoring sites and a preliminary synthesis of data collected from 1980 to 1982 for SORDU (as well as JIRDU and NERDU) can be found in Billé (1983). The location of some of the major towns having key climate stations is shown in Figure 2.2. Linear regressions were used to relate annual mean rainfall or temperatures with elevation. Climate diagrams (Michel Corra, ILCA, unpublished data) were based on analytical assumptions of Walter et al (1975) in which plant growing periods were assumed to be those times when monthly rainfall (mm) was twice the ambient temperature (°C)—these being times when soil moisture storage was most likely. Lengths of growing periods (LGPs) based on climate data were estimated in Cossins and Upton (1988a: pp 118–119) using a water-balance model of FAO (1978). Monthly rainfall data for five sites were used to calculate LGPs based on the assumption that plant growth occurs only when monthly rainfall exceeds a threshold of half the potential evapotranspiration. Length of growing

Figure 2.2. *Primary geological features of the central Borana Plateau.*



Source: EWWCA (1987).

period was also assumed to be normally distributed with a coefficient of variation of 30%. Dry-matter (DM) production of forage was assumed to be directly related to LGP on the basis of 17 kg DM/ha/day of growth (Cossins and Upton, 1988a).

How environmental variables influenced distributions of native plant species was analysed by Corra (1986) using 134 one-hectare sites throughout the study area. Field procedures followed Goudron et al (1968): Each site was characterised in terms of: (1) dominant plant species (presence/absence); (2) vegetative physiognomy (i.e. bushland, grassland, woodland etc) scored into one of five categories as in Pratt and Gwynne (1977); (3) colour of the top soil into one of four groups (Munsell Color, 1975); (4) soil reactivity (positive or negative) to 4.0-M hydrochloric acid to assess acidity; (5) slope scored into one of four categories; (6) elevation measured with an altimeter and scored into one of six classes; (7) per cent tree crown cover, shrub crown cover, herbaceous (grass and forb) cover, bare soil and exposed bedrock; and (6) presence or absence of gulley or sheet erosion. These data were analysed in two ways: (1) frequency distributions of plant species across all categories of each environmental variable for tabular display; and (2) an integrative method using detrended, canonical correspondence analysis (CANOCO), a form of ordination (ter Braak, 1988). This was intended to quantify interactions among environmental variables in terms of their effects on plant species distribution. The ordination exercise was depicted as a graph which integrates all variables in explaining their effects on the occurrence of each plant species. Plant species occur as points on the graph and the environmental variables are shown as vector arrows or points, depending on whether the variables are continuous or discrete. Plant species nomenclature in this volume follows Pratt and Gwynne (1977) and AGROTEC/CRG/SEDES Associates (1974d).

Chemical analyses of forage materials followed standard methods for organic matter, nitrogen, fibre and *in vitro* digestibility (Goering and Van Soest, 1970; AOAC, 1980; Van Soest and Robertson, 1980). Tannins in browse forage are reported from Woodward (1988) and her analytical methods followed Reed et al (1985) and Reed (1986).

Information on social aspects of resource management and water production from wells was obtained through survey and/or systematic observation (Cossins, 1983c; Donaldson, 1983; Cossins and Upton, 1987). Methodological details will be reported in the discussion as warranted.

2.4 Results and discussion

2.4.1 Natural resources of the central Borana Plateau

2.4.1.1 Geology

Four basic geological formations comprise the central Borana Plateau as defined in Figure 2.2 and reported in EWWCA (1987: pp 55–59). Other descriptions of these formations are in Pratt and Gwynne (1977: pp 3–13). The formations include:

Pre-Cambrian basement complex

This comprises about 38% of Figure 2.2, and consists of granites, gneisses and migmatites. This is part of the Mozambican Belt of East Africa and is between 600 and 950 million years old. These formations are the result of warping, folding and up-lifting of substrates from the earth's crust. Rocks are varied in colour and often have a banded appearance due to separation of mineral components under high temperature. Basement-complex parent materials underlie areas having mountainous, undulating or flat relief. Basement-complex parent materials tend to dominate soil formation at higher elevations on the Borana Plateau and this has implications for soil chemistry and plant associations (see Section 2.4.1.5: *Native vegetation*). Fractured depths of the basement-complex formation make up many of the discontinuous aquifers that supply the deep wells (see Section 2.4.1.7: *Water resources*).

Sedimentary deposits

These were deposited during the Jurassic Period some 180 million years ago. They comprise about 2% of Figure 2.2 to the north-east, and are composed of shales, sandstones and limestones. These materials largely resulted from oceanic activity.

Volcanics

These comprise about 20% of the area in Figure 2.2 and were deposited during the Tertiary to Quaternary Periods (i.e. from 70 to 3 million years ago). This was associated with massive tectonic disturbances that created the Rift Valley. Volcanics consist of a Trap Series component to the west (Figure 2.2) which occurred during the Oligocene and Miocene subdivisions (i.e. 25 to 40 million years ago), fissural basalts to the south-west and quaternary basalts to the south deposited three million years ago. All of these overlay basement-complex formations up to a thickness of 500 m. The group of craters evident around the town of Mega (Figure 2.2) represents a chain that ends at Marsabit in Kenya (EWWCA, 1987). Volcanics also contribute mountains and hills and underlie areas with undulating and flat relief. Volcanics tend to occur more, however, at lower elevations of the study area, which has implications for soil chemistry and plant associations (see Section 2.4.1.5: *Native vegetation*). The few crater lakes in the study area are known for their salty water. Recovering salt from these lakes is a source of employment near Mega (D. L. Coppock, ILCA, personal observation). Salty water is reportedly also an important feed intake for camels at Dilo Goraye to the south-west (D. L. Coppock, ILCA, personal observation). Some crater bottoms also harbour deep water wells (see Section 2.4.1.7: *Water resources*).

Quaternary deposits

These comprise about 40% of the area in Figure 2.2 and were deposited at least three million years ago. They have resulted from alluvial (river, lake or swamp deposition) or eluvial (*in situ* weathering of rock) processes.

In sum, the central Borana Plateau is diverse in terms of the types and ages of parent materials for soil formation. These factors influence soil fertility which, in turn, influences vegetation characteristics.

2.4.1.2 Landscape

The terrain of the central Borana Plateau includes a central mountain range, scattered volcanic cones and craters and gently undulating and flat plains. The basement-complex mountains largely run from north-west to south-east from Yabelo to Moyale and north from Arero (Figure 2.2); some peaks attain 2000 m in height. These peaks are often distinctive because they contain massive, protruding blocks of resistant rocks that have separated from the more readily erodible materials.

It is important to note that the undulations of the plains are too gentle and irregular to be described as a catena which is a common landform elsewhere in East Africa (Pratt and Gwynne, 1977). There are distinctions, however, in soil and vegetation among lowland sites in valleys and depressions compared to upland sites and these have important implications for land use (see Section 2.4.1.3: *Soils* and Section 4.3.6: *Cultivation*). Except along the Dawa River (Figure 2.2), which was excluded from most of ILCA's research, there are no seasonally flooded areas or catchments which could support riverine vegetation or gallery forests. The study area is thus distinctive because it lacks reliable surface water during most of the year (see Section 2.4.1.7: *Water resources*). These points are made because patches or corridors of seasonal or permanent wetlands have been increasingly recognised as crucial pastoral resources (Coppock et al, 1986a; Ellis et al, 1986; Scoones, 1991).

Landscape units or land systems have been defined as "areas in which there is a recurring pattern of topography, soils and vegetation" (Christian and Stewart, 1953 cited in Pratt and Gwynne, 1977: p 9). Landscape classification systems thus attempt to incorporate climatic, topographic and edaphic criteria. Some 104 landscape facets have been proposed for the central Borana Plateau by Assefa Eshete et al (1986). This classification, integrating aspects of climate, soils, vegetation and land use, will be introduced in Chapter 3: *Vegetation dynamics and land use* and Annex C: *Ecological map of southwestern Borana*.

Detailed technical descriptions of the geology of the southern rangelands are reported in AGROTEC/CRG/ SEDES Associates (1974i) and EWWCA (1987). Geological maps at a national scale can be found in Kazmin (1973). A physiographic map of the study area can be found in EWWCA (1987: p 54). This map divides the region into four large drainages or watersheds: (1) Dawa Wenz to the north-east; (2) Laga Sure to the south-east; (3) Laga Ririba to the north-west; and (4) Laga Walde to the south-west. (The general introduction to East African geology and landscapes in Pratt and Gwynne (1977) is also recommended reading).

2.4.1.3 Soils

Soil develops over time from interactions of parent material, weathering and accumulation of organic matter. Overall, rangeland soils of East Africa are regarded as having low fertility. This is principally attributed to the very old age of common parent materials (Pratt and Gwynne, 1977: p 9). Range soils may vary substantially in fertility, however. In general, soils with more clay that are derived from lava or other materials low in quartz are often regarded as having higher fertility than lighter, sandier soils derived from granites and sandstones higher in quartz. This can be extrapolated to landscapes: Bottomlands of valleys and other sites with impeded drainage may be expected to have greater fertility than soils on slopes or hilltops. Despite their low fertility compared with soils in wetter zones, common range soils have a reduced risk of accelerated nutrient loss from leaching because of the lower rainfall. Precipitation regimes ranging from 500 to 900 mm/annum have been proposed as thresholds over which leaching can interfere with maintenance of soil fertility (Pratt and Gwynne, 1977: p 13). The low rainfall of rangeland areas may also depress response of range soils to mineral fertilisers. This is because water is assumed to be the major limiting factor to plant growth in many rangeland systems (Noy-Meir, 1973; Pratt and Gwynne, 1977). Ludwig (1987) disputes this, however, and notes that nutrient limitations can be important constraints in run-on areas or patches in dry-land systems where water availability is less of a constraint.

Soil structure and fertility

This section reports on soil surveys for ILCA research sites in Ethiopia conducted by Kamara and Haque (1987; 1988). Sites analysed in the southern rangelands were near Mega, Sarite ranch, Dembel Wachu, Melbana, Yabelo, Medecho and Dubluk (see Figures 2.2 and 3.1 for map locations). The other sites included Debre Birhan, Debre Zeit, Gudder, Deneba, ILCA headquarters, Wogele, Woreta and Were Ilu distributed among the northern and north-central highlands, Soddo in the southern highlands and Zwai in the Rift Valley. The surveys were intended to provide baseline information from representative sites that could be used in designing agronomic trials. Sites were thus not selected randomly and data were not intended for statistical analysis. The survey does, however, provide some useful background for understanding variation in Ethiopian soils and edaphic constraints found in the southern rangelands.

Vertisols near Mega and at Sarite ranch on the Borana Plateau were described by Kamara and Haque (1987: pp 11, 26, 64–67, 81 and 84). Upland soils at Dembel Wachu, Medecho, Dubluk, Melbana and near Yabelo were described by Kamara and Haque (1988: pp 5, 7, 16–18, 24, 26, 30, 46, 62–73, 81 and 83). The following material will only briefly review some general results. Kamara and Haque (1987; 1988) should be consulted for details and a standard soils text for clarification of technical parameters or methods employed.

Vertisols are brown or grey soils that are often poorly drained, are high in organic matter and have a clay content of over 60% (Kamara and Haque, 1987). In the rangelands Vertisols have a restricted distribution in valley bottoms, low-lying plains and on flat surfaces in the central mountain range.

Compared to the surface soil (i.e. the top 20 cm) of 15 other Vertisol sites studied throughout the Ethiopian highlands and lowlands, the rangeland Vertisols were typically average in most respects (Kamara and Haque, 1987). For example: (1) available phosphorus (P) ranged from 0.3 to 39.4 ppm across all 17 sites with a mean of 7.8 ppm, and the average for the rangeland sites was 10.9 ppm; (2) per cent total nitrogen (N) ranged from 0.02 to 0.29% across all sites with a mean of 0.13% and the average for the rangeland sites was 0.10%; (3) per cent organic matter (OM) ranged from 1.5 to 5.7% across all sites with a mean of 3% and the average for the rangeland sites was 2.9%; (4) pH ranged from 4.98 to 7.52 across all sites with a mean of 6.02 and the average of the rangeland sites appeared more alkaline at 7.62; (5) bulk density (throughout the profiles) ranged from 0.83 to 1.48 g/cm^3 across all sites with a mean of 1.18 g/cm^3 and the average of the rangeland sites was 1.04 g/cm^3; (6) total porosity (throughout the profiles) ranged from 54 to 84% across all sites with a mean of 65% and the average of the rangeland sites was 71%.

Available water capacity (AWC) ranged from 1.4 to 4 mm/cm over the 17 sites with a mean of 2.4 mm/cm. The average for the rangeland sites was at the low end with 1.52 mm/cm. The picture changes somewhat for total AWC, which reflects variation throughout the profiles. Total AWC ranged from 362 to 686 mm over 17 sites with a mean of 515 mm. The average for the two rangeland sites was 573 mm. Soil depths were only evaluated either to a maximum depth of 2 m or until bedrock was reached. Only four out of the 17 sites had soil depths <2 m, and one of two in the rangelands was in this category (i.e. 180-cm depth). Nearly all of the Vertisol sites (including the rangeland sites) were judged to have an erosion risk of none to slight (Kamara and Haque, 1987: p 32).

In contrast to Vertisols, the upland soils in Ethiopia vary from yellow, brown, grey or red in colour. They are better drained and usually have more equitable proportions of sand, silt and clay (Kamara and Haque, 1988). The clay allows for greater ability to store moisture and nutrients while sand has the least ability in these respects. In the rangelands, upland soils are widespread and occur on mountains, ridges, upland swales and hilly and level plains. The six rangeland sites averaged 53% sand, 17% silt and 30% clay. The eight sites elsewhere in Ethiopia had an average composition of 40% sand, 23% silt and 37% clay. Based on these patterns it could be stipulated that the upland soils of the rangelands have a lower ability to retain water and nutrients than upland soils elsewhere.

Upland soils in the rangelands appeared similar to those found elsewhere in Ethiopia in most other respects (Kamara and Haque, 1988). For example: (1) for the non-rangeland sites available P averaged 3.25 ppm (range: 0.63 to 14.5 ppm) while the rangeland sites averaged 2.8 ppm (range: 1.19 to 5.29 ppm; three sites having values >44 ppm were excluded because this was thought to be related to past fertiliser use); (2) per cent total N for the non-rangeland sites averaged 0.11% (range: 0.01 to 0.16%) while the rangeland sites averaged 0.09% (range: 0.04 to 0.14%); (3) per cent organic matter (OM) for the non-rangeland sites averaged 2.8% (range: 1.6 to 4.8%) while the rangeland sites averaged 2.4% (range: 0.9 to 4.3%); (4) pH for the non-rangeland sites averaged 6.7 (range: 5.1 to 8.1) while the rangeland sites averaged 7.1 (range: 6.4 to 7.8); (5) bulk density for six non-rangeland sites averaged 1.22 g/cm^3 (range: 0.99 to 1.35 g/cm^3) while the rangeland sites averaged 1.41 g/cm^3 (range: 1.19 to 1.63 g/cm^3); (6) total porosity (five sites) ranged from 49 to 61% across all sites with a mean of 54% and the one rangeland site had a value of 49%.

In terms of AWC the non-rangeland sites averaged 1.54 mm/cm (range: 0.80 to 2.08 mm/cm) while the rangeland sites averaged 1.33 mm/cm (range: 0.32 to 2.66 mm/cm). For total AWC the non-rangelands sites averaged 312 mm (range: 176 to 405 mm) while the rangeland sites averaged 43% less at 179 mm (range: 35 to 409 mm). Three of eight non-rangeland sites had soil depths <2 m and these averaged 165 cm (range: 160 to 170 cm). All of the rangeland sites had soils <2 m deep (average: 144 cm; range: 125 to 170 cm). Three of eight non-rangeland sites were scored as having at least a slight-to-severe risk of erosion. Five of six sites were scored at the same level for the rangelands.

The above material provides some basis for proposing hypotheses regarding regional variation within the major soil classes, but the data are notable for their lack of variability in most respects. For example, Kamara and Haque (1987; 1988) concluded that all of the soils studied were markedly deficient in N and P content for sustained and intensified cultivation without fertilisation. Concerning site variation, it is reasonable to hypothesise, at least for the upland soils, that the rangeland sites are sandier and shallower. This suggests that the upland soils in the rangelands are less capable to store nutrients and moisture than sites elsewhere. This could be a major production constraint given that availability of nutrients and moisture are lower in the rangelands (see Section 2.4.4.1: *Rainfall*).

Differences between Vertisols and upland soils appear to be greater than the regional variation within either group. It is reasonable to postulate that compared to the upland soils, the Vertisols have a higher content of N, P and OM and a higher AWC conferred by their higher proportion of clay and silt and greater depth. The Vertisols are probably also far less vulnerable to erosion. In sum, these postulated differences are in agreement with the contention that Vertisols offer a more reliable substrate for sustainable cultivation than upland soils (Kamara and Haque, 1987).

Given these differences between soil groups, it is also evident that it is the relative proportion of each at the landscape level that would largely define the major contribution of soil to the character of agricultural enterprise in any given region. For example, it has been estimated that <10% of the southern rangelands is suitable for sustainable cultivation. This is largely related to the low proportion of Vertisols (and deep upland swales) that occur on the Borana Plateau. In contrast, the northern Ethiopian highlands are regions of intense cultivation, probably because of the dominance of deep Vertisols (Westphal, 1975). Conversely, the very high proportion of shallow upland soils in the southern rangelands probably makes for a greater vulnerability of the system to opportunistic cultivation and/or heavy grazing pressure (see Section 3.3.1: *Ecological map and land use*).

This simple dichotomy supports the views of Pratt and Gwynne (1977: p 9) who contend that categorising soils with regards to erodibility is really all that is needed for a fundamental understanding of how soil contributes to the stability and resilience of rangeland systems, and that agronomic studies of soil nutrient features in rangelands are less necessary. This also may support the idea that rangeland systems are more often regulated by moisture availability (Noy-Meir, 1973). A more recent view, however, is that one must take a site-specific approach to judge whether water or soil nutrients are the most limiting factor to plant production in a rangeland system (Ludwig, 1987). This may fit well in the southern rangelands where Vertisols and upland soils provide a testable dichotomy. It is perhaps most relevant to hypothesise: (1) That plant production on the upland soils of the southern rangelands is more likely to be regulated by available water rather than soil nutrients during most of the year; and (2) that plant production on Vertisols or deep upland swales is more likely to be regulated by nutrient availability since soil moisture is relatively more plentiful.

Recognition of this dichotomy is probably fundamental to understanding prospects for the long-term sustainability of the pastoral system in light of increasing pressure from cultivation and cattle grazing (see Sections 4.4.1.1: *Pastoralism and cultivation* and 7.2: *A theory of local system dynamics*).

2.4.1.4 Climate, primary production and carrying capacity

Climate is principally defined by interactions of rainfall and air temperature that determine seasonality and the breadth of ecological niches for plant and animal species. Although AGROTEC/CRG/SEDES Associates (1974d; 1974i; and 1974j) dealt with aspects of climate in the southern rangelands, it was from a more limited data base than exists today.

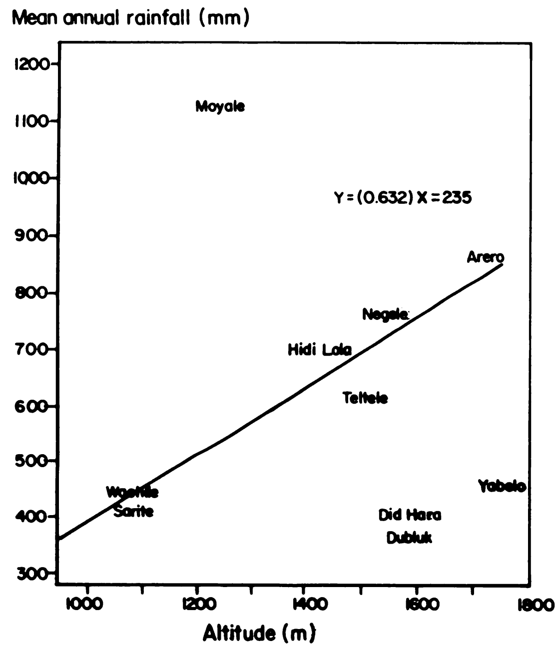
Rainfall

Monthly and annual rainfall statistics for 10 years over the period 1980 to 1989 can be found in Table A1, Annex A. The following is a preliminary analysis and conclusions are not definitive because a minimum of 50 to 60 years may be required to establish accurate rainfall patterns in semi-arid areas (Billé, 1983). For example, the 1980–89 data include the 1983–84 drought and some annual means are probably biased downwards. This is because multi-year droughts are thought to occur at a lower frequency than once every 10 years (see below).

Complete data were obtained for seven of 10 sites. Rainfall varied substantially with location. Annual mean rainfall in the seven sites varied from about 440 mm at Wachile to 1100 mm at Moyale on the Kenya border, with an overall average of 700 mm (Table A1, Annex A). Variability was uniformly high and ranged from 38 to 57% of annual means. Annual rainfall varied significantly with elevation in a simple linear regression for six sites (N=6; r^2=0.94; P=0.001; see Figure 2.3). This indicates that over the range of 1000 to 1700-m elevation, annual rainfall increased by 64 mm for each 100 m.

The final regression deleted stations at Moyale, Yabelo, Did Hara and Dubluk. Moyale was dropped because its position on the escarpment with the northern Kenyan desert subjects it to a higher rainfall, and Yabelo and Did Hara were dropped

Figure 2.3. *Linear regression analysis of mean annual rainfall as a function of altitude for six sites in the southern rangelands.*



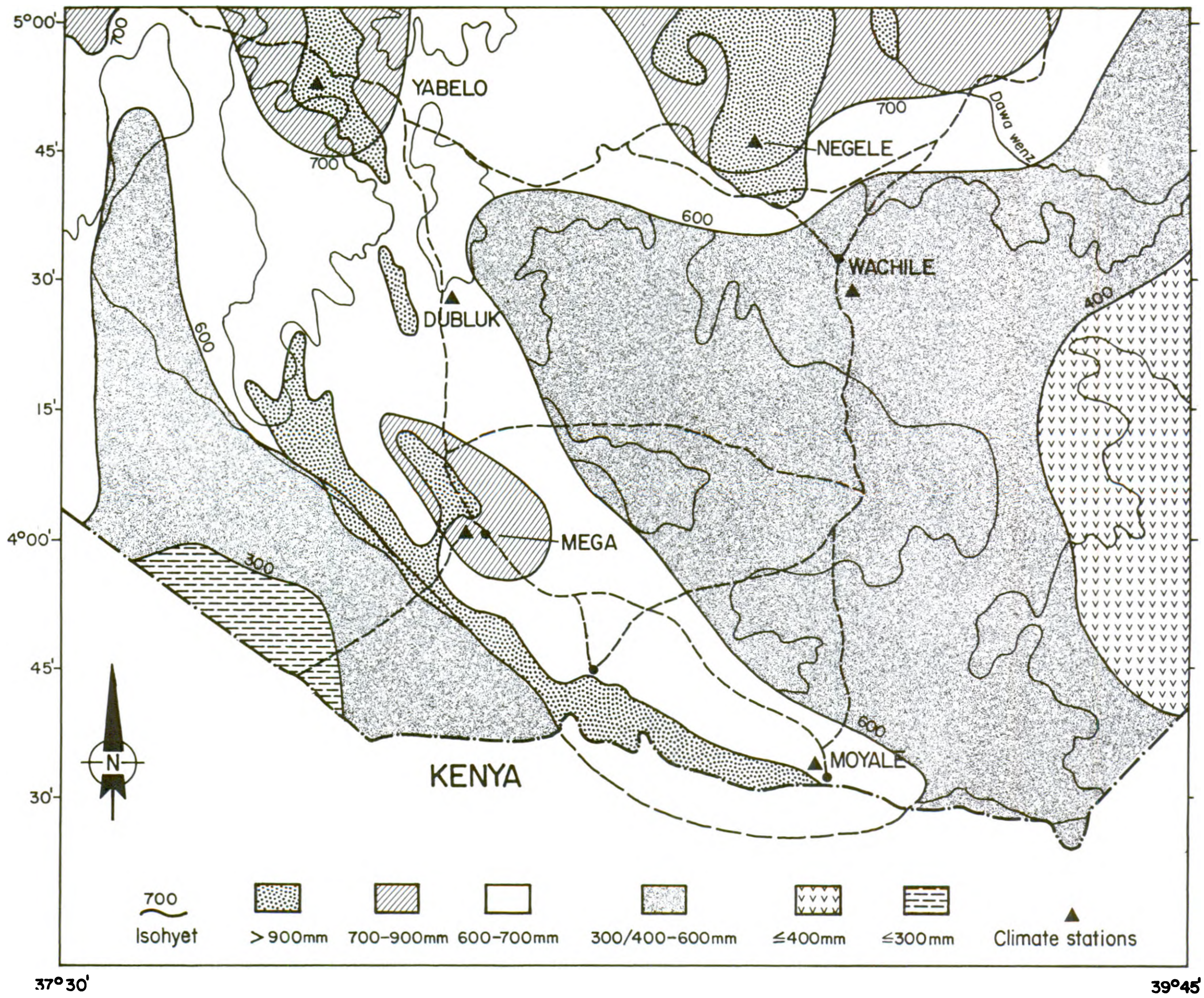
because they occur in a rain shadow of the central mountain range (Billé, 1983). Dubluk was dropped because of a lower confidence in the data quality (D. L. Coppock, ILCA, personal observation). A rainfall map of the study area in which five moisture zones are depicted is shown in Figure 2.4.

Mean annual totals for rainfall alone do not indicate effectiveness of rainfall for plant production. Effectiveness is strongly influenced by seasonal concentration of moisture and reliability of receiving threshold amounts within certain time intervals (Pratt and Gwynne, 1977: p 13). Data in Table A1, Annex A, indicate pronounced concentrations of rainfall in a bimodal pattern. As a first example, each rainy period is defined as being three months in length to illustrate seasonality. In this case 59% of the annual rainfall occurred during March, April and May at all seven sites while another 27% fell during September, October and November. In sum, 86% of the rain occurred during six months. Over twice as much rain fell from March through May as in September through November. Now considering a two-month duration for each rainy period, 48% of the annual rainfall occurred during April and May, with 20% falling during October and November. Sixty-eight per cent occurred during four months. Over 2.3 times as much rain fell in April and May as in October and November.

Billé (1983) considered that a monthly rainfall of 60 mm was the minimum required to stimulate green-up of herbaceous vegetation in the southern rangelands. He therefore calculated probabilities of rainfall exceeding 60 mm for six sites in each month based on data from 1957 to 1981. All of the sites were at higher elevations and could be considered representative of the study area as a whole (i.e. half occur on the periphery of the study area). The general perspective is useful, however, and the analysis is shown in Table A2, Annex A. Averaged across all sites, the probability of receiving 60 mm ranged from about 0.20 or less from June through August and December through February. The driest month was January with an average probability of 0.09. Probabilities ranged from 0.48 in March to 0.93 (April) and 0.78 (May) during the heavier rainfall period. For the lighter rainfall period probabilities ranged from 0.35 (September) to 0.78 (October) and 0.58 (November). Throughout the rest of this report the period March through May will be referred to as the long rains, while September through October will be referred to as the short rains (see also Billé, 1983; Cossins and Upton, 1988a).

Numbers of rainy days for the long and short rains on a decade (10-day) basis are displayed in Tables A3 and A4, Annex A. These data illustrate some of the short-term, temporal variation in rainfall delivery that can have a bearing on plant growth (G.

Figure 2.4. *Rainfall zones on the Borana Plateau.*



Source: EWWCA (1987) as adapted from Billé (1983).

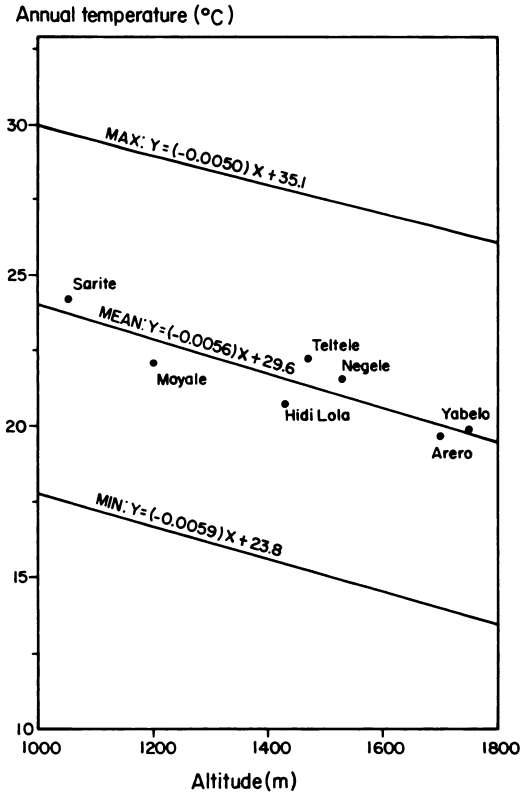
King, University of New South Wales, personal communication). Using drier Wachile and wetter Moyale as extremes, it can be seen from Table A3, Annex A, that the peak rainy month of April is characterised by a fairly even distribution of precipitation throughout the three decades. Wachile averaged 3.4 rainy days out of 10 while Moyale averaged 5.9. March and June were similar in the numbers of rainy days for Wachile (average of 1.6 out of 10) or Moyale (average of 2.4 out of 10) and the increasing and decreasing trends in decade rainfall are apparent (Table A3, Annex A). For the peak rainy month of October during the short rains, Wachile averaged 2.1 rainy days out of 10 while Moyale averaged 3.4 (Table A4, Annex A). September and November were similar for Wachile with an average of 1.3 rainy days out of 10, but Moyale showed 1.5 for September and 3.5 for November.

Air temperature

Compared to rainfall, air temperatures vary much less throughout the year in most of sub-Saharan Africa. Temperature thus plays a more minor role in defining seasonality in Africa than in temperate environments. The key issue in warmer climates is how temperature modifies effectiveness of rainfall by influencing evaporation. This in turn affects plant production and the distribution of plant species. Temperature also imposes limitations on whether introduced exotic plants can become established (Skerman, 1977).

The seasonal homogeneity of air temperature on the Borana Plateau is illustrated in Table A5, Annex A. At Sarite ranch (the warmest site) and Yabelo (the coolest site), day-time maxima varied by only 4 to 5°C all year, while night-time minima varied by <2°C. Simple linear regressions relating maximum, mean and minimum temperatures with elevation across seven sites are shown in Figure 2.5. All relationships were significant (N=6; r^2=0.52; P≤0.05) and indicated that temperatures decreased on the order of 1°C with each 200-m increase in elevation.

Figure 2.5. *Linear regression analysis of annual air temperatures as a function of altitude for seven sites in the southern rangelands.*



Seasonality, forage production and carrying capacity in an average rainfall year

Plant growing seasons for a selection of sites are depicted in Figure 2.6 (a-d). These diagrams were produced under assumptions for soil water balance (see Section 2.3: Methods). Moyale (Figure 2.6b) is merely shown for reference given the higher rainfall there. Others, however, illustrate, that compared to higher and wetter sites (i.e. Negele and Arero), sites at lower and drier elevations (such as Sarite) have a shorter growing period during the long rains and only a nominal growing period during the short rains. Sites such as Sarite could thus have more of a unimodal rainfall pattern which could yield regional variation in net primary production (NPP) and plant species composition. To be most accurate, water-balance models should incorporate estimates of potential evapotranspiration (PET), but there are insufficient field data from the Borana Plateau to make these calculations. The reader is referred to FAO (1984) and EWWCA (1987: p 63) for some estimates of PET for other regions in southern Ethiopia.

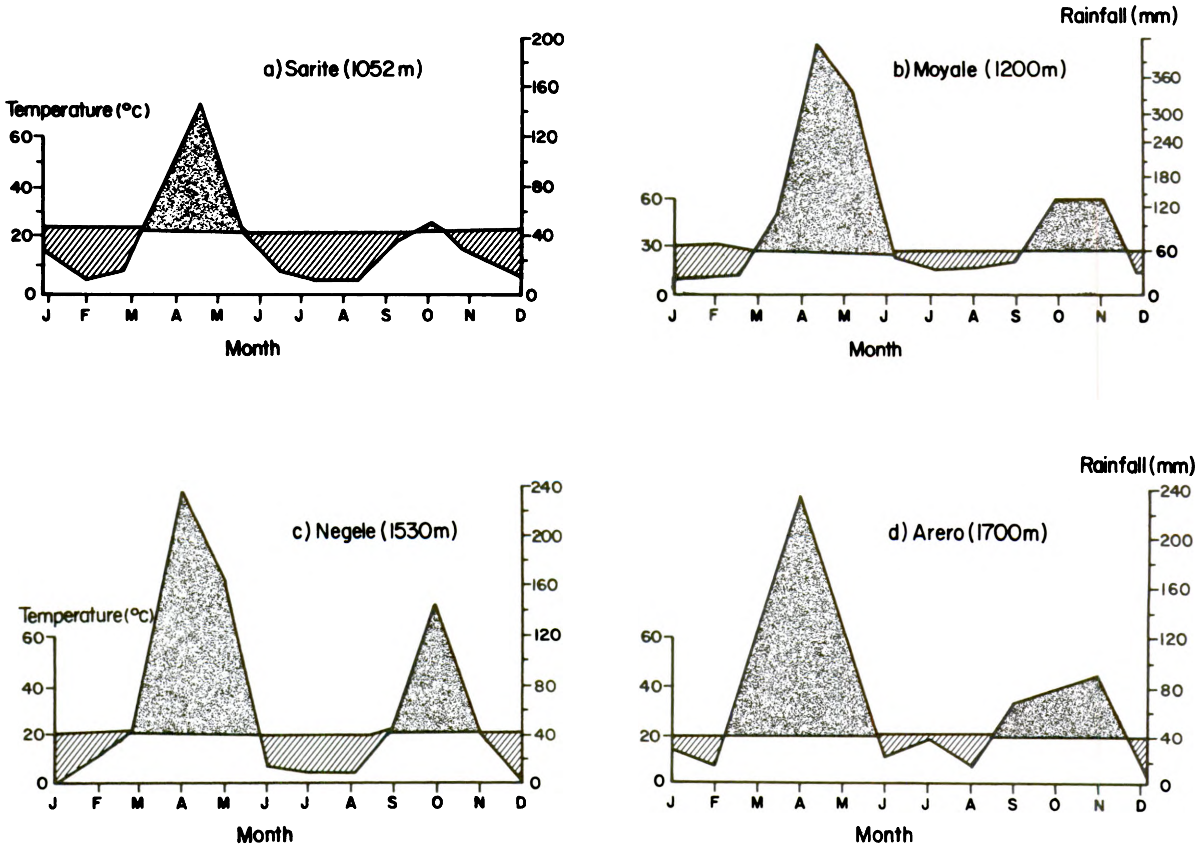
Results from the LGP model used in Cossins and Upton (1988a) are shown in Table 2.1. There was a range of 65 to 95 growing days for the long rains and 46 to 67 growing days for the short rains during average rainfall years. The total annual growing period ranged from about 3.8 to 5.0 months. These estimates may be conservative because the authors assumed that there was a carry over of zero soil-moisture storage and rainfall alone contributed the moisture for plant growth at any given time (Cossins and Upton, 1988a: p 121).

Figure 2.7 depicts regional patterns of numbers of plant growing days and NPP in an average rainfall year from Cossins and Upton (1988a). This analysis indicates that because the northern zone has from 27 to 47% more growing days than other zones, annual forage production in the northern zone is 12 to 25% higher. In the northern zone around 2.7 t of dry matter (DM)/ha/year may be produced as a result of 140 growing days. In the other zones this ranges from: (1) 1.5 t DM/ha/year from 102 growing days (west); (2) 2.0 t DM/ha/year from 125 growing days (central); and (3) 1.9 t DM/ha/year from 110 growing days (east).

Cossins and Upton (1987: p 202) reported stocking rates of livestock in the four zones throughout the study area in the "average" rainfall year of 1982 to 1983 (see Figure 2.7). In the wet season cattle stocking rates varied from about 13 to 23 head/km^2 in the western and eastern zones, respectively, with an overall density of about 20 head/km^2. For small ruminants, figures ranged from 7 to 17 head/km^2 in the western and central zones, respectively. The overall density for small ruminants was about 8 head/km^2. For the 15 475 km^2 study area this translates to 309 000 cattle and 124 000 small ruminants or a combined total of 17 Tropical Livestock Units (i.e. 250-kg equivalents/km^2). In the dry season the overall mean for cattle decreased by 20% to 16 head/km^2 and thus 248 000 head for the study area overall. The total density of TLUs for the dry season was around 14 TLU/km^2 while the weighted average density for the year was about 16 TLU/km^2.

Pratt and Gwynne (1977: p 112) estimated that the "safe" carrying capacity for 600, 500 and 400 mm of annual rainfall in East Africa was 6, 7 and 11 ha/TLU/year, respectively. These are densities at which livestock productivity/head is not compromised and vegetation is not appreciably altered by grazing. Conservatively assuming an average of 500 mm of annual rainfall for the study area overall,

Figure 2.6 (a–d). *Climate diagrams for four sites.*



Source: Michel Corra (ILCA, unpublished data).

the "safe" carrying capacity is 14 TLU/km^2. This suggests that for the central plateau overall, the livestock population was stocked at or near carrying capacity in 1982 to 1983. The livestock population was probably at this level again by 1988 following the decimating effects of the 1983 to 1984 drought (Solomon Desta, nd; see also Chapter 6: *Effects of drought and traditional tactics for drought mitigation,* and Section 7.2: *A theory of local system dynamics).*

Dry and drought years and their effects on net primary production and carrying capacity

In the LGP analysis of Cossins and Upton (1988a), a dry year and a drought (or very dry) year were defined as years in which the LGP is less than 75% or 50% of the long-term mean, respectively. Given their assumptions about annual rainfall distribution (see Section 2.3: Methods), they concluded that a dry year occurs once in five years and a drought

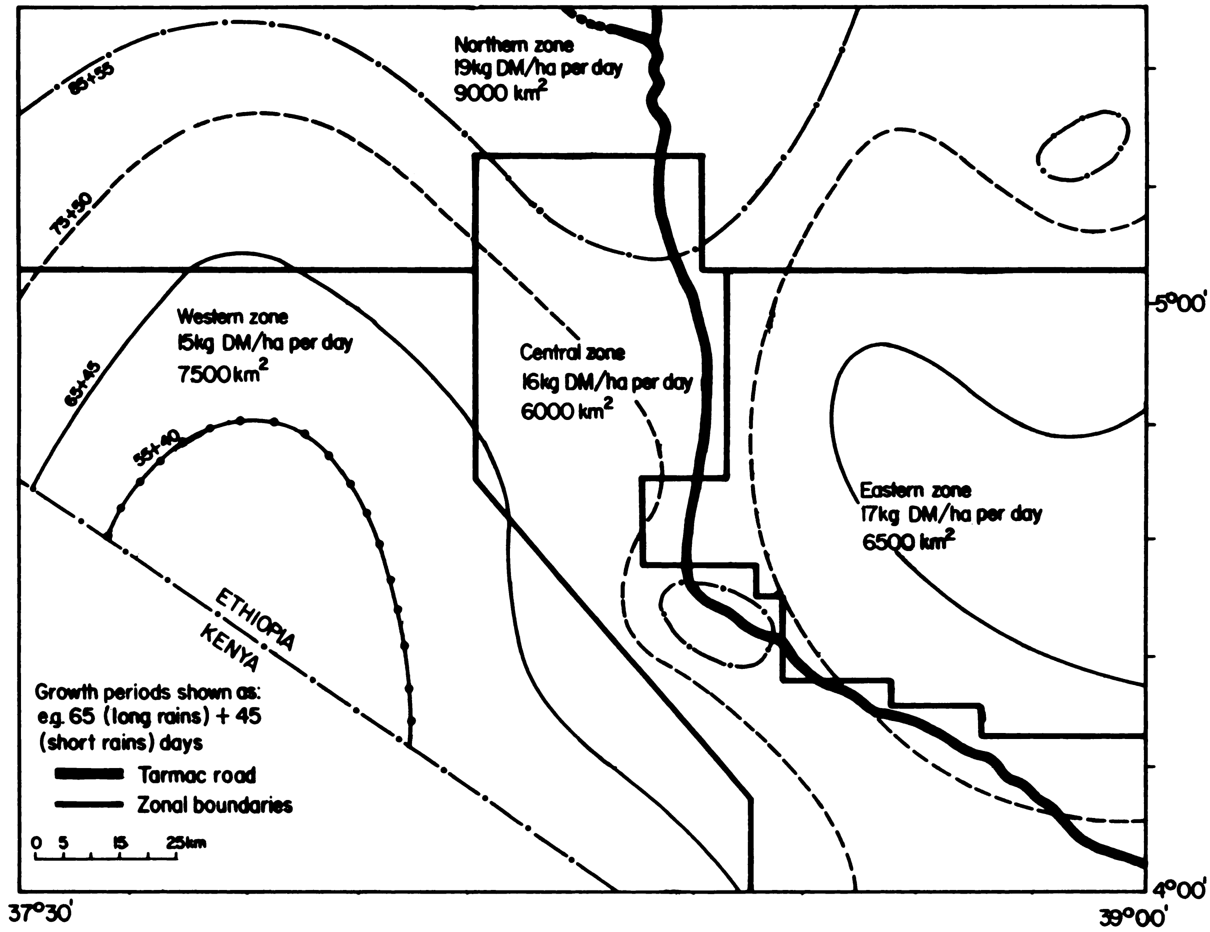
Table 2.1. *Estimated mean lengths of growing period (LGP) at five sites in the SORDU sub-project area*[1].

Site	Number of years recorded	Long rains (days)	Coefficient of variation (%)	Short rains (days)	Coefficient of variation (%)	Total (days)	Coefficient of variation (%)
Negele	29	84	25	67	26	151	19
Yabelo	6	95	26	51	66	146	33
Mega	3	87	31	52	19	139	25
Moyale	5	65	40	49	69	114	50
Did Hara	5	70	47	46	83	116	59

1 See text for methodological details.

Source: Cossins and Upton (1988a).

Figure 2.7. ***Regional variation in annual growing periods and zonal categorisation on the Borana Plateau.***



Source: Cossins and Upton (1987).

year once in 20. It was noted that this proposed frequency agreed with estimates for northern Kenya from the historical record as analysed by Hogg (1980).

Cossins and Upton (1988a: pp 121–122) calculated how NPP could change in dry and drought years as a result of variation in LGP. Given the assumption that LGP and NPP are directly correlated, they estimated that for the study area overall, NPP would drop by 25 to 50% in dry and drought years, respectively. The relative effect may vary somewhat among zones, however, with the north affected less because of its more favourable position in the higher rainfall belts of the southern highlands (see Section 1.3: Climate and zonation of the lowlands). Many cattle were reportedly moved to the north of the study area from other zones during the 1983–84 drought (see Section 6.3.1.1: *Livestock dispersal and herd composition*).

It thus may be anticipated that the carrying capacity for livestock would similarly decline by 25 to 50% in dry and very dry years to 10 and 7 TLU/km², respectively. There is evidence to support such dramatic declines in carrying capacity from the 1983 to 1984 drought (see Section 6.2.1: *Effects of drought in the lower semi-arid zone*). While the utility of the carrying capacity concept has been recently challenged (Ellis and Swift, 1988; de Leeuw and Tothill, 1990; Bartels et al, 1990), observations here indicate that carrying capacity is a relevant concept for interpreting system dynamics (see Section 7.2: *A theory of local system dynamics*, and Chapter 8: *Synthesis and conclusions*).

It is important to note that the designation of drought as a one-year event is inconsistent with other analyses (e.g. Donaldson, 1986) which describe droughts on the Borana Plateau as multiple-year phenomena (see Section 6.1: *Introduction*). Although a 25 to 50% reduction in NPP is a substantial shock to the system in any given year, the vast majority of cattle mortalities and risk of human famine usually occurs in the second of consecutive dry years. Thus, the definition of drought used henceforth in this report is when two or more consecutive dry years occur in which the LGP is less than 75% of the mean.

A dry year is primarily indicated to the pastoralists by a substantial failure of the long rains. Two consecutive failures of the long rains mean a serious drought situation (see Section 6.1: *Introduction*). From the rainfall analysis of Cossins and Upton (1988a), it can be calculated that the probability of any two consecutive years having near or above-average rainfall is 0.64. The probability of two consecutive years being a combination of an average and a dry year is 0.32. The probability of a two-year drought is 0.04.

Dry years and drought obviously have major implications for animal production and human welfare (see Chapter 6: *Effects of drought and traditional tactics for drought mitigation*). Cossins and Upton (1988a) defined dry years and drought solely on the basis of metereological phenomena. In Section 7.2 (*A theory of local system dynamics*) it is argued that higher populations of cattle and people today have increased the vulnerability of the production system to what could otherwise be inconsequential fluctuations in rainfall. This perspective considers that both rainfall deficiency and population density interact to exacerbate the negative effects on the production system.

2.4.1.5 Native vegetation

Plant life histories and savannah ecology

Plant communities on the flat and hilly plains of the central Borana Plateau consist of diverse mixtures of woody and herbaceous vegetation. The dominant community type may thus be characterised as tropical savannah (Plate 2.1); Pratt and Gwynne, 1977). Savannah systems are known for variation in their proportion of woody and herbaceous material as well as the marked shifts in composition that occur in response to heavy grazing, browsing, burning and drought, either alone or in various combinations (Norton-Griffiths, 1979; Walker and Noy-Meir, 1982). In some cases grazing shifts the community toward more trees while browsing and fire favour grass. Much attention has been oriented towards studying the equilibrium behaviour of savannahs; i.e. understanding to what extent savannahs can be altered or degraded beyond recovery to a previous condition (Walker and Noy-Meir, 1982).

Perennial woody plants contribute from 5 to 75% of total plant cover on the central Borana Plateau depending on location. Their recent dominance in many plant communities has been hypothesised to be related to heavy cattle grazing and/or the absence of burning (see Section 3.4.2: *Environmental change*). Woody plants can have either positive, negative or no effect on the livestock system. It has been observed, for example, that some woody plants are important as sources of forage, cover, fuel and other uses for the pastoral household economy. It has also been hypothesised that woody plants contribute nutrients to soils of overgrazed sites from their annual leaf fall. Some of the negative attributes may include limiting access to herbaceous forage by cattle and reducing growth of herbaceous vegetation in the understorey through competition for light and moisture. These issues are reviewed in Sections 3.3.5.2: *Household use of plants and pastoral perceptions of range trend* and 3.4.2: *Environmental change*.

Importantly, the dominant herbaceous plants in the southern rangelands are perennial, rather than annual, grasses. The persistence of perennials is favoured here because of the relatively high rainfall and its bimodal delivery. Pratt and Gwynne (1977) contend that perennial grasses are more likely to occur in East African rangelands when annual rainfall exceeds 250 mm.

Some of the important features of perennial grasses for African livestock systems have been reviewed by Ukkerman (1991). He contends that the

Plate 2.1. *Perennial savannah communities in the southern rangelands vary from open grasslands to bush-encroached areas.*

Photograph: Shewangizaw Bekele

productivity of perennials is usually considerably higher than that of annuals, but that some of this advantage is offset because a larger portion of the biomass of perennials is lower in nutritive value than annuals. The importance of perennials for livestock is that they are always ready to green up and grow in response to even small quantities of rainfall. Annuals require more rain over certain periods than perennials because soil moisture has to be high enough for annuals to germinate and successfully complete their life cycles (Harper, 1977). Perennials are thus a more reliable source of green forage at critical times of the year. These include the beginning and end of wet seasons and after brief showers in dry seasons (Ukkerman, 1991).

Perennials are thus an important source of forage stability. Besides their quick greening up, this stability is conferred also by the internal circulation of nutrients within the plant, which allows smaller losses of nutrients in leaves from fire, weathering and grazing compared to annuals (Ukkerman, 1991). The permanent rooting system of perennials also better protects soil against erosion (Ukkerman, 1991).

Perennials are preferred by livestock and are often sensitive to heavy grazing. This is because frequent grazing elicits regrowth which can exhaust root stores of nitrogen and carbon. Grazing also trims off above-ground growing points (see Ukkerman, 1991).

Annuals are more tolerant of heavy grazing, but also risky and unstable. This is again because the production of annuals depends on receiving a certain threshold of moisture before any growth occurs. Annuals, in theory, could only be eliminated by grazing if the pressure is high enough to defoliate plants each year before they set seed and replenish the seed bank. Given that annual grasses may set seed within a month after the first rains (Coppock, 1985), it is unlikely that this degree of grazing pressure could be maintained over a large region. A discussion of the role of perennial and annual grasses in conferring varying degrees of population stability in African pastoral systems is presented in Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics.* A hypothesis for episodic overgrazing of the perennial grasses of the southern rangelands, with implications for range management and monitoring, is presented in Section 7.2: *A theory of local system dynamics.*

Seasonality and forage nutritive values

For mature cattle to achieve a sustaining level of energy intake, dietary crude protein (CP; i.e. per cent nitrogen x 6.25) concentration of about 7% (on a dry-matter basis) is considered the minimum for a positive nitrogen balance (ARC, 1980). This threshold can increase for small ruminants, growing cattle and lactating cows, but 7% CP still serves as a useful guideline. Similarly, a suitable minimum digestibility of dry matter is commonly assumed to be on the order of 50% (Coppock et al, 1986b).

The seasonal rainfall patterns in African rangelands are well known for bringing about fluctuations in forage CP content and digestibility (Pratt and Gwynne, 1977; Coppock et al, 1987a). Wet seasons are often characterised by dramatic increases in CP content and digestibility from new growth of forage; CP content can often rise to two to three times maintenance requirements. During dry seasons CP content and digestibility may decline to levels below maintenance. Livestock thus store protein and energy in wet periods and then may lose both in dry periods. Whether or not cattle survive a dry season is also related to the length of time they are on nutritionally deficient diets. Their endurance is related to the amounts of protein and energy they were able to store during the previous wet season.

In a perennial grass system like the southern rangelands, the concentration dynamics of forage nutrients are due to seasonal movements of nitrogen in the plant as well as differences in the degree of construction of cell wall (Coppock et al, 1987a; Ukkerman, 1991). During wet periods when grasses are actively growing, nitrogen is translocated to actively photosynthesising tissues which have lower ratios of carbon to nitrogen. New cell wall is also at a state of reduced lignification. The reverse occurs in dry periods when nutrients are translocated to the roots for storage and cell wall lignifies to a higher degree. Browse forage, in contrast to grass, tends to maintain higher nitrogen contents in leaves and stem apices longer into the dry season (Coppock et al, 1987a). In part, this is because the growing season is longer for many woody plants because their roots provide access to moisture in deeper soil layers (Coppock et al, 1987a). This is not to say, however, that all green browse is suitable forage in dry periods. Some perennially leafy browse species have leathery leaves adapted to minimise water loss and are poor in nutritive value (Coppock, 1985). Getting nitrogen from other types of leaves can also be hindered by tannins which reduce forage palatability and nitrogen retention (Woodward, 1988; Coppock and Reed, 1992).

Grab samples of seven common perennial grasses were collected during five different seasons in the southern rangelands during 1982 to 1983, which was an average rainfall year (ILCA Nutrition Unit, unpublished data). Species included *Cenchrus ciliaris, Chloris mycrostachya, Chrysopogon plumulosus, Cynodon dactylon, Panicum maximum,* *Pennisetum stramineum*, and *Themeda triandra* with an average of four samples/species/season. Some overall seasonal means (*N*=27) are reported here because grab samples are only useful for showing general trends over time. Grab samples do not necessarily reflect material actually selected by livestock and the proportions of these species in cattle diets were also unknown. Average seasonal values ranged from 10% CP during the long rains in April 1982 to 5% CP at the end of the warm dry season in March 1983. From June 1982 through February 1983 values remained relatively steady between 6 and 7% CP on average.

In a study of comparative benefits of hay making using local grasses (reported in Section 7.3.1.3: *Forage improvements*), Mulugeta Assefa (1990) estimated values for CP and *in vitro* digestible dry matter (IVDDM) for grab samples of standing grasses collected during the warm dry season of 1988 to 1989. He reported a mean of 4% CP and 30% IVDDM for these samples. The IVDDM value is exceptionally low for East African range forage. Similar values, however, were found for other grass material collected in the 1989 to 1990 dry season (Coppock, 1993a).

While the results above have some utility, they probably underestimate the quality of the diverse diets selected by animals. Menwyelet Atsedu (1990) conducted a study in which the composition and quality of calf diets were estimated through direct observation of grazing calves during the dry season of 1988 to 1989. Diet profiles were calculated based on the dry-weight contribution observed in bite counts. Forage samples were hand-plucked in an attempt to mimic the calf grazing and chemically analysed to characterise nutritive value. He reported an average of 11.8% CP and 51% IVDDM on a dry-matter basis for 40 grazing trials (Menwyelet Atsedu, 1990: p 47).

Woodward (1988) studied the nutritional dynamics of browse forages selected by goats, camels and sheep in the Beke Pond region near Yabelo during 1985–86. Data for 23 important species are provided in Woodward (1988: pp 166–172), and they illustrate the wide variation in chemical content across species and plant parts as well as some influence of season. Compared to browse stems, browse leaves were typically higher in nitrogen (N) content and lower in neutral detergent fibre (NDF) within a given species regardless of sampling period. Browse provided a relatively stable source of protein to browsing livestock throughout the year when evaluated with respect to the minimum dietary guideline of 7% CP. Averaged over all samples of leaves and stems, mean values for browse ranged from 18.7% CP during the long rains (*N*=19) to 10.0% CP during the cool dry season (*N*=21), 13.8% CP in the short rains (*N*=19) and 13.1% CP in the warm dry season (*N*=20). Standard errors were less than 12% of the means in all cases. The high levels of CP in browse forages over different seasons is a common phenomenon that has been reported elsewhere in East Africa (Pratt and Gwynne, 1977; Coppock et al, 1987a). Interpretation of the feed value of the CP is made complicated, however, by the presence of tannins and *proanthocyanidins* in many forages (Woodward, 1988). These compounds have a variety of effects on nutrition, including reducing forage palatability and the proportion of dietary N assimilated by the animal. The presence of tannins, however, does not always imply that negative effects on nitrogen balance will occur (Coppock and Reed, 1992; see Section 7.3.1.3: *Forage improvements*).

In sum, while the nutritional studies based on grab samples or feeding observations were variously limited in design and scope, they do support the idea that forage nutritive value markedly fluctuates with season and that browse forages probably retain a higher CP content than grasses during dry periods. It is also likely that selective feeding at least that of calves, achieves higher quality diets than that estimated by grab samples. It is important to note that these studies can illuminate only a very small part of the picture of the nutritional ecology of livestock here. Since green forage probably provides more than enough CP concentration for compensatory growth and production of cattle in any given wet season (see Sections 5.3.2: *Calf growth and milk offtake* and 7.3.3.4: *The calf: Prospects for growth acceleration),* the main issue of interest becomes the role of rainfall and stocking rate in regulating the amount of time animals have in wet periods to achieve the body condition needed to reproduce and survive the following dry season. Of considerable importance, then, is whether animals are limited in the quantity of forage they consume during wet seasons and whether such limitations are due to wastage of forage and/or competition among livestock. Evidence will be presented (Section 7.2: *A theory of local system dynamics*) that the simple model of CP limitation for livestock in dry seasons of average rainfall years (Mosi et al, 1976; Coppock et al, 1986b) needs to be significantly altered to include dynamics of livestock population cycles, if key constraints of nutrition on cattle production are to be understood. It is likely that this simple CP model holds in the southern rangelands only for a few years after a drought has ended when cattle density is low. Once the herd has recovered its numbers, chronic deficits of energy may become the prime limiting nutritional factors for cattle production and this is postulated to be due to competition for forage within the cattle population throughout the year, not just in dry seasons (see Section 7.2: *A theory of local system dynamics*).

Flora

The flora of the southern rangelands has been previously described. For a comprehensive species list the reader is referred to AGROTEC/CRG/SEDES Associates (1974d) which has documented scientific names and authorities of some 300 species. Other species list are provided in Corra (1986), Woodward (1988) and Tamene Yigezu (1990). Jenkins et al (1974) lists important forages from the southern rangelands. Nomenclature reported below does not include authorities. Authorities follow those provided in AGROTEC/CRG/SEDES Associates (1974d) and Pratt and Gwynne (1977).

The more common woody genera include *Acacia, Commiphora, Combretum, Cordia, Terminalia, Aspilia, Albizia, Juniperus, Rhus, Boscia, Boswellia, Cadaba, Balanites, Salvadora, Dobera, Pappea, Grewia, Delonix* and *Boswellia* spp. Common herbaceous genera include *Cenchrus, Cynodon, Themeda, Pennisetum, Enteropogon, Bothriochloa, Brachiaria, Sporobolus, Panicum, Chloris, Aristida, Dactyloctenium, Dichrostachys, Leptothrium, Heteropogon* and *Hyparrhenia*.

A number of plant species common to the southern rangelands are recognised as valuable livestock forages (Pratt and Gwynne, 1977: pp 240–264). These primarily include dry, dehiscent fruits of *Acacia tortilis* and leaves of *A. brevispica, Grewia* and *Cadaba* spp. Some of the following are regarded as nutritious all year and at all growth stages (e.g. *Cenchrus ciliaris, Themeda triandra,* and *Chloris roxburghiana)* while others are of greatest value only during rapid growth phases (e.g. *Pennisetum, Cynodon, Dactyloctenium, Enteropogon* and *Leptothrium* spp.

Plant species distributions in relation to environmental variables

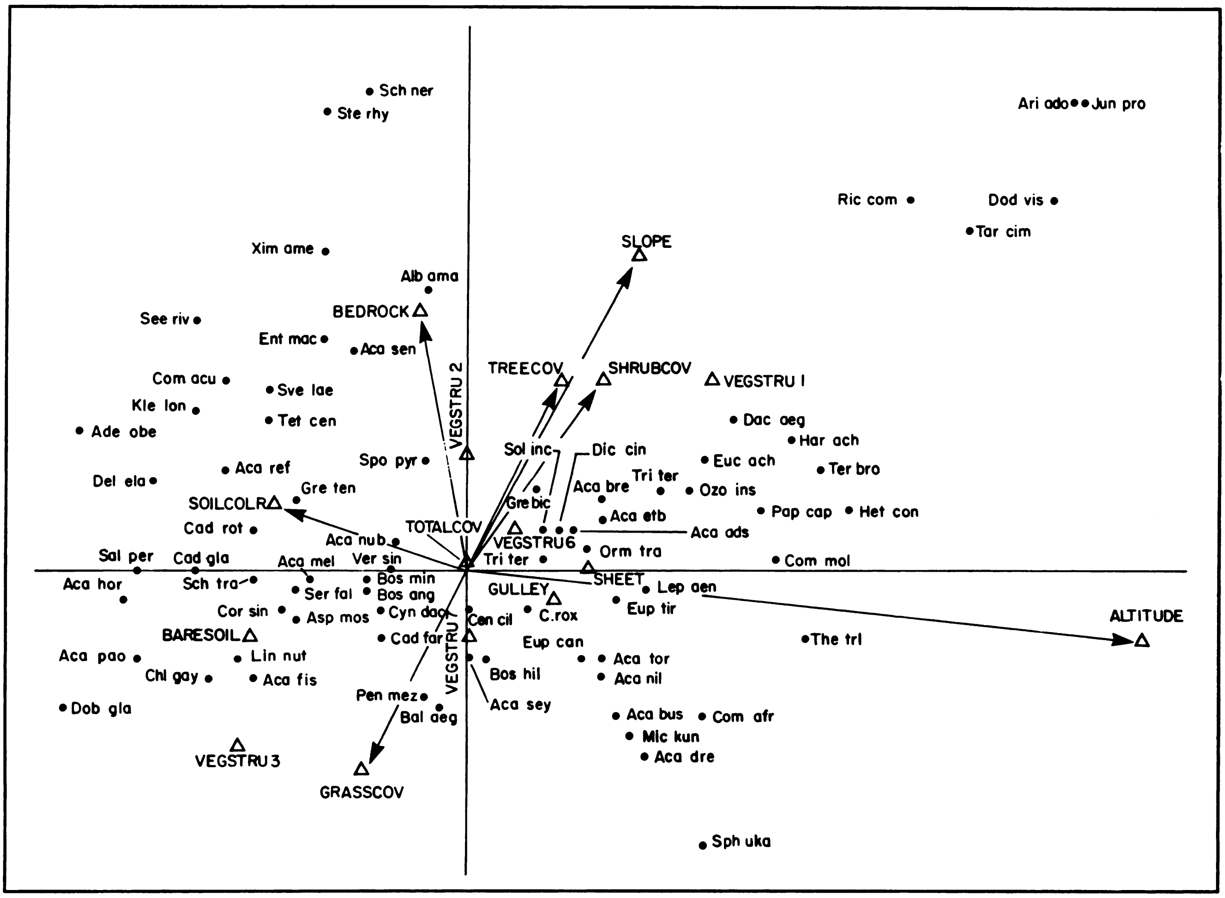
Tables A6 to A10, Annex A, were derived from Corra (1986) and depict the distribution of 55 key plant species according to elevation, soil colour, slope, vegetation type and soil acidity. Species towards the middle of the list in each table tend to be broadly distributed over a given environmental factor while those listed at the top or bottom are more restricted in occurrence. These data can be used to construct crude niches for species that could be useful as guidelines for range rehabilitation and/or further research (see Section 7.3.1: Range management and improvements). For example:

1) *Acacia tortilis,* an important forage tree, has a wide range over all factors investigated;
2) *A. horrida,* an invading woody species in the vicinity of Sarite ranch, tends to be found more on flat terrain at elevations less than 1550 m in bush grassland or bush thicket community types;
3) *Juniperus procera,* an important timber-producer for urban construction, tends to be found in woodlands on reddish soils derived from basement-complex substrates, on steep slopes and at elevations above 1600 m;
4) *Cynodon dactylon* and *Cenchrus ciliaris,* important herbaceous forages, have wide ranges over all factors investigated; and
5) *Themeda triandra,* another important herbaceous forage, tends to occur over 1200 m on a wide range of basement-complex soils and slopes in woodland and grassland formations.

The interaction of environmental features on plant species distribution was clarified by the ordination exercise for 75 species using CANOCO (Figure 2.8). The diagram includes: (1) two main horizontal and vertical axes; (2) seven vectors (arrows) that represent increasing value for continuous environmental variables; (3) discrete (presence/absence) environmental variables whose geometric means are represented in the graph space by triangles only (not by vector arrows); and (4) 75 "average location points" on the graph for each species.

The diagram is interpreted by understanding that: (1) the most influential continuous variables (i.e. vector arrows) on plant species distribution are those arrows which are: (i) closest to running parallel to the horizontal or vertical axes; and (ii) also happen to be greater in length; and (2) species points are located relative to the arrows and isolated triangles that represent discontinuous variables. Another point of clarification concerns how to visualise trend in the diagram. For example: (1) higher altitudes are to the right of the figure and lower altitudes are to the left; (2) slopes become steeper towards the top of the figure and flatter towards the bottom; (3) soil colour changes on a continuum from browns and greys to the left of the figure to reds on the right. If discrete variables (represented by triangles) end up near the intersection of the two main axes, their explanatory value in terms of influencing plant species distributions was interpreted as lower in the analysis. For example, VEGSTRU1 indicates the epicenter of the woodland type, and GULLEY indicates the epicenter of the gully erosion sites. The results are interpreted as follows:

Figure 2.8. *Diagram of the canonical correspondence analysis depicting the occurrence of 75 plant species as affected by 10 environmental factors in the southern rangelands.*



Where continuous variables include: (1) ALTITUDE = elevation in metres, with higher values occurring to the right side of the figure and lower values to the left; (2) BEDROCK, TREECOV, SHRUBCOV, GRASSCOV, TOTALCOV and BARESOIL represent per cent cover for exposed rock, trees, shrubs, herbaceous plants, total vegetation and bareground, respectively. Cover values increase in the direction of the associated vector arrow; (3) SLOPE = slope in degrees from a horizontal plane. Slope also increases in the direction of its vector arrow; (4) SOILCOLR = hue of top soil ranging from browns and greys to the left of the figure to reds on the right. Discrete variables include: (1) presence or absence of SHEET or GULLY erosion and (2) vegetative physiognomic class, where VEGSTRU1 = woodland, VEGSTRU2 = bush-thicket, VEGSTRU3 = grassland, VEGSTRU6 = bushland, and VEGSTRU7 = bush-grassland. Species include Aca bre = *Acacia brevispica*; Aca bus = *A. bussei*; Aca dre = *A. drepanolobium*; Aca etb = *A. etbaica*; Aca fis = *A. seyal v. fistula*; Aca hor = *A. horrida*; Aca mel = *A. mellifera*; Aca nil = *A. nilotica*; Aca nub = *A. nubica*; Aca pao = *A. paollii*; Aca ref = *A. reficiens*; Aca sen = *A. senegal*; Aca sey = *A. seyal* v. *seyal*; Aca tor = *A. tortilis*; Ade obe = *Adineum obesum*; Alb ama = *Albizzia amare*; Ari ado = *Aristida adscensionis*; Asp mos = *Aspilia mossambicensis*; Bal aeg = *Balanites aegyptica*; Bos ang = *Boscia angustifolia*; Bos min = *B. minimifolia*; Bos hil = *Boswelia hildebrandtii*; Cad far = *Cadaba farinosa*; Cad gla = *C. glandulosa*; Cad rot = *C. rotundifolia*; Cen cil = *Cenchrus ciliaris*; Chl gay = Chloris gayana; Chl rox = *C. roxburghiana*; Com acu = *Combretum aculeatum*; Com mol = *C. molle*; Com afr = *Commiphora africana*; Cor sin = *Cordia sinensis*; Cyn dac = *Cynodon dactylon*; Dac oeg = *Dactyloctenium aegyptium*; Del ela = *Delonix elata*; Dic cin = *Dicrostachys cinerea*; Dob gla = *Dobera glabra*; Dod vis = *Dodonia viscosa*; Ent mac = *Enteropogon macrostachyus*; Euc ach = *Euclea* sp; Eup can = *Euphorbia candelabrum*; Eup tir = *E. tirucalli*; Gre bic = *Grewia bicolor*, Gre tem = *G. tembensis*; Har ach = *Harpachne* sp; Het con = *Heteropogon contortus*; Jun pro = *Juniperus procera*; Kle lon = *Klenia longiflora*; Lep aen = *Leptothrium senegalense*; Lin nut = *Lintonia nutans*; Mic kun = *Microchloa kuntii*; Orm tra = *Ormocarpum trachycarpum*; Ozo ins = *Ozoroa insegnis*; Pap cap = *Pappea capensis*; Pen mez = *Pennisetum mezianum*; Ric com = *Ricothamnus* sp; Sal per = *Salvadora persica*; Sch ner = *Schoenefeldia* sp; Sch tra = *Schoenefeldia transiens*; See riv = *Sesamothamnus rivae*; Ser fal = *Sericocomopsis pallida*; Sol inc = *Solanum incanum*; Sph uka = *Sphaeralcea* sp; Spo pyr = *Sporobolus pyramidalis*; Ste rhy = *Sterculia rhynchocarfa*; Sve lae = *Svensonia laeta*; Tar cim = *Tarcothamnus cinerea*; Ter bro = *Terminalia brownii*; Tet cen = *Tetrapogon cenchroides*; The tri = *Themeda triandra*; Tri ter = *Tribulus terrestris*; Ver sin = *Vernonia cinerascens*; and Xim ame = *Ximenia americana*. Species were selected because they illustrated variability in response to environmental factors.

Source: Michel Corra (ILCA, unpublished data).

1) because their vectors were closest to the horizontal and vertical axes, altitude and percentage of exposed bedrock were the main explanatory variables for plant species distributions overall. Together, altitude and per cent exposed bedrock explained 82% of the total

variation with about 60% explained by altitude alone (note that this is also indicated by the greater length of the altitude arrow);

2) bedrock exposure, however, was also related to several other factors. As per cent bedrock exposure increased, so did slope and per cent tree and shrub cover (Figure 2.8). These conditions are all consistent with ascending a mountain, for example. Similarly, as per cent bedrock decreased per cent grass cover increased, consistent with lowland sites. The vector for soil colour ran opposite that for altitude, indicating that as altitude decreased sites were dominated by more brown and grey soils. Soil colour, however, had relatively little influence in the analysis overall as indicated by the angle and short length of its vector arrow; and
3) overall, the distribution of species points is perhaps most notable because of the relative lack of distinct clustering. This suggests that over the range of environmental variables examined, most species appeared to be widespread in distribution. However, some key indicator species emerged and these help in interpreting the diagram: (1) *J. procera* appears in the upper right-hand corner with *Aristida adscensionis*, and this suggests an association of these species at high altitudes, on steep slopes and in concert with other associated factors previously described; (2) *T. triandra* (in the lower right quadrant) occurs at a somewhat lower elevation and flatter slopes on redder soils; and (3) *A. horrida* (near the top of the lower left quadrant) occurs on flatter slopes on brown/grey soils at lower elevations.

In sum, the main point is that altitude (and the corresponding factors of rainfall and temperature) is strongly related to other variables including exposure of bedrock, type of plant cover, soil colour and soil reactivity as the main explanatory factor overall for plant species distributions. The majority of plant species were notable, however, for their wide distribution in the study area. Because of this it was decided not to define specific plant communities or associations from the CANOCO analysis (Michel Corra, ILCA, personal communication).

2.4.1.6 Native fauna

To date there have not been any comprehensive studies of wildlife in the southern rangelands. Including wildlife issues into a comprehensive development and management strategy is desirable, however, and that is why wildlife resources are briefly reviewed here.

The only systematic wildlife data collected by ILCA on the Borana Plateau are a few tabulations of ostriches (Struthio camelus) and large herbivorous mammals from aerial surveys in 1983 to 1985 (Assefa Eshete et al, 1987). Other efforts to inventory wildife or regulate its exploitation in the study area have been limited, being conducted out of a small government office in Yabelo.

Wildlife interests are represented at higher levels on interdepartmental committees within the Ministry of Agriculture when key policy issues regarding local resource management come under review. One example is the re-introduction of prescribed fire in the southern rangelands to help control bush encroachment, a proposed policy change reviewed in 1990–1991 (see Section 7.3.1.4: Site reclamation). There has been a recent and increasing interest in conducting formal surveys and studies to quantify wildlife resources in the southern rangelands as well as to better understand interactions among wildlife, livestock and pastoralists. Such work has been proposed to help form the basis for establishing a controlled system of nature preserves and would be a collaborative effort between Ethiopian and foreign institutions (C. Hillman et al, Ethiopian Wildlife Conservation Organisation, personal communication).

The large mammalian and avian species in the study area are generally those which thrive under conditions of restricted availability of drinking water. Most of the species are thus common elsewhere in arid and semi-arid East Africa. Some key species reported here were observed by ILCA staff in the study area during 1985–1990, usually from sightings of live animals or examination of road mortalities. What follows is not intended as a comprehensive listing. Common and Latin names given here follow Haltenorth and Diller (1977) and Williams and Arlott (1980):

1) predatory and/or scavenging mammals include: lion (*Panthera leo*), cheetah (*Acinonyx jubatus*), caracal (*Caracal caracal*), serval (*Leptailurus serval*), spotted hyena (*Crocuta crocuta*), striped hyena (*Hyaena hyaena*), aardwolf (*Proteles cristatus*), black-backed jackal (*Canis mesomelas*), bat-eared fox (*Otocyon megalotis*), civet (*Viverra civetta*) and Egyptian mongoose (*Herpestes ichneumon*). Black colour phases for the serval, and possibly for caracal, have also been observed. Lions and spotted hyenas constitute the main predatory threat to livestock;
2) herbivorous mammals include: warthog (*Phacochoerus aethiopicus*), North African crested porcupine (*Hystrix cristata*), Grevy's zebra (*Hippotigris grevyi*), Burchell's zebra (*H. quagga*), gerenuk (*Litocranius walleri*), gazelle (*Gazella* spp), oryx (*Oryx gazella*), lesser kudu

(*Tragelaphus imberbis*), bushbuck (*T. scriptus*), Gunther's dik-dik (*Madoqua guentheri*), giraffe (*Giraffa camelopardalis*) and Cape hare (*Lepus capensis*). Swayne's hartebeest (*Alcelaphus buselaphus Swaynei*), considered a threatened subspecies in Ethiopia, was never seen by ILCA staff but a small number reportedly occur to the north near Yabelo (Haltenorth and Diller, 1977: p 83; C. Hillman, Ethiopian Wildlife Conservation Organisation, personal communication). The large herbivores have only been observed as individuals or in small groups. There are no large herds *per se* that could conflict with pastoral land use today. Except for occasional feeding on cultivated legume plots by kudu (Hodgson, 1990) or raids by warthogs on maize fields (D. L. Coppock, ILCA, personal observation), it can be said that the large herbivores pose no constraint to the livelihood of the pastoralists. This is unlike situations for the pastoral Maasai where wildlife can be a major competitive factor for forage and habitat (Pratt and Gwynne, 1977);

3) primates include the olive baboon (*Papio cynocephalus*) and vervet monkey (*Cercopithecus aethiops*). Baboons, as elsewhere in Africa, are a threat to maize fields;
4) predatory and/or scavenging birds include: Secretary bird (*Sagittarius serpentarius*), white-headed vulture (*Trigonoceps occipitalis*), hooded vulture (*Necrosyrtes monachus*), Egyptian vulture (*Neophron percnopterus*), bateleur (*Terathopius ecaudatus*), pale chanting goshawk (*Melierax poliopterus*), tawny eagle (*Aquila rapax*), black kite (*Milvus migrans*) and black-shouldered kite (*Elanus caeruleus*);
5) other birds include: ostrich (*Stwthio camelus*), crested francolin (*Francolinus sephaena*), yellow-necked spurfowl (*F. leucoscepus*), helmeted and vulturine guinea fowl (*Numida meleagris* and *Acryllium vulturinum*, respectively), kori bustard (*Ardeotis kori*), white- and black-bellied bustards (*Eupodotis senegalensis* and *E. melanogaster*, respectively), crowned plover (*Vanellus coronatus*), ring-necked dove (*Streptopelia capicola*), namaqua dove (*Oena capensis*), orange-bellied parrot (*Poicephalus rufiventris*), white-bellied go-away-bird (*Corythaixoides personata*), nightjars (*Caprimulgus* sp), Abyssinian roller (*Coracias abyssinica*), African hoopoe (*Upupa epops africana*), red and yellow-billed hornbills (*Tockus erythrorhynchus* and *T. flavirostris*), Von Der Decken's hornbill (*T. deckeni*), D'Arnaud's barbet (*Trachyphonus darnaudii*), rosy-patched shrike (*Rhodophoneus cruentus*), honeyguides (*Indicator* sp), taita fiscal (*Lanius dorsalis*), grey wren warbler (*Camaroptera simplex*), grey tit (*Parus afer*), golden-breasted bunting (*Emberiza flaviventris*), paradise whydah (*Steganura paradisaea*), Speke's weaver (*Ploceus spekei*), red-billed buffalo weaver (*Bubalornis niger*), white-headed buffalo weaver (*Dinemellia dinemelli*), grey-headed social weaver (*Pseudonigrita arnaudi*), black-capped social weaver (*P. cabanisi*), white-crowned starling (*Spreo albicapillus*), superb starling (*S. superbus*), golden-breasted starling (*Cosmopsarus regius*), red-billed oxpecker (*Buphagus erythorhynchus*), black-headed oriole (*Oriolus larvatus*), dwarf raven (*Corvus edithae*) and the Abyssinian bush crow (*Zavattariornis stresemanni*). The last species is the only one endemic to the study area (Williams and Arlott, 1980: p 399);
6) common reptiles include a variety of non-venomous and venomous [cobras (*Naja* spp), black mamba (*Dendroaspis angusticeps*), puff adder (*Bitis arietans*)] snakes. Some of the poisonous snakes are responsible for a few livestock mortalities (Donaldson, 1986: p 40). Other reptiles include lizards (*Agama* sp) and leopard tortoises (*Geochelone* spp); and
7) termites (unknown spp) are widespread on both red and grey soils. They are mentioned here because they reportedly play important roles in nutrient processing and cycling in African savannahs (Morris et al, 1982). Termites are also an important constraint to several development activities such as grain storage and hay making among Borana pastoralists (Hodgson, 1990; see Section 7.3.1.3: *Forage improvements*). Bruchid beetles (*Callosobruchus* spp) are important parasites on acacia seeds (Tamene Yigezu, 1990; Menwyelet Atsedu, 1990). They probably have a role in the population regulation of trees (see Section 3.3.4: *Population ecology of woody species*) and their infestation of *A. tortilis* fruits constrains storage of these materials for use as protein supplements for livestock in dry periods (see Section 7.3.1.3: *Forage improvements*). Tick species are numerous (Hill, 1982; Nicholson, 1985) and constitute major threats to animal health and milk production (see Section 5.4.3: *Cattle mortality and health*). Tsetse flies (*Glossina* spp) occur in woody habitats along the Dawa River (Figure 2.2) and are known to spread trypanosomiasis among camels which browse along the Dawa in dry periods (Sileshi Zewdie, SORDU veterinarian, personal communication). Tsetse flies also occur along the Segen River near the border with Gamu Gofa. Boran in the Teltele area graze cattle along this river during dry periods (Menwyelet Atsedu, Colorado State University, personal communication).

The study area thus has a rich fauna, but the status of key populations is unclear. It seems reasonable to speculate, however, that the larger mammalian herbivores and carnivores are under chronic pressure from the pastoralists given the high densities of people and livestock in the region (see Section 7.2: *A theory of local system dynamics*). It has also been reported that a large decrease in the local wildlife populations occurred as a result of the conflict between Ethiopia and Somalia in the late 1970s. Larger herding mammals were driven to northern Kenya and apparently never returned (Menwyelet Atsedu, Colorado State University, personal communication). ILCA staff commonly observed the larger wildlife species on the government ranches at Dembel Wachu and Sarite, which appeared to provide superior forage biomass and cover. The ranches were typically understocked with SORDU cattle and excluded pastoral herds (D. L. Coppock, ILCA, personal observation; see Section 3.4.2: *Environmental change*). These ranches are in the process of being returned to the pastoralists (see Section 1.4.5.5: *Ranch development*) and this may bode ill for wildlife. Making proposed nature preserves compatible with the realities of intense livestock exploitation is a key priority in integrated resource management and requires surveys of possible refuge areas where the pastoralists have been less able to herd their stock because of lack of surface water. These include the steep mountainous sites throughout the study area. Getting local people involved in sharing the benefits of wildlife conservation may represent the most viable strategy over the long term (Pratt and Gwynne, 1977).

Long-time residents of the southern rangelands do report that species such as giraffe appear much less abundant today than a generation ago (Tafesse Mesfin, TLDP General Manager, personal communication). It is reasonable to hypothesise that pressure on species such as giraffe has come from traditional use of their hides to make buckets for lifting water from the deep wells and collecting milk (see Sections 2.4.1.7: *Water resources* and 4.3.5: *Dairy processing and marketing*). Other species like zebra may be desired for products traditionally perceived to have medicinal value (D. L. Coppock, ILCA, personal observation).

Despite the fact that the Borana pastoralists are heavily armed, there has never been any indication in 10 years of household surveys (see Section 4.3.1: *General household structure and economy in average rainfall years* and Section 6.3: *Results*) that wildlife products are routine or significant components of the pastoral household economy. The people have never been observed to eat wild mammals, game birds or eggs, although this may occur to some degree in the poorest households during difficult times. It is thus speculated that competition for habitat would be the prime factor underlying most of the interactions among pastoralists and wildlife here, as postulated for other pastoral systems in East Africa (Pratt and Gwynne, 1977: p 222). Hunting *per se* may only be an important factor for a few key species. For example, lions occasionally prey on pastoral stock in the study area, and groups of men attempt to hurt them (D. L. Coppock, ILCA, personal observation). Certain regions are also recognised as more favourable for lions for their increased bush cover (see Section 3.3.1: *Ecological map and land use*).

The Boran reportedly have a conservation ethos for flora and fauna that is highly developed (Kassam and Gemetchu Megerssa, 1990). Aspects of this will be reported in Chapter 8: *Synthesis and conclusions*.

2.4.1.7 Water resources

The water resource on the central plateau is perhaps the most fundamental feature that has shaped Borana society (Helland, 1980b; Cossins and Upton, 1987; Bassi, 1990). The deep wells in particular are a focal point for social organisation and ritual (Helland, 1980b). Surface water has traditionally been scarce in the southern rangelands, and during the past 16 years TLDP has espoused a conservative policy of water development in order to avoid problems of social disruption and range degradation observed elsewhere in Africa as a result of uncontrolled water development (Girma Bisrat, PADEP Coordinator, personal communication). This policy has been maintained in the face of local pressure and official influence to develop water access in the form of boreholes (AGROTEC/CRG/SEDES Associates, 1974i; EWWCA, 1987).

This section describes the major water resources traditionally used by Borana pastoralists. Activities to develop water resources by governmental and non-governmental organisations are described in Section 7.3.1.1: *Water development activities*.

Water resources in the study area are dominated by the deep wells which are not found elsewhere in SORDU. The study area is thus not representative of the southern rangelands as a whole in terms of water. In over 70% of SORDU (particularly to the east, far north, south and west of the study area), water for livestock and people traditionally has been procured from ephemeral ponds, perennial springs, the perennial Dawa River, a very few seasonal streams and shallow temporary wells dug in stream beds during dry periods. The ethnic groups in these areas include Somali, Garri, Gabra, Burgi, Konso and others (AGROTEC/CRG/SEDES Associates, 1974e; 1974f; 1974g) who reportedly prefer to move animals to distant water sources in dry periods rather than invest a large effort in digging permanent wells (AGROTEC/CRG/SEDES Associates, 1974i: p 72).

The Boran mostly use ponds in rainy periods and wells in dry periods to supply water for people and animals. These sources have different costs and benefits. The ponds are easily accessed but are available for only a short period of time. The wells are usually a permanent source of water, but require a large input of labour to lift water to the surface. Social rights of access vary with seasonal and perennial water sources (Helland, 1980b) and these are highlighted below.

The wells: Associated resources and social institutions

In a comprehensive survey by AGROTEC/CRG/SEDES Associates (1974i), the southern rangelands were demarcated into two large regions with differing water-bearing properties: (1) a basement-complex formation dominant to the west with more favourable water storage characteristics; and (2) a stratigraphic sequence to the east. The survey also reported that there was a total of 543 hand-dug wells which occurred to the west, clustered in some 35 to 40 groups broadly classified as either crater, shallow (*adadi*), or deep (*tula*) wells (Helland, 1980b; Cossins, 1983c; Donaldson, 1983; Cossins and Upton, 1987). AGROTEC/CRG/ SEDES Associates (1974i) estimated that all hand-dug wells represented 96% of the permanent traditional water points on the central plateau. Wells were mapped, and measures of well depth, water discharge and water quality (physical and chemical factors) reported in AGROTEC/CRG/SEDES Associates (1974i; 1974j). The extractable water volume from all traditional sources of permanent water (wells and springs) was calculated to be about 13 800 m^3/day during the dry season of 1972 to 1973, with the hand-dug wells providing 84% of this total. Wells located on alluvial substrates were estimated to yield 54% of the total well water, followed by 31% from those on basement-complex formations 9% from those on sedimentary formations and 6% from those on volcanics. The wells were estimated to provide about half of the annual water requirement for people and stock, with ephemeral ponds providing most of the remainder. Many of the largest and most reliable wells have been dug in the highly fractured Precambrian (gypsum and granite) rocks that offer numerous large and discrete aquifers. One conclusion of the work on water quality was that, while water from all wells was uniformly drinkable, the quality was generally regarded to be highest from wells on volcanic substrates (AGROTEC/CRG/SEDES Associates, 1974i: pp 73–74); Nicholson, 1984).

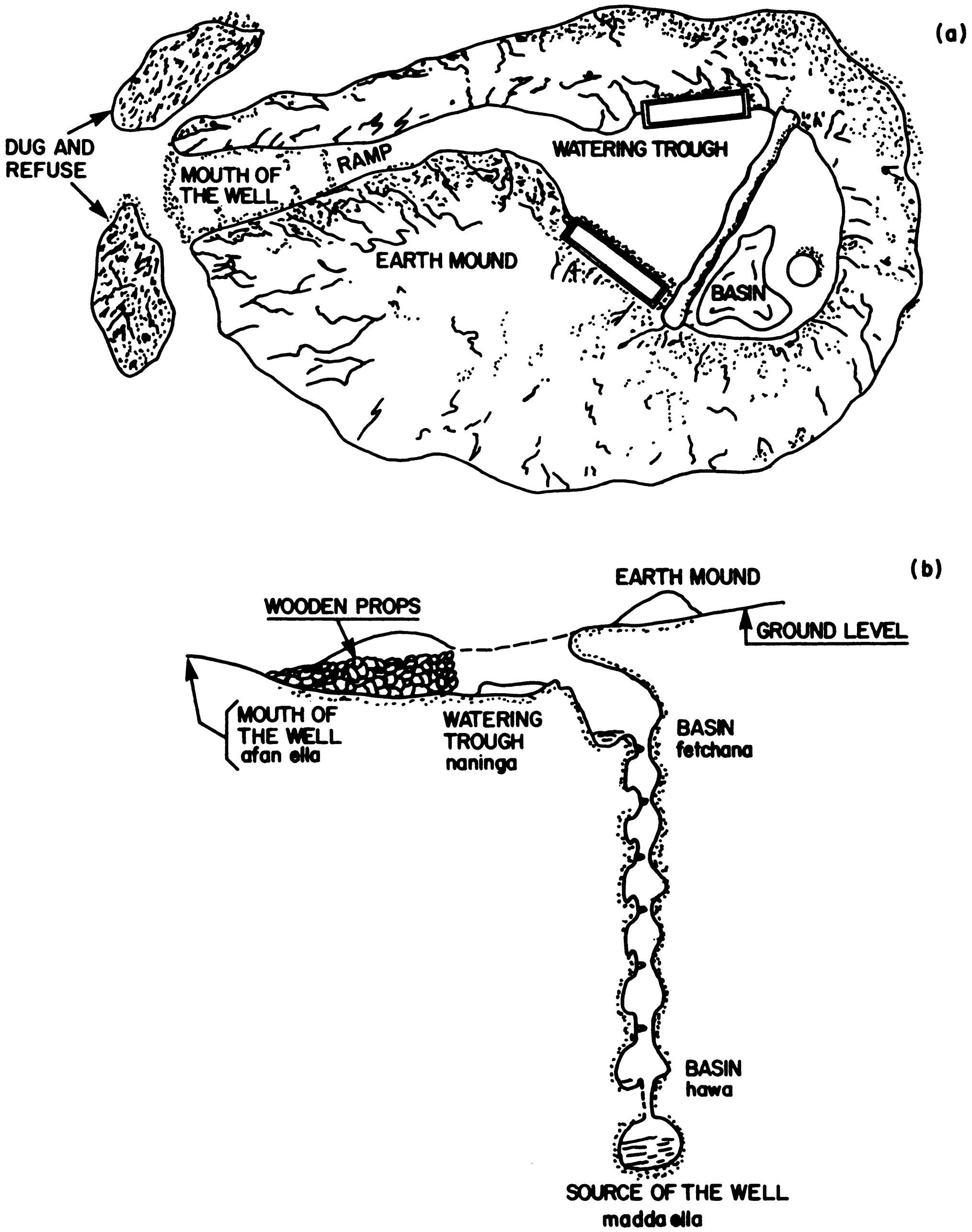
The wells usually occur in groups of four to 20. Crater wells can be found in the bottom of volcanic craters such as at Dilo Goraye or Medecho. *Adadi* wells consist of wide shafts dug into alluvium and can be up to 10 m deep (Helland, 1980b; Cossins and Upton, 1987). The *tula* (deep) and crater wells, however, are usually much deeper and require a massive excavation with shafts commonly sunk into rock. Shallow *adadi* wells may be dug at any time and thus can be an opportune source of water. *Tula* and crater wells, in contrast, are old; it is often contended that they were dug by another ethnic group possibly more than 500 years ago (M. Bassi, Institute of Ethiopian Studies, personal communication). Helland (1980b) cites Haberland (1963) who believed that the wells had been dug by an unknown Megalithic culture. Helland (1980b) reported that the Boran claim that the wells had been dug by the Warday, a southern Oromo people who were expelled by the Boran and now reside in Kenya (see Section 2.4.2.1: *History*). Helland (1980b), however, also cited Asmarom Legesse (1973) as accepting the idea that the Boran dug the wells themselves.

If the Boran inherited the wells, they have had to adjust their original social system to provide sufficient labour for operation of the well system. Regardless, at least until very recently, new wells have not been excavated. Old wells, however, have been easily brought back into service since 1989, presumably to help cope with a high cattle population (see Section 7.2: *A theory of local system dynamics*). These are cases where old cave-ins or erosion had to be cleaned out. While this can be difficult, it represents a far easier task than starting a new excavation (Hodgson, 1990; Tamene Yigezu, SORDU manager, personal communication). There has been more pressure in the last few years from the Boran on SORDU to dig new wells using modern machinery, but this has been resisted. The Boran have proposed to pay for this with cattle sales (see Section 7.3.1.1: *Water-development activities*). Examples of new wells being initiated with pastoral resources are reported later in this section.

The *tula* wells comprise the most reliable sources of water. They are reported to have a smaller discharge of water during dry and drought years (EWWCA, 1987), or when a watershed just happens to receive lower than average moisture in an otherwise average rainfall year (D. L. Coppock, ILCA, personal observation). Nine groups of *tula* wells to the east are reported to never dry up, even during severe drought (Cossins and Upton, 1987). It is these wells and their surrounding foraging regions that comprise the last fall-back regions during a severe drought (see Section 6.3.1.1: *Livestock dispersal and herd composition*).

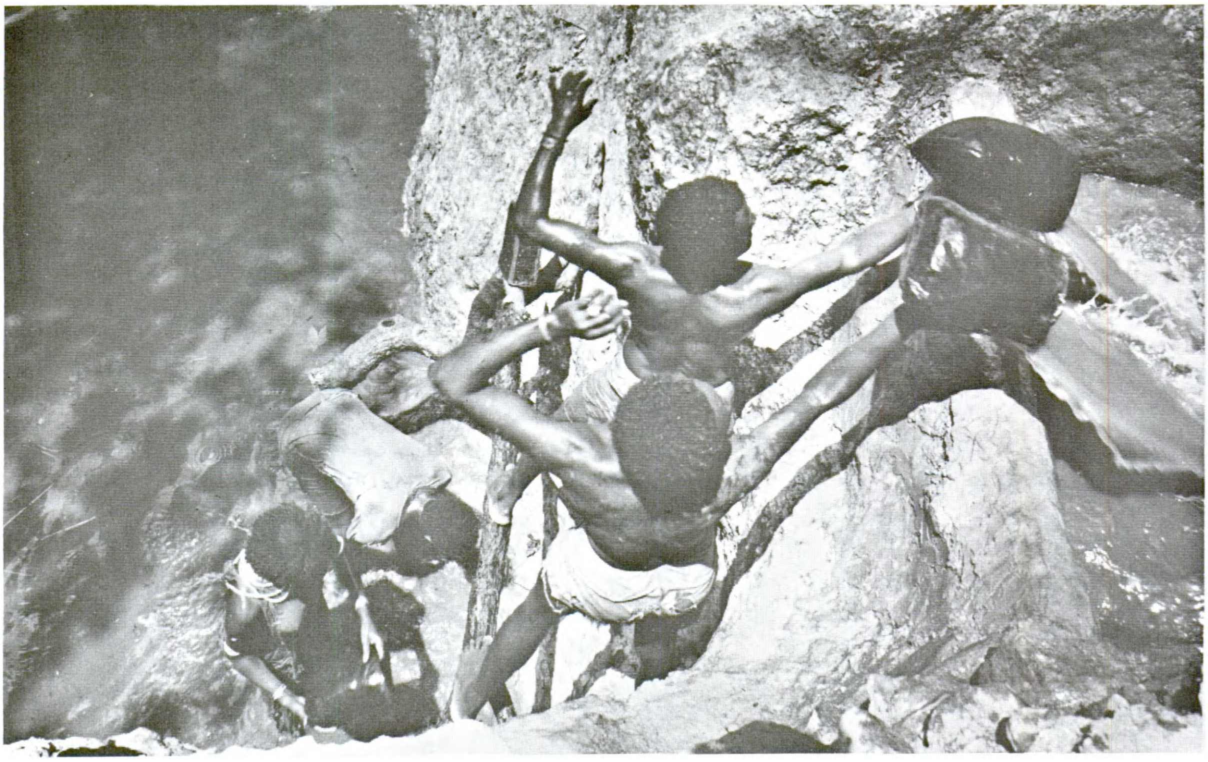
The *tula* wells are impressive feats of engineering (Figure 2.9a,b; Plate 2.2 a,b; Helland, 1980b; Cossins, 1983c; Donaldson, 1983; Cossins and Upton, 1987). Animals and people enter the well site by travelling down a long (i.e. 50 to 150 m) narrow ramp flanked by high earthen walls. Entry is regulated by an individual on duty at the gate of a thorn fence who enforces the prescribed order of herds to be watered each day. The drinking area for animals is a large flat platform (*dargula*) some 5 to 10 m below the ground surface. The *dargula* also has a supervisor who helps keep the watering and exit of stock orderly. The well proper consists of several parts. The water source (*madda ella*) is accessed by a shaft up to 30 m deep which may be 1 to 3 m in diameter. At the top of the shaft is a large

Figure 2.9 (a,b). *Schematic diagrams of a* tula *well on the Borana Plateau: (a) aerial view and (b) lateral view.*



Source: Cossins and Upton (1985).

Plate 2.2 (a, b). *(a) Borana men using* okole *to lift water from the* fetchana *(reservoir) to* naninga *(trough) in a* tula *well; and (b) cattle drinking at a* naninga *attached to a* fetchana.



storage basin (of hundreds of litres capacity) called *fetchana*, several metres above which is a system of clay watering troughs (*naninga*) that services up to several dozen cattle and other stock at a time. A chain of 5 to 20 people (usually males and referred to as a *gogessa*) (Helland, 1980b)] stands on lashed wooden platforms or rocky protrusions in the shaft and pass water from the *madda ella* to the *fetchana*. One to three more people (youths and adults of both sexes) pass water from the *fetchana* to the *naninga*. Water is passed using small durable leather buckets (2 to 5-litre capacity). These buckets (*okole*) often have a thumb hole in one of the two upper corners and are traditionally made of giraffe or buffalo hide (Donaldson, 1983; Cossins and Upton, 1987). With the increased scarcity of these wildlife species, plastic or metal containers are more commonly used nowadays. These are more awkward to handle than the traditional ones (Hodgson, 1990).

Lifting water begins early in the morning to first fill the *fetchana*. After this a steady flow of water is maintained from the *madda ella* to the *fetchana* and from the *fetchana* to the *naninga*; this whole task is physically intense (Cossins and Upton, 1987) and is spurred by rhythmic chanting. After a few hours the work crews are replaced. Rates of water extraction have been estimated as 2.4 to 7.5 m^3/hour (Cossins, 1983c). During periods when

Photograph: JEPSS

water discharge is low or the number of animals to be watered is high, watering may continue through the night aided by light from torches. Leakage of water from buckets, *fetchana* and *naninga* have been identified as sources of inefficiency in water lifting and some development solutions have been proposed and/or implemented (Cossins, 1983c; Cossins and Upton, 1988b; Hodgson, 1990; see Section 7.3.1.1: *Water-development activities*).

A continuous and coordinated supply of labour is thus essential to the smooth functioning of *tula* wells (Helland, 1980b; Cossins, 1983c; Donaldson, 1983; Cossins and Upton, 1987). Labour is supplied by the users of each well. In contrast to the demand for labour to herd cattle whereby one herder can manage some 50 cattle at least, the demand for labour to lift water is more of a direct linear relationship between numbers of people and animals and may underscore a key management constraint in the system. Members of poorer households may supply labour to water larger herds of the wealthy, and in exchange the poor receive food and an occasional promise of a future calf (Cossins and Upton, 1987). Labour is also needed to regulate animal traffic, constantly sweep the ramp and platform of loose soil, collect manure and to repair the *naninga* each morning with fresh clay.

Water rights indirectly confer grazing rights by virtue of gained access to nearby forage. It has been estimated that the grazing radius of cattle from a water source is on the order of 16 km (Helland, 1980b; Cossins and Upton, 1987). Access to local grazing due to water access is only mediated when needs of herds with different production priorities are considered. Lactating herds (*loni warra*) based at *olla* reportedly have the grazing priority over satellite herds of dry cows and males (*loni forra*). Haberland (1963), as cited by Helland (Chr Michelson Institute, personal communication), stated that a herd already occupying a given grazing area has priority over others that want to enter.

The labour required to lift water places a very high demand on the population during dry periods. Data in Table 2.2 indicate that from 1 to 60% of available people in different regions may be required to lift water from various wells on a given day in the warm dry season.

Wells are usually located within a two to four hour walk from encampments or villages (*olla*; see Section 4.3.2: *The encampment and the role of cooperative labour*). *Olla* can have anywhere from 4 to 60 households, but average 10 to 15. Many *olla* form a circle or semicircle within a 10 to 16-km radius of a given well group. Cossins and Upton (1987: p 203) state that virtually all *olla* lie within 16 km of a well. The *olla* supply animals to be watered and labour to operate the wells. In the dry season cattle are commonly watered once every three days, small ruminants once every five days and camels once every 8 to 14 days (Cossins and Upton, 1987; see Section 5.4.4: *Cattle productivity and watering frequency*). These watering regimes represent an attempt to optimise labour input in livestock management (Cossins, 1983c; Cossins and Upton, 1987). The average number of 250-kg Tropical Livestock Units (TLUs) watered per 3-day cycle at particular wells may average from 5000 to 17 700 in the central and eastern zones of the study area,

Table 2.2. *Potential available labour[1] and labour required[2] for daily operation of 139 traditional wells[3] during dry seasons of 1982 on the central Borana Plateau.*

Age group (years)	Males: Total no. available	Males: No. used[4] E/F	Males: No. used F/N	Males: No. used D	Males: Per cent used	Females: Total no. available	Females: No. used E/F	Females: No. used F/N	Females: No. used D	Females: Per cent used
10–14	4941	85	60	0	3	6331	32	141	0	3
15–20	4669	1078	462	0	33	4955	64	362	0	9
21–25	3581	1178	412	0	44	5505	462	188	0	12
26–30	2176	924	384	0	60	3854	250	136	0	10
31–35	3309	356	158	0	15	1376	53	48	0	7
36–40	816	143	78	0	27	1927	2	20	0	1
41–45	1904	64	40	1000	60	3028	0	3	0	<1
46–50	3581	2	20	1000	29	2202	2	0	0	<1
50+	816	0	0	0	0	—	—	—	—	—

1 Estimated from aerial survey of population and household demographic structures extrapolated within the proximity of 139 wells.

2 Includes active workers and those held in reserve.

3 Wells included *tula, adadi* and crater types combined.

4 Where E/F = *ella* to *fetchana* stage; F/N = *fetchana* to *naninga* stage; and D = *Dargula* stage. For definition of terms, see the text.

Source: Cossins (1983c).

respectively (see Figure 2.7 for a map of zones (Cossins and Upton, 1987)). Donaldson (1983) estimated that individual well groups could service from 3500 head in a 3-day watering cycle at Arabelle in the west to 47 000 head at Burbur (or Borbor) to the east. Cossins and Upton (1987: p 205) calculated that the only region where well water is not a significant constraint, compared to forage, is to the east. Water shortages that result in unexploited grazing may be most acute to the west and north (Cossins and Upton, 1987).

The watering schedule is formulated by a well council composed of well users (*chora ella*) (Helland, 1980b; Cossins and Upton, 1987; Bassi, 1990). Every well belongs to a particular clan (Helland, 1980b). Clans are intermediate levels of organisation in the kinship system (Asmarom Legesse, 1973: p 39). There are about 17 clans in the Borana system divided among two social moieties (Asmarom Legesse, 1973; M. Bassi, Institute of Ethiopian Studies, personal communication). In the classic sense, the clan in Borana is composed of families claiming descent from a common male ancestor. The clan affiliation of a particular well corresponds to the identity of the *abba ella* or well father (Helland, 1980b). The responsibilities and accompanying duties that underpin the relationship between an *abba ella* and his well is known as *confi* and is a sort of trusteeship. The *confi* is patrilinearly inherited and cannot be lost, even if the well collapses through disuse and someone else re-excavates it (Helland, 1980b). The *confi* may be transferred to a caretaker on a temporary basis if the *abba ella* moves elsewhere. In this case the holder of the *confi* is under the scrutiny of clan elders who ensure that the caretaker fulfills his obligations in accordance with the *Ada-Sera Borana*, or the customs and laws of the Boran (Helland, 1980b).

Daily routines at the well such as cleaning ramps, repairing small cave-ins and lifting water are supervised by an officer known as an *abba hirega* or father of the watering order, who is appointed by the well council (Helland, 1980b). The watering order (or rotation) usually lasts three or four days. On day one the holder of the *confi* usually functions as *abba hirega* (Helland, 1980b). Overall authority over use of the well is vested in the well council. Watering rights in any well must be gained and maintained through participation in the well council, and watering rights indirectly confer grazing access rights (Helland, 1980b; Bassi, 1990). Setting the watering rotation is the most important task of the well council, because this implies allocating watering privileges when water volume is a constraint, such as in a dry year or drought (Helland, 1980b; Bassi, 1990). A recent example of this was a situation where a non-resident herdowner with a very large cattle herd needed access to a certain well. He was not denied access, but instead was relegated to be last in the watering order. The constraints of having to water cattle at night because of low water discharge in this particular dry season meant that the herd had to be moved elsewhere (M. Bassi, Institute of Ethiopian Studies, personal communication).

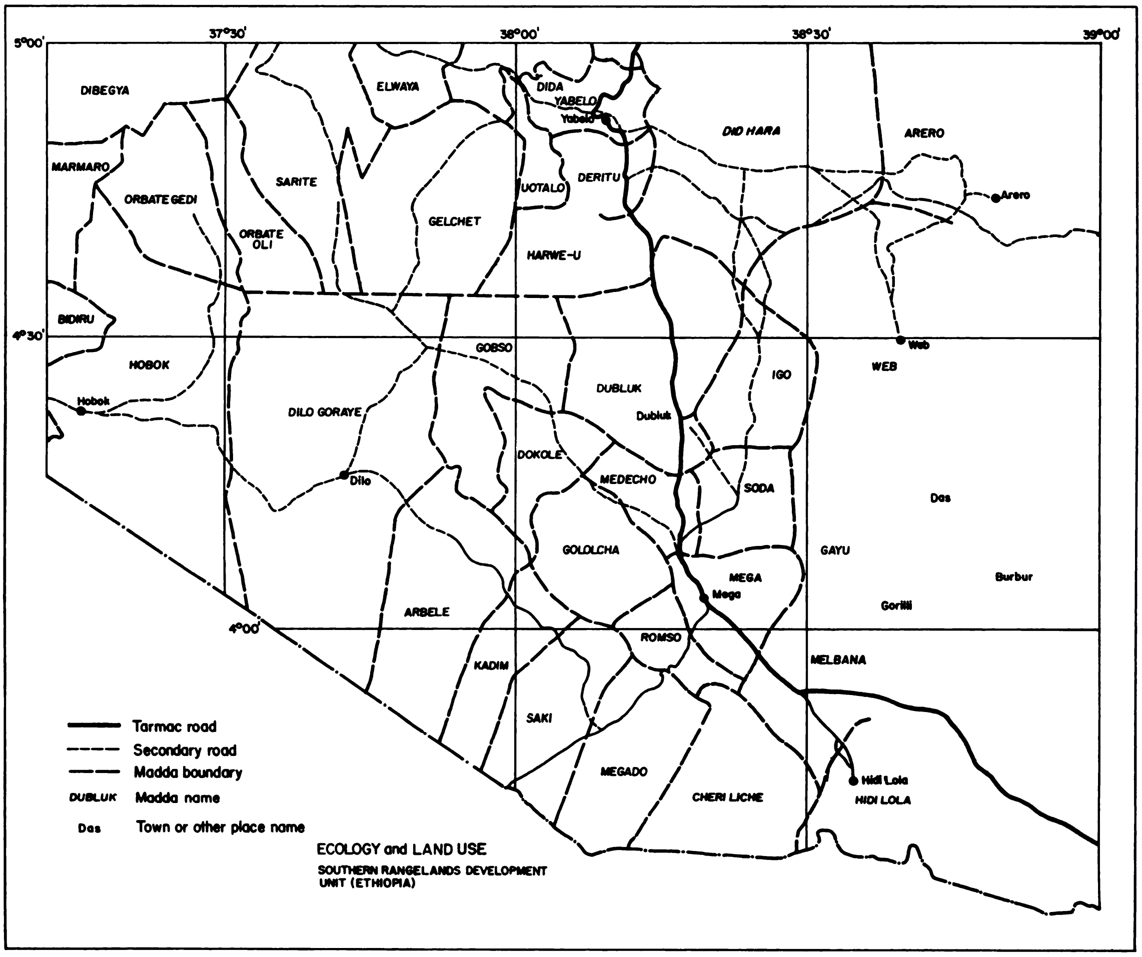
There are also limits on the number of cattle that can be watered for a given herdowner. Owners with more than 200 head can be turned away, particularly if they have not recruited enough labour and/or local forage resources are in short supply (D. L. Coppock, ILCA, personal observation). This illustrates the contention that there are few explicit or formal rules governing access to wells, but that access is indirectly governed through contacts, persuasion and competition (Helland, 1980b). In principle, a clansman of an *abba ella* cannot be formally excluded from a particular well but inspection of watering orders reveals that there are many exceptions (i.e. users who are not clansmen). Bassi (1990) reported eight groups of clans that appeared to collaborate in the management and use of wells.

Clan affiliation is thus just one factor needed to gain access to a given well, but clan organisation of the Boran is cross-cut by other organising principles such as the *Gada* system and age sets or *Hariya* (Helland, 1980b; see below). Clans are also linked by marriage, friendship and other alliances, and all are legitimate bases for claiming watering rights (Helland, 1980b). In support of this view, Bassi (1990) noted that descent relationships other than clan-based ones allowed access to wells, but seniority within a clan usually had a prioritising function. Bassi (1990) also found that descendants of persons who had donated cattle in support of the original excavation of wells (*abba mele*) also had special access rights, regardless of other descent linkages. People who had certain personal relationships with the *abba ella* also gained access, as did those who merely joined their cattle with another herd which already had user rights (Bassi, 1990). Helland (1980b) reported that key decision makers can be bribed. Gaining access to a well also depends to a large extent on how successful a man is in presenting and defending a claim before the well council (Helland, 1980b). Council meetings are informal and any man can attend and voice his opinion. Decisions are made by gradually reaching consensus within the framework of continual reference to the *Ada-Sera Borana* (laws and customs). Concepts of legality and legitimacy are flexible to allow for individual interpretations of rules (Helland, 1980b; Bassi, 1990). It is also likely that acute problems with forage supply enter the assessment of whether well access can be granted in a particular area (Cossins and Upton, 1987) and this may override other considerations to favor local residents over immigrants during periods of crisis (see Section 7.2: *A theory of local system dynamics).*

Participation in well excavation can also be important to gain future access to water. Bassi (1990) reported that traditionally a well can be dug on behalf of an individual or clan. If initiated by an individual, he pays at least a large part of the expenses himself. He can become the *abba ella* of the well and choose who uses the water with him. If initiated by a clan, clan members share all expenses and use follows the traditional model described in Helland (1980b). Bassi (1990) reported the outcome of two general meetings held in 1989 where the excavation of new wells at Dubluk was discussed. The Dubluk well was dug at the initiative of a local Borana administrator who paid about EB 3300 of the expenses himself. It was later determined, however, that a clan could use the well and the administrator was refunded by clan members. Bassi (1990) noted that cash, not cattle, was collected for the reimbursement, showing the Boran had adapted to changed economic circumstances. Cattle have been the traditional form of remuneration for well excavation work (Asmarom Legesse, 1973).

The wells influence one level of land use referred to as *madda*. Most Boran live and herd their milking animals in one *madda* (Hogg, 1990a). There are about 35 *madda* on the central plateau with an average size of 500 km^2. These were first mapped in the early 1980s and have been used as a basis for regional administration and tax collection by the government (Hogg, 1990a). A 500-km^2 *madda* can contain around 100 *olla*, 4000 people, and 10 000 cattle (see Section 4.3.2: *The encampment and the role of cooperative labour*). A *madda* map is shown in Figure 2.10. The delineation of fixed boundaries is misleading because tradition allows people and

Figure 2.10. *Boundaries of* madda *regions on the Borana Plateau as interpreted by ILCA and TLDP staff in the early 1980s.*



Source: Assefa Eshete et al (1986).

animals to move among *madda*. Hogg (1990a) defines *madda* as regions in which the residents have defined rights of access and responsibility for the upkeep of a particular group of wells. In a similar definition oriented towards water, the term *madda* links the life-giving properties of water to the Borana world view and can be translated from Oromigna as "origin", "springs" or "wells" (J. Helland, Chr Michelsen Institute, personal communication).

People have the right to use wells in other *madda* with permission. This is more common for *loni forra* (satellite dry) herds which can roam outside their home *madda* to avoid resource competition with *loni warra* (resident milking) herds (Cossins and Upton, 1987; Hogg, 1990a). Some *madda*, particularly to the east, are prioritised for *loni forra* on a collective basis and have traditionally served more as reserved grazing areas during drought rather than *madda* having a large population of permanent residents (see Section 6.3.1.1: *Livestock dispersal and herd composition*). Haberland (1963) also emphasised that *madda* do not correspond to clan territories, but instead serve many clans.

Clans have no norms for common residence and rather serve as regionally dispersed systems for social networking to obtain access to a wider array of resources (Bassi, 1990). For example, although each well in a cluster of 15 may primarily serve one clan, members of all of the 15 clans would probably have access to much of the same grazing. While Hogg (1990a) defines *madda* in terms of water rights, he also listed *madda* as only one level of territorial organisation. This interpretation may be disputed (J. Helland, Chr Michelsen Institute, personal communication). The role of *madda* as territorial units may be more implicit than explicit. It is also possible that *madda* function as territories or common areas in a dynamic fashion depending on resource availability. Some *madda* boundaries were observed to be closed to non-residents during times of scarce grazing in the dry season of 1989–90, but there was intense social pressure to reopen these borders (D. L. Coppock, ILCA, personal observation). It is also possible that some functions of *madda* evolve over time in response to changing population pressure or social circumstances (see Section 7.2: *A theory of local system dynamics*). The social diversity of *madda* may not allow them to be regarded as a truly cohesive organisational unit (M. Bassi, Institute of Ethiopian Studies, personal communication). Despite this *madda* can be useful as units for the implementation of some types of development projects that focus on widely recognised regional problems (Hogg, 1990a; Bassi, 1990).

Figure 2.11 illustrates an example of dry-season grazing radii for cattle in relation to well groupings in the study area. Areas outside the grazing orbits are accessed during and soon after rainy periods using ephemeral ponds. Improving efficiency of use for range outside of dry-season grazing orbits was a major objective behind the pond construction project undertaken by TLDP and described in Section 1.4.5.2: *Water development strategy*. Before the pond construction programme, it was estimated that <70% of the grazing on the central plateau was accessible to cattle using traditional water sources (N. J. Cossins, former ILCA rangelands team leader, unpublished data). Schematic diagrams of cattle grazing orbits in relation to use of ponds and wells in dry and wet seasons are shown in Figure 2.12a, b. These diagrams show a seasonally variable watering frequency of once every two to three days for *loni warra* (milking) herds in wet and dry seasons, respectively, while *loni forra* (dry) herds usually drink once every three days regardless of season. The *warra* herds are constrained in that they must return to the encampment each evening for milking.

The critical nature of the wells in dry-season watering of livestock is demonstrated by the information presented in Table 2.3. Of the 337 000 head of livestock observed watering during the warm dry season of 1982, about 77% were watered at wells and 23% were watered at springs.

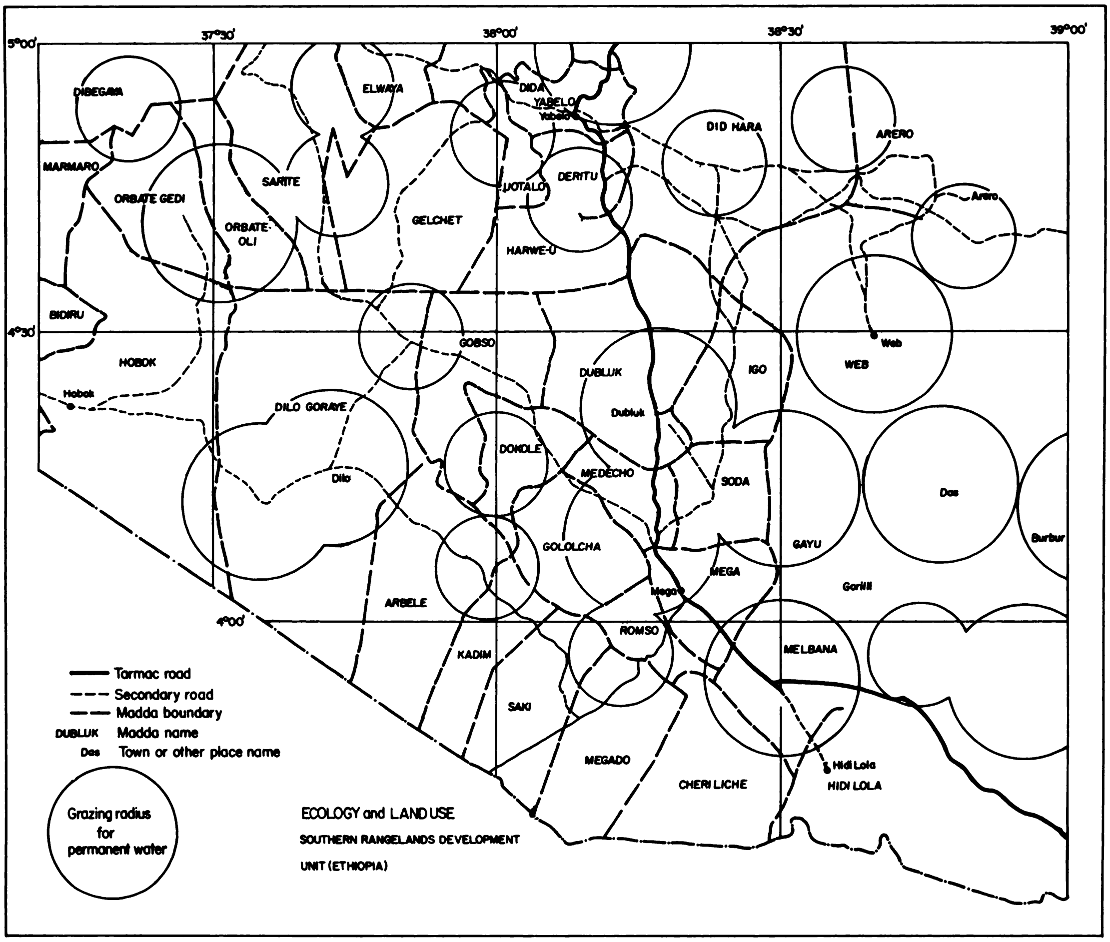
Other water sources

In their comprehensive survey, AGROTEC/CRG/SEDES Associates (1974i) noted that there were some 25 mountain springs and 31 boreholes in the SORDU region during the early 1970s, and that these contributed only about 10% and 6%, respectively, of the daily water extraction estimated for the dry season of 1972–1973. The wells provided the remainder. The boreholes were constructed in earlier development efforts and ranged from 25 to 370 m in depth. They are of no real consequence to the pastoral system overall and will not be considered further.

The springs occur mostly in sedimentary and alluvial formations (90% of the total), with the remainder located in the basement-complex and volcanic areas. Although a perennial source of water, springs are also too limited in water volume to be of anything but local consequence. Development of springs may involve simple pipe systems to better channel water to drinking areas for people and animals (Hodgson, 1990).

Another minor source of water are temporary pools, puddles and run-off (see Section 7.3.1.1: *Water development activities*). These are common in rainy periods and are termed *lola* (Helland, 1980b). Use of this water is governed by free access, but priority may go to people who live closest to these sources (Helland, 1980b).

Figure 2.11. *Cattle grazing radii in relation to permanent water points (wells) and* madda *regions on the Borana Plateau.*

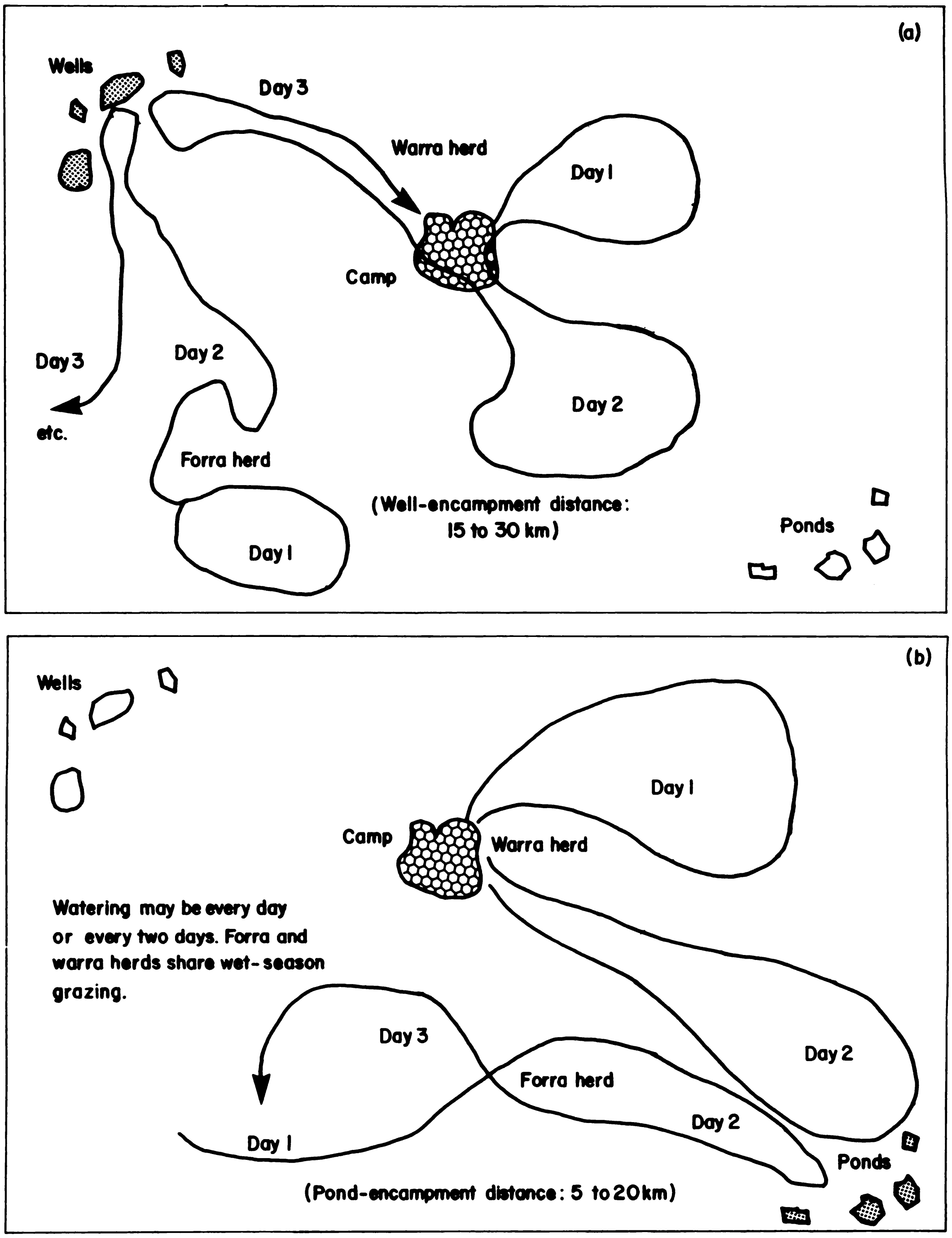


Source: Assefa Eshete et al (1986).

After the wells, ponds are the most important water source on the central plateau and are termed *hara* (Helland, 1980b; Hodgson, 1990). There is no formal estimate of the number of ponds in the traditional system prior to mechanised pond-development programmes which started in the 1950s (Tilaye Bekele, 1987). A map of all types of ponds in the SORDU area is provided in Tilaye Bekele (1987: p 18), but the scale may be inappropriate to enumerate all of the smaller ponds. Ponds were traditionally excavated during dry seasons when the people were still physically fit and the soil was suitably dry for easy removal. Soil removal employed simple wooden tools and hands for scooping. Metal hand tools were not widely available until the late 1980s and animal power was also never used (see Section 1.4.5.2: *Water development strategy*). The initiative to excavate a pond usually comes from a local leader eventually referred to as the pond father or *abba hara.* Excavation starts in a place where water collects naturally and soil or silt is removed each year by individuals who expect to make use of the pond (Hodgson, 1990). It is unclear if the *abba hara* provides food or cattle as remuneration to pond workers; he may only provide leadership. This may also depend on the size of the pond. The use of *hara* is not subject to the same degree of regulation invoked for wells, although they do need some regulation and upkeep as siltation is a recurrent problem (Tilaye Bekele, 1987). Helland (1980b) postulated that the more reliable a pond is each year, the more likely that it will receive regular maintenance of its thorn fence and use will be monitored more closely.

In sum, while this all serves as a useful initial survey of water resources on the Borana Plateau, much of the information regarding regulation of access and even location of water points can be improved upon. Recent work in the Pilot Project (see

Figure 2.12. *General patterns of cattle-grazing orbits in relation to watering frequency in (a) the dry season and (b) the wet season in the Borana management system.*



Source: Cossins and Upton (1985).

Section 1.4.3: *The SERP and the Pilot Project*) has provided more accurate information on water utilisation (R. S. Hogg, TLDP consultant, personal communication). A comprehensive livestock survey conducted by Solomon Desta (nd) also gives details on types and locations of water points throughout the SORDU project area.

2.4.2 Introduction to Borana history and social organisation

2.4.2.1 History

Since some key aspects of Borana history and social organisation have already been mentioned this section will review a few more details, with

Table 2.3. *Four types of traditional wells and their associated livestock populations during the warm dry season (February to April) of 1982 on the central Borana Plateau.*

Well type[1]	Livestock			
	Cattle	Sheep and goats	Equines	Camels
Tula[2]	78 966	12 440	3693	623
Adadi[3]	61 495	23 191	2022	615
Crater[4]	43 104	51 664	2954	2091
Spring[5]	46 615	4755	2036	1045
Total	230 180	92 050	10 705	4374

1 For descriptions of well types, see the text.

2 These include Web, Igo, Dubluk, Gayu, Das, Melbana and Elwaya.

3 These include Borbor (which alone served 75% of the cattle and 97% of the sheep and goats for this well type), Kobole and Romso; Elkum, Sadetei and Hobok not included (the latter was not in operation because of rains that provided surface water to the west).

4 These include Goraye, Dilo, Medecho and Megado. Kula was not included.

5 These include Debesso, Utalo, Arabelle, Arero, Dokole, Faro, Gobso, Saki, Tesi, Gololcha, Harwe-U and Mega; 40% of cattle for this well type were served at Arero and Mega, while 76% of the camels were served at Arero. El Dima, Gulaba and Kadim were not included.

Source: Cossins (1983c).

emphasis on some of the complex mechanisms by which the Boran attempt to regulate human population growth, settle disputes, interpret and enforce resource-use policies and redistribute wealth. These are essential factors in understanding how best to implement technical improvements in the local economy, food security strategies and general well-being. This is not intended, however, as a comprehensive review of the large body of scholarly information on the structure, functions, rituals, politics and history of Borana society. That is beyond the scope of this volume. For an in-depth ethnographic analyses the reader is referred to Huntingford (1955), Haberland (1963) and Asmarom Legesse (1973). The last work is mostly referred to here as the benchmark source out of convenience, but it reportedly contains some controversial material (Helland, 1980b; M. Bassi, Institute of Ethiopian Studies, personal communication).

The Boran are a branch of the Oromo (or Galla) peoples whose language belongs to the Cushitic subfamily common to most of north-eastern Africa (Asmarom Legesse, 1973). Most of the Oromo speak closely related dialects of the Oromigna (or Galliñña) language and share a common cultural heritage. The Oromo are regarded as one of the most expansive African cultures on record (Asmarom Legesse, 1973). Their spread over much of what is now Ethiopia and Kenya during the 1500s resulted from massive population growth combined with an aggressive, militaristic culture. About half of present-day Ethiopia fell under their dominance, including what are now the administrative regions of Gojjam and Tigre (Asmarom Legesse, 1973).

The cradle of Oromo culture is generally recognised as a large, rectangular area that begins at the north-central edge of present-day SORDU and extends north to the Bale Administrative Region (Asmarom Legesse, 1973). This region has many hills and mountains and includes ecosystems in the lowlands as well as the southern highlands. It is thus dominated by a much more *mesic* climate compared to the ILCA study area. Today these highland, humid, subhumid and upper semi-arid environments are exploited by a variety of agropastoral and farming peoples (Westphal, 1975). The closest other group to the ILCA study area are the agropastoral Gujji, another Oromo people who share many cultural features with the Boran (Asmarom Legesse, 1973; Helland, 1980b). Today some of the most important Borana shrines are found in Gujji territory (Asmarom Legesse, 1973). The centre for political and ritual activity for the Boran, however, is found in the southern rangelands.

It is unclear whether what is now the ILCA study area was invaded from the north during the Oromo expansion of the 1500s (expelling an indigenous group like the Warday; see Section 2.4.1.7: *Water resources*), or had already been occupied as part of the Oromo cradleland (Asmarom Legesse, 1973; Helland, 1980b; Wilding, 1985a; Hogg, 1990a). This point also relates to the question of who originally dug the wells on the central plateau. Asmarom Legesse (1973) contends that most of the traditional cultural institutions of the Oromo are still preserved among both the Gujji and Boran, implying that they have either always resided undisturbed in these areas or supplanted much weaker peoples who had little reciprocal influences on their original Oromo culture. In the Ethiopian highlands the Oromo culture has been somewhat diluted by the Amharic and Tigriñña-speaking peoples (Asmarom Legesse, 1973). There is evidence that the present Borana territory in the southern rangelands has been somewhat reduced since 1910, mostly due to Somali encroachment from the east. This is reportedly due to drought and/or overgrazing that caused the Boran to move their cattle westward with the vacuum being filled by Somali herds of small ruminants and camels better suited to the induced habitat change (Asmarom Legesse, 1973). Pressure prevails on all sides of the Boran today, however, with Somali to the east, Gujji and Arsi to the north and north-east and Hamer to the west, among others. Low-elevation desert occurs to the south in Kenya. Large-scale conflicts occurred between the Boran and Somali in the late 1970s during the Somali invasion of Ethiopia. Small isolated conflicts between the Boran and Gujji occurred to the north during the 1983 to 1984 drought when both groups were pressed for resources (P. Webb, IFPRI, unpublished data). Numerous armed conflicts occurred among Boran, Gabra, Gujji and other groups throughout the last half of 1991, largely as a result of stress from low rainfall, weapons proliferation and the demise of central governmental authority (D. L. Coppock, Utah State University, unpublished correspondence).

The Oromo expansion period was reportedly spurred by aspects of the *Gada* system in which periodic, outward pulses for warfare were essential cultural components (Asmarom Legesse, 1973; 1989). The *Gada* as a generation system (distinct from an age grade system) is introduced below. It has also been hypothesised that after the Oromo expansion the people remaining in the cradleland modified some of the tenets of the *Gada* system in order to provide means for population regulation (Asmarom Legesse, 1973). This could have been an attempt at cultural adaptation to crowded conditions in a core region prone to degradation, with limited opportunities for emigration. The point is that apparently at least some segments of the society shifted their cultural ways from an orientation towards high population growth rates and expansionism to one of population regulation as a response to a limited resource base. Asmarom Legesse (1973) reported the likelihood of such population control among the Boran from his demographic analysis of the 1960s. The Boran reportedly had slow rates of population growth earlier this century (see Section 2.4.3: *Human population growth*). A major question today is whether the people are still able to regulate population growth given a shrinking or static resource base, destabilising effects from outside the traditional sector and with no opportunities for territorial expansion (Helland, 1980b).

2.4.2.2 Some cultural and organisational features

Kinship

In the Borana social system descent is recognised only through the male line and men and women descended from a common ancestor constitute a corporate group in that they share many collective rights and obligations. The social system is best described as a hierarchy (Asmarom Legesse, 1973: p 39). The smallest unit is the hearth (*ibidda*) which corresponds to the nuclear family with one male head of household, his wife or wives and children. This is followed by the *warra* (extended family), *mana* (lineage) and *gosa*, which broadly nests clans within submoieties and moieties.

When a woman marries she acquires the right to her own home and forms a new household unit with her husband. Married women are the household managers but are subordinate to men who serve as the household heads and represent the household to the outside world (Hogg, 1990a). The men are called *abba warra* or father of the households. They make the strategic decisions regarding livestock production and sales. The household is discussed further in Section 4.3.1: *General household structure and economy in average rainfall years*. Extended families may have all close relatives residing in the same *olla*, but this is not a requirement. The father of the encampment (or *abba olla*) is selected from among the *abba warra*. He is a respected individual who provides leadership, but otherwise has no special authority over other members of the *olla* (Haberland, 1963).

Lineages are the basic component of the descent system and are usually reported as 6 to 10 generations deep. As the basic source of the privileges, duties and identity of members, lineages determine roles in ritual, water management and wealth redistribution (Asmarom Legesse, 1973).

Clans are groups of lineages. It has been speculated that lineage members are unable to trace their links to a common ancestor (J. Helland, Chr Michelsen Institute, personal communication). Hogg (1990a), however, contends that lineages within a clan share a common male ancestor. Clans are not corporate property-owning groups, nor is it desirable that they reside in the same location; the reverse is actually more advantageous (see Section 5.3.1: *General aspects of cattle management*). Clan members are expected to help each other in times of hardship and clans can provide a wider network of mutual assistance than individual lineages (Bassi, 1990; Hogg, 1990a). Members of clans reportedly settle their disputes amicably at clan meetings in which clan elders (*jarsi gosa*) use moral authority to settle disputes, imposing fines on wrongdoers and seizing property (Hogg, 1990a). Clans thus also have roles in ritual, maintenance and regulation of water resources and the redistribution of wealth (see below).

There are two moieties (*Sabbo* and *Gona*) and these represent the highest social division of Borana society (Asmarom Legesse, 1973). Members of one moiety can only marry into the opposite moiety, and moieties are approximately equal in population size, distributed evenly throughout the central plateau at the *olla* level. The source of social justice in the system is the balance of power between *Sabbo* and *Gona* that permeate all aspects of collective decision making. The *Sabbo* moiety contains three submoieties with two clans each and each clan contains from 3 to 16 lineages or minor lineages. The number of lineages and minor lineages total about 60. The *Gona* moiety is different. It contains two submoieties, each with seven clans, but no discernible lineages. The moieties, and occasionally the submoieties, can be involved in ritual and political conflict. Moieties play a prominent role in the election of *Gada* councillors (see below). The men, responsible for organising the election of *Gada* leaders every eight years, and act as the ultimate adjudicators of major conflict, are the heads of the two moieties referred to as *Kallu*. They also have ritual leadership duties (Asmarom Legesse, 1973). Bassi (1990) contends that the size and operation of functional descent groups such as clans may vary depending on moiety. Moieties share duties in politics through the *Gada* system and the age set system (see below).

Assemblies

The Boran debate and reach consensus through assembly (Hogg, 1990a). Participation at meetings can cut across many levels in the social hierarchy. Local assemblies can deal with an issue at the household, *olla*, neighbourhood or *madda* level. Any household head can come and express his views (Hogg, 1990a). If a problem cannot be resolved at lower levels it is passed to a clan assembly or to *Gada* officials. The ultimate body of appeal is the assembly of all Boran (the *Gumi Gayu*) held every eight years in southern Ethiopia. It was last held in 1988 (see below).

Social aspects of wealth redistribution

Clans provide perhaps the best degree of networking required for reliable redistribution of wealth, as shown by the following account (M. Bassi, Institute of Ethiopian Studies, personal communication):

> Clan assemblies generally occur each year from April through August except during a drought. Meetings may be called by any wealthy clan member and anyone in the clan can attend, although people in need of cattle usually dominate. A small meeting would have some 30 to 40 people and lasts about a week. All clan leaders (*jalaba*) must attend. There may be up to 100 such meetings each year in total, which suggests that some of the 17 or so clans have more than one meeting/year. Meetings may also be skewed towards one moiety over another; over 90% of the meetings enumerated by M. Bassi (Institute of Ethiopian Studies, personal communication) were in the *Sabbo* moiety. People who have lost virtually all of their cattle (referred to as *quolle*) petition the leaders for cows at these meetings. The clan must respond with some help, but if the *quolle* lost cattle through negligence or inappropriate sales the request may be denied. Losses of animals to disease may imply partial negligence while losses during drought are usually accepted as wholly legitimate. Traditionally, each of the several *quolle* would receive 5 to 10 milk cows, with each wealthy clan member giving at least one cow. However, it is reported that in the past decade, it has been more difficult to meet the demands of *quolle*, both because of an increasing number of *quolle* and the substantial losses of cows from herds of the wealthy during the 1983 to 1984 drought (see Section 6.3.2: *Drought effects in the upper semi-arid zone*).

Spirituality

The Boran follow indigenous religious beliefs. Islam has been reported to be making inroads very recently, perhaps through the small sympatric groups of Muslim Gabra (C. Fütterknecht, CARE-Ethiopia, personal observation).

The Boran believe that God sent down *Kallu*, their supreme spiritual leader, who taught the Boran how to sacrifice animals and instructed them in the "Peace of Borana" or *Naigaya Borana* (Hogg, 1990a). The importance of the "Peace of Borana" should not be underestimated. It is invoked in all aspects of collective decision-making and shapes debate and consensus according to traditional values of well-being and law (Asmarom Legesse, 1973; Helland, 1980b). It helps ensure that internal disputes are settled in an egalitarian manner without violence; that cordial cooperation facilitates water-point maintenance and resource allocation; and that criminals are punished through exclusion from community resources. It is unclear whether the "Peace of Borana" has ever been transcribed. This may be an important task that underpins design and implementation of appropriate development strategies (see Chapter 7: *Development-intervention concepts).* It is also unclear whether Borana philosophy contains prophetic predictions of future calamity. It has been recently reported that some Boran in the ILCA study area are fearful of an imminent and ill-defined natural catastrophe perceived to be worse than the 1983 to 1984 drought (M. Bassi, Institute of Ethiopian Studies, personal communication; D. L. Coppock, ILCA, unpublished data). This is mentioned because such an outlook could have a decisive influence on the participation of the Boran in certain types of long-term development activities (see Chapter 7: *Development-intervention concepts).*

The *Hariya* age-set system, the *Gada* generation system and the *Gumi Gayu* (all Boran) assembly

Asmarom Legesse (1973: p 50) noted that the *Gada* system offers one of the world's richest social contexts for the study of relationships between time and human society. Describing and interpreting such a complex system in full is beyond the scope of this volume. Readers interested in details are referred to Asmarom Legesse (1973).

Asmarom Legesse noted that Borana society is stratified into two distinct, but interwoven, systems of peer-group structures for males. One is a system of age sets (*Hariya*) in which members are recruited on the basis of age. This is similar to age-set systems practised by other groups such as the Kikuyu, Maasai and Nuer. Age sets are listed in Asmarom Legesse (1973: p 60) and these consist of 10, 8-year blocks from age 12 to 91. Each set thus consists of similarly aged males born in the same 8-year period who share a corporate identity that evolves over their lifetimes. The members of each age set share a series of basic and collective military, economic, political and ritual duties, with a rite of passage occurring between stages. For example, a common typology of an age-set system may consist of: (1) young boys herding stock; (2) young men acting as warriors and livestock raiders; (3) mature men being eligible for herd ownership and marriage; and (4) older men assuming ritual and political duties. One common interpretation of such systems is that they are authoritarian, governed by the elderly, and serve to maintain the social and economic status quo. Asmarom Legesse (1973: pp 112–113), however, disputes this in the case of the Boran. He argues that their age-set system serves to distribute privileges more equitably across generational lines. For example, the old and young Borana males tend to have more ritual power while those at the intermediate levels tend to have more political authority. This allows, what would otherwise be marginalised, generations to have meaningful roles within the system (Asmarom Legesse, 1973: p 117). For the purpose of clarity, in this review it is assumed that the ritual and political duties in the age-set system are largely distinct from those invoked in the *Gada* grades (see below), although this is only occasionally explicit in Asmarom Legesse (1973).

The *Gada*, in contrast to age sets, is a system in which males are recruited into generation classes (*luba*) on the basis of genealogy (Asmarom Legesse, 1973). There are very many *Gada* classes, and these are in a perpetual state of being created every eight years, whereas age sets are a given. The members of a *luba* thus have a similar status of genealogical relatedness (but not necessarily a similarity in age), and they collectively pass through a series of *Gada* grades that last eight years in duration. These grades are 11 stages of social development and responsibility in relation to the philosophy of maintaining the "Peace of Borana" (see below). Compared with simple age sets, *Gada* systems are more unusual and complex. The *Gada* system of the Boran may have evolved from a simple age-set system some 500 years ago. Gada systems are also found in other Oromo people in Ethiopia such as the Gujji to the north of the study area (Asmarom Legesse, 1973). The *Gada* and age-set systems occur in parallel and cross-link each other at certain stages while their ultimate functions are complementary.

All Borana males thus have a position in an age set as well as in a *Gada* class. They are simultaneously in the process of passing through a segment of the age set and a certain *Gada* grade (Asmarom Legesse, 1973). Females obtain an ancillary position in a *Gada* class through their fathers and later husbands, but have no position in the age sets. In some respects *Gada* grades have roles that are grossly similar to those of age sets with the degree of similarity depending on the particular age set and grade taken. Whether a male in a certain *Gada* grade can perform all pertinent duties must be related to age to some degree (but this also is not explicit in Asmarom Legesse, 1973).

The key functional difference between recruits for age sets and *Gada* classes is that while cohorts in the age sets are similar in age, a given *Gada* class can contain persons that are vastly different in age. The genealogical association, for example, could be that members of a certain class are grandsons of brothers but one grandson could be an infant and the other 20 years old. The basic rule is that regardless of the age of the father, his infant son enters the grade system 40 years (i.e. five grades) behind.

The *Gada* grades described in Asmarom Legesse (1973: pp 52–69) and occupied by a large number of genealogical *luba* include:

1) Grade I (*daballe*) which includes all the sons born to the senior men currently in the powerful *Gada* grade VI (see below). These sons have a feminine appearance in terms of hairstyles and dress and are treated preferentially. They are considered to be among the principle mediators between man and God;
2) Grade II (Junior *Gamme*) which includes 8-year-old initiates from among the *daballe,* who consequently receive a name and a masculine status. They are now eligible to become herders of small ruminants and calves. This grade could also include infants born to men in Grade VII;
3) Grade III (Senior *Gamme*) which includes 16-year-old initiates from grade II who are old enough to herd cattle on *forra* and participate in hunting and raiding. It also includes infants born to men in Grade VIII;
4) Grades IV and V members (*Cusa* and Junior and Senior *Raba*) includes 24-year-old initiates from grade III who can become mature warriors or raiders. Junior *Raba* after age 32 can marry. These two grades each span 24 years in total with a maximum age of 45; it is not 48 because the Senior *Raba* period is preempted by a period of transfer of power to the next grade. These grades can also include infants born to men in Grades IX and X;
5) Grade VI members (*Gada*) are the ones who can be elected to positions of *Gada* councillors. The initial age range upon entry into Grade VI is from birth to 45 years and thus includes infants born to men in the final Grade XI (see below). The political roles thus must vary markedly from junior to senior members, but all (including young children) can enjoy a similar status in ritual (Asmarom Legesse, 1973). The senior elected members of the *Gada* council act as upholders of the "Peace of the Boran" philosophy by serving as "supreme court" members for conflict mitigation and as leaders for ritual prayer and sacrifice (Asmarom Legesse, 1973; Helland, 1980b; Hogg, 1990a);
6) Grades VII through X cover 27 years and are referred to as *Yuba* as a whole. The Yuba contain males having an entry age of anywhere from 8 to 53 years and an exit age of 35 to 80 years. There are no infants in this grade because there is no grade above 11 (see no. 5 above). The roles include politics and ritual and at least partial retirement for older members. Men in Grade VII also have important ritual and political duties during the *Gumi Gayu* assembly; and
7) the terminal and sacred grade is *Gada Mojji*, with an entry age of 35 to 80 years. This grade is followed by full retirement, but it is unclear if this is mandatory for all members regardless of age.

This description of the *Gada* grades is slightly at variance with some details of the model of Asmarom Legesse (1973: p 131). It portrays, however, a basic and informative picture. The apparent high virility of the very old men in Grades IX, X, XI (i.e. at 72 years of age at least) is attributable to two factors: (1) they marry very young fertile wives (starting at age 13); and (2) their wives can carry on with an active *cicisbeism*, or extramarital relations with lovers from their husband's *luba*. The children born from these liaisons are recognised as children of the husband.

Asmarom Legesse conducted a computer simulation analysis on the demographic stability of the *Gada* system given that members of different grades have different and absolute rules regarding child rearing. These fundamental rules have traditionally included: (1) no man is allowed to have children before a minimum age of 40 (note that this would be in Grade V and there is no entry slot for newborn sons five grades lower); and (2) no man is allowed to marry before a minimum age of 32. Details that underscore these major rules include: (1) since the children of *cicisbeism* are regarded as children of husbands, this effectively stops recruitment from wives as well; (2) junior males in *Gada* grade VI also are not allowed to father children; (3) senior males in the *Gada* grade VI are allowed to procreate only sons; and (4) men are only supposed to raise sons starting at age 40 after their fatherhood ceremony, can raise daughters only after they are 48. Asmarom Legesse (1973: p 68) also stated that the traditional premarital sex rules for men support the structure of the *Gada* system. Marriage for men can also be delayed by economics in terms of the need to attain a modest bridewealth (D. L. Coppock, ILCA, personal observation).

For these rules to be enforced it is apparent, given that young men are not celibate (Asmarom Legesse, 1973), that something must happen to: (1) all children born before a husband turns 40; (2) those children born to junior men in the *Gada* grades; (3) those daughters born to senior men in the *Gada* grades; and (4) those daughters born to men between the ages of 40 to 48. Asmarom Legesse concluded from demographic analysis that various forms of infanticide and putting infants up for adoption outside the system were occurring during his field work in the early 1960s. This occurred despite an official ban on infanticide from the Ethiopian Government (Asmarom Legesse, 1973).

Asmarom Legesse also concluded from his simulation analysis that the *Gada* system has had considerable effects on Borana population growth for hundreds of years. He hypothesised that the transformation of the *Gada,* from a simple age set system to its present forms, was related to the period of rapid population growth in the 16th century. Calculating back from the computer simulation and his demographic survey of 1963, he stipulated the year 1623 as a likely time when rules limiting reproduction that are in effect at the present came into being. Starting with a normal age-graded population structure in 1623, and then imposing *Gada* rules on reproduction, he simulated a 40% decline in population until the year 1703. The decline continued until 1863 when the population stabilised at about 50% of the original density. After a period of steady-state performance, the population then exhibited a modest degree of growth. This huge effect of the *Gada* on population dynamics was in part due to the postulated large portion (30%) that the affected male cohort, aged 16 to 40, comprised of the original population.

Population regulation, cultivation in the highlands and massive territorial expansion throughout Kenya and Ethiopia (see Section 2.4.2.1: *History*) were all strategies to accomodate high population density in Oromo society during the 1600s. In the 1960s, however, Asmarom Legesse noted that only 18% of the male population was aged 16 to 40 so that *Gada* practices would be anticipated to have a smaller effect on population regulation. There was also no indication that the position of the population on the *Gada* cycle had stabilised since the late 1800s, and it was unclear if it would ever stabilise in the future. Asmarom Legesse also noted that the numbers of retirees in the advanced *Gada* grades were increasing while numbers in the lower grades were dwindling. The Boran however, perceived this to be due to declines in fertility and not to instability in the *Gada* cycle.

Other factors may thus come into play regarding population regulation in the southern rangelands, and these prominently include effects of an improved delivery of health care, food aid and a decline of traditional leadership and values plus routine regulation of conception, topics addressed in the next section.

The *Gumi Gayo* (Assembly of the Multitudes) is a pan-Borana meeting that takes place for a week once every eight years in the southern rangelands. It last occurred in 1988. This is regarded as the most inclusive event in Borana life (Asmarom Legesse, 1973). The *Gumi*, which holds the ultimate authority regarding all matters, is an assemblage of representatives of all Boran. But it is actually the multitude that sits in judgement, often led by an *Abba Gada*. A transcript of a meeting in 1966, attended by 600 persons, is reported in Asmarom Legesse (1973: pp 94–99). The agenda dealt with resource conflicts, divination for the future, patching-up schisms among submoieties, intertribal issues involving the Rendille and debate on 12 cardinal rules that had been violated as a result of a decline in customs and carelessness. These codes involved routine administration, social behaviour, the care of horses, sale of water, feminine modesty and rules of bridewealth. In the debates there was a deliberate attempt at rethinking and modifying customary laws where appropriate (Asmarom Legesse, 1973: p 97).

The outcome of the meeting in 1988 included proclamations on a wide range of topics (D. L. Coppock, ILCA, unpublished data). These included that: (1) encouragement be given to keep water points in good condition; (2) owners of ponds and wells must not accept money from users; (3) everyone establish *kalo* or fodder reserves for calves and sick cattle in the dry season; (4) everyone make an effort to determine where *forra* cattle can freely graze; (5) everyone try to stop unnecessary cultivation of land; (6) trees with value for forage and shade must not be disturbed; and (7) government tax on salt from salt craters (Soda, Dilo Goraye, etc) be reduced to former levels.

There was also a debate on alcohol abuse in the community. All points above except (7) have a fundamental bearing on the implementation of technical improvements in the system as well as managing it well enough for sustainable output, topics dealt with in detail in Chapter 7: *Development-intervention concepts*.

2.4.3 Human population growth

Helland (1980b) reviewed the *Gada* system and rules on reproduction as proposed by Asmarom Legesse (1973) and Haberland (1963), and noted the importance of population regulation for the Boran as an ecological adaptation because of their reliance on a finite resource base. Citing AGROTEC/CRG/SEDES Associates (1974e) for estimates of population growth, he found the net rate of natural increase in the Borana population in 1972–73 to be on the order of 1.5 to 1.8% per annum. An annual outmigration and urbanisation rate of 5% was also stipulated, which would lead to a net growth rate of 1 to 1.3% per year. This means that the population would double every 55 years, a very low growth rate for semi-settled pastoralists such as the Boran (Meir, 1987).

Helland (1980b), however, expressed concern about the degree of control that the *Gada* system retained given increasing outside influences on the society. The demise of traditional regulation of population growth among Somali pastoralists due to external forces was noted by Swift (1977). Sindiga (1987) noted that improved human services facilitated population growth among the Maasai. Surveys of Borana society conducted in 1990 (Coppock, 1992b) confirm that wide generation gaps are perceived by the elders, and that mushrooming small towns on the plateau are probably having a pervasive effect on social attitudes and economic trends. The generation gaps involve variation in traditional values and changes in economic attitudes towards livestock commercialisation. Respondents from the older generation in the survey felt, for example, that male youths were being increasingly attracted to opportunities outside the traditional sector, such as participating in the cattle black market to Kenya and routine selling of more cattle than the elders felt was prudent. The elders were also very concerned about the looming critical labour shortage that would occur as a result of young men leaving the system (Coppock, 1992b). It must be said, however, that the younger generation probably has fewer options to diversify their economic activities given current population pressure and lower per capita numbers of cattle (see Section 7.2: *A theory of local system dynamics*). Herding cattle appears to be a less-attractive option for young men contemplating their future today compared to the past, as it is probably more difficult to become wealthy from herding cattle today. Besides, they are now aware from contacts with outsiders that there may be more attractive options elsewhere (see Section 7.1.3: *Review of dynamics and past interventions*).

Regarding the importance of *Gada,* Helland (1980b) added that it was not clear how many Boran really follow the *Gada* rules today or how the rules are articulated in general throughout the population. Demographic studies on the Borana Plateau carried out by B. Lindtjørn (University of Bergen, unpublished data) in the late 1980s estimated a net population growth rate of 2.5%, consistent with that for other semi-settled pastoral groups (Meir, 1987). This growth rate has a population-doubling time of 28 years. Menwyelet Atsedu (1990: p 31) presented data from AGROTEC/CRG/SEDES Associates (1974e) and SORDU in 1988 that suggest that the human population in the western half of the Borana Plateau doubled from 261 000 to 520 000 over 15 years. This means a population growth rate closer to 5% per annum, but it should be expected to include a large component of highland immigrants moving into small towns in the rangelands. It is unclear whether the exact same areas were sampled in the surveys by AGROTEC/CRG/CEDES Associates (1974e) and SORDU whose survey also may have included a larger area (Menwyelet Atsedu, 1990: p 31). From an aerial survey in 1982, Milligan (1983) estimated a human population of about 91 000 to 135 000 for the study area giving a mean density of 7.3 persons/km^2.

It seems reasonable to hypothesise from the data of AGROTEC/CRG/SEDES Associates (1974e) and B. Lindtjørn (University of Bergen, unpublished data) that the net population growth rates among the Boran are increasing. Several factors could be contributing to this: (1) *Gada* rules and values are becoming less adhered to; (2) rural systems of social surveillance imposed by the Ethiopian Government during 1978 to 1991 were an effective check on illegal practices such as infanticide; (3) improvements in health delivery and access to cereals through food aid and markets enhance the health and fertility of women in their child-bearing years. Another factor that may become more important in the future is the reported recent and growing interest in Islam by the Boran (C. Fütterknecht, CARE-Ethiopia, personal communication). Given that Muslims have larger families, the spread of Islam has important implications for population growth (M. Bassi, Institute of Ethiopian Studies, personal communication). It may also pose some threat to the *Gada* system itself in the future.

In one sense there appear to be contradictions between some of the *Gada* tenets and other aspects of contemporary ritual. For example, M. Bassi (Institute of Ethiopian Studies, personal communication) noted that fertility is greatly emphasised in the ritual ideology and Borana women want many children, but in practice fertility may be curtailed—two sons being the desired norm. Besides the *Gada* rules (above), the Boran practise some form of contraception. This may be as simple as women breast-feeding their young children for several years, which may contribute to long-term anoestrus. Birth control also has an economic function in that each household tries to have children in proportion to their economic condition as reflected in herd size. Drought and other perturbations, however, make it more difficult for the Boran to plan family size in this manner given their often unpredictable losses of cattle (M. Bassi, Institute of Ethiopian Studies, personal communication).

Although human morbidity was widespread during the 1983 to 1984 drought (see Section 6.3.1.4: *Human diet and mortality*), the human population appeared to be little affected in terms of drought-related mortality. Cossins and Upton (1988a) reported negligible deaths from the survey of five *olla* at Did Hara, Medecho and Melbana. In a survey of 48 Borana and Gabra households near the Beke Pond in 1987 (D. L. Coppock, ILCA, unpublished data), no deaths were reported due to the drought. More than 35 families, however, reported one birth each during the drought (see Section 6.3.2.2: *Human welfare*). Although regional variation relating famine and human mortality is to be expected, there was no evidence from these limited surveys that human mortality rates were affected by this drought in a density-dependent manner (i.e. higher drought-induced mortality because of a larger pre-drought population). This was in marked contrast to cattle, as 45% of milk cows, 57% of calves and 22% of mature males died (Donaldson, 1986; see Section 6.3.1.1: *Livestock dispersal and herd composition*).

This thus introduces a concept that is probably fundamental to understanding the hypothesis that the Borana production system is becoming increasingly vulnerable to drought and poverty (introduced in full in Section 7.2: *A theory of local system dynamics*). This hypothesis proposes that cattle mortality can be affected in a density-dependent manner as a result of environmental perturbation while human mortality, at least during recent times, has not been appreciably affected. For a comprehensive view of integrated research and development perspectives, the reader should consult Chapter 8: *Synthesis and conclusions*.

Chapter 3

Vegetation dynamics and resource use

Summary

This chapter reviews ecological site classification and mapping of the central Borana Plateau and aspects of environmental change induced by pastoral land use. A secondary objective is to highlight use of native vegetation by pastoral households and livestock. An ecological map (at a scale of 1:500 000) is presented that integrates soils, vegetation and climate in defining six agro-ecological zones for a 26 600-km^2 area: subhumid (6.5% of the region), upper semi-arid (22.4%), lower semi-arid (40.3%), arid (19.2%) and bottomlands (11.6%). These zones vary in resource dynamics and management. For example, while the subhumid zone has recently been stable in terms of the aereal extent of forests, the upper semi-arid zone has been vulnerable to grazing-induced bush encroachment. Roughly 16 species of woody plants have been implicated as encroachers in the southern rangelands. Traditional pastoral units of resource allocation (*or madda*) vary in extent of zonal diversity. Three of 29 madda contain all the six zones while 10 others contain three zones or less. By the mid-1980s about 40% of the study area had experienced significant bush encroachment, while erosion attributable to grazing pressure affected 19% of the study area. These trends are coincident and most apparent in upper semi-arid regions having hilly relief and in the vicinity of permanent water development where pastoralists have become more sedentary. Less than 2% of the study area was under small-scale cultivation in 1986 following the 1983 to 1984 drought, and this was concentrated in bottomlands and upland sites in the subhumid and upper semi-arid zones.

It is postulated that variation in the long-term grazing history of *madda* can be assessed using inventories of woody plant populations. A primary mechanism is hypothesised to be effects of heavy grazing of herbaceous plants by cattle on promoting woody cover by reducing fire risk. For example, sites currently enduring heavy grazing pressure could be diagnosed by high densities of very young woody plants, while sites that had heavy grazing pressure in the past that was discontinued several decades ago could be diagnosed as having moderate to high densities of mature woody plants. It is contended that the Boran used to exploit the rangeland in terms of a sustainable patch dynamic but that this has recently been compromised by high population growth. The patch dynamic may have consisted of the following stages: (1) pastoralists settled around a well group characterised by mixed savannah vegetation; (2) cattle depleted the local environment by overutilising the grass layer and transporting nutrients to corrals at encampments; (3) woody plants invaded as competition from grasses was lessened and fire risks reduced; (4) negative change in vegetation for cattle encouraged pastoralists to abandon the area; (5) maturing stands of woody plants restricted access by herbivores and added nutrients to soils through leaf litter; and (6) the grass layer gradually recovered to an extent where fire risk increased and fires re-established mixed savannah vegetation by thinning stands of woody plants. It is at this stage that the site could be re-occupied by pastoralists; it has been speculated that this cycle could take 60 to 100 years for completion.

Comparative analyses of upland sites subjected to continuous grazing versus those protected for seven years suggest that perennial grasses are relatively resilient in terms of cover and productivity in response to grazing; the major effect of continuous grazing over the short term appears to encourage forbs that probably have a lower grazing value for cattle. Other studies indicate that it is difficult to generalise concerning interactions among woody and herbaceous vegetation of species, woody plant density and site. Tree-removal experiments suggest that some woody species can reduce herbaceous production by over 50%. Other research indicates that herbaceous cover can increase under canopies of large tree species. Local informants report that a moderate degree of woody encroachment can be beneficial to the diversity of the grazing system overall, but once encroachment becomes advanced it usually has negative consequences for pastoralism.

During the 1980s the Boran noted that they were less able to burn the rangelands compared to earlier times because of: (1) government policy prohibiting burning; and (2) the need to use standing herbage as forage, not fuel, because of the high numbers of cattle. The Boran commonly voice the view that range trend is declining as a result of high stocking rates. Higher densities of people also reportedly preclude the freer movements of households as in previous generations.

Studies of population ecology of two encroaching woody species (*Acacia brevispica* and *A. drepanolobium*) indicate that: (1) large quantities of seeds are produced during the warm, dry season

(i.e. November through March); (2) seed pools are largely at the soil surface; (3) despite substantial seed production, recruitment of seedlings is very low, probably due in large measure to parasitism and seed loss because of predatory insects; and (4) seeds vary in terms of ecological cues required for germination. *Acacia brevispica* seeds may be stimulated to germinate by fire. Seeds of both species germinate more in response to additional moisture and shallow planting depths (<3 cm). Neither species appears to rely on maintaining a large seed pool in the soil. Seedling establishment is probably thus an episodic phenomenon dependent on coincident factors related to grazing pressure, insect populations and rainfall in the current year of seed production.

Analysis of livestock feeding habits in the upper semi-arid zone indicates that cattle are exclusively grazers while camels are browsers. Sheep (with 36% dietary browse) and goats (84% dietary browse) are mixed feeders. Only two of 29 browse species provided most of the browse forage overall, and one (*A. brevispica*) is commonly regarded by range managers as an encroacher. Other important species that should receive development attention as forage resources include browses such as: *Euclea shiperi, Dichrostachys cinera, Rhus natalensis, Pappea capensis, A. etbaica, Grewia tembensis, G. bicolor, Ormocarpum mimosoides, A. tortilis, Balanites* spp, *Cadaba farinosa,* and *Capparis tomentosa.* Browse species vary markedly in morphology and concentrations of tannins and other anti-nutritional elements for livestock. Goats, camels and sheep appeared to select against browses with higher levels of phenolic compounds especially during wet seasons when forage abundance and diversity were greatest. A variety of native grasses are also critical for the production system. Grasses important for calf feeding include: *Pennisetum, Chrysopogon, Cynodon*, and *Cenchrus* spp. Native plants have many uses as human food, medicine, construction materials and for other cultural purposes. A list of 114 plant species and their uses in the Borana traditional economy is provided. Few common species are without any utility. Woody species that are increasing in the environment and apparently with low forage value and household use include: *A drepanolobium, Albizia amare, A. horrida* and *A. mellifera.*

3.1 Introduction

There is much debate over the effects of pastoralists and their livestock on the sustainable productivity of drier environments. Negative trends such as desertification and bush encroachment have been commonly attributed to overgrazing and/or cultivation inappropriate to pastoral systems (Charney et al, 1975; Lamprey and Yussef, 1981; Lamprey, 1983; Billé, 1985; Sinclair and Fryxell, 1985; Cloudsley-Thompson, 1988). In contrast, others contend that vegetation dynamics are more attributable to rainfall fluctuations independent of human activity (Rasmusson, 1987; Ellis and Swift, 1988). One central aspect of the debate is thus defining the degree to which climate or people influence environmental trends.

The primary objective of this chapter is to review and synthesise results that pertain to the effects of the Borana pastoralists and their livestock on vegetation composition and trend, as well as those which deal with the competitive interactions among woody and herbaceous plants and aspects of seed production and germination of important woody species. A secondary objective is to review pastoral use of vegetation, including livestock feeding habits, uses of plants by households and perceptions of the Boran regarding environmental change. The third objective is to present current patterns of land use based on an ecological mapping exercise.

3.2 Methods

3.2.1 Ecology and land-use map

Surveys of twelve 20 x 20-km regional blocks (see below), Landsat imagery and other reconnaissance data collected during 1982 to 1985 were used to prepare an ecological map at a scale of 1:500 000 for a 26 600-km^2 region (Assefa Eshete et al, 1986; for a review of the study area see Section 2.2: *Study area selection and system delineation*). This approach delineated six agro-ecological zones, with three to six ecological units/zone and an average of four subunits/ecological unit. Key issues relevant to resource use, range management and ecological sustainability were noted at unit and subunit levels, with trends over time identified using previous maps by AGROTEC/CRG/SEDES Associates (1974d, 1974i, 1974l), aerial photographs and satellite imagery (Assefa Eshete et al, 1986: pp 3, 21). The new map was justified because previous maps of the region had insufficient detail for land-use planning (Assefa Eshete et al, 1986: p 1).

3.2.2 Long-term vegetation change

Research reported here was primarily conducted during 1982 to 1986 (Billé, nd; 1982, 1985; Billé and Assefa Eshete, 1983a; 1983b; 1984; Billé et al, 1983; Billé and Corra, nd; 1986; Assefa Eshete et al, 1986). One objective of this work was to formulate hypotheses that linked livestock pressure to compositional dynamics in plant communities and conduct preliminary tests. In total this work focused on twelve 20 x 20-km blocks selected based on ecological and development criteria (Billé, 1982). Two blocks were located in the arid zone, eight in the lower semi-arid zone, and two in the upper semi-arid zone. The arid zone (19% of the study area) occurs at <1200 metres above sea level with an annual rainfall <450 mm, while the upper semi-arid zone (22% of the study area) occurs between 1500 to 1700 with an annual rainfall of 600 to 700 mm. The lower semi-arid zone (40% of the study area) occurs between the arid and upper semi-arid zones and is intermediate in rainfall. Observations from other work on range trend in the subhumid zone will also be referred to in this chapter, but this work did not involve analysis of blocks (Assefa Eshete et al, 1986; Pratt, 1987a,b). The subhumid zone (7% of the study area) typically occurs over 1600 m and has 700 to 1200 mm of annual rainfall. The arid and lower semi-arid zones occur on a diverse assortment of granitic and volcanic soils and their mixtures, and in many instances shallow soils significantly contribute to an edaphic source of aridity. Basement-complex soils tend to dominate higher elevations (see Section 2.4.1.1: *Geology*).

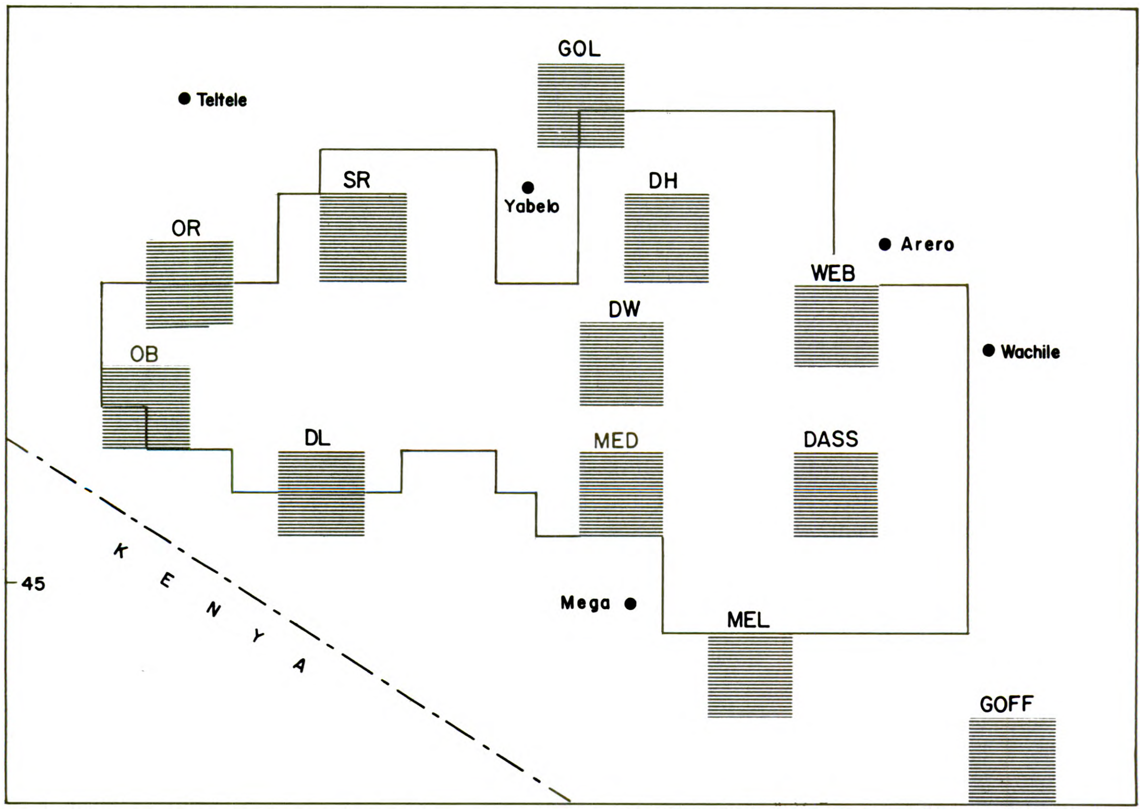
Analysis of the 20 x 20-km blocks was designed to compare environmental trends by contrasting frequency distributions of grazing intensity, degree of erosion, grass and woody cover and density and age structures of woody populations from extensive rapid sampling. Blocks were compared that varied in historical intensity of pastoral use and thus would serve as natural treatments (Figure 3.1). These analyses compared: (1) four blocks in the lower semi-arid zone (in the Dass, Goff, Melbana and Web *madda*) that represented various stages of pastoral impact in the deep-wells area (Billé et al, 1983); (2) two blocks in the lower and upper semi-arid zones (at Medecho and Did Hara *madda*, respectively) that varied in recent duration of pastoral use due to immigration in response to water development at Did Hara or emigration from Medecho (Billé and Assefa Eshete, 1983b); and (3) data from one block at Gololcha (1600 to 1900 m elevation) at the boundary between upper semi-arid and subhumid zones where development of a large, permanent pond recently allowed a high degree of pastoral sedentarisation (Billé and Assefa Eshete, 1984) and a high density of resident livestock. A cattle density of 52 head/km^2 was recorded in Gololcha in 1982, roughly twice the density for the rest of the study area overall (Milligan, 1983: p 37). The annual rainfall at Gololcha is about 700 mm (see Section 2.4.1.4: *Climate, primary production and carrying capacity*).

The four semi-arid blocks studied by Billé et al (1983) at Dass, Goff, Melbana and Web represented regions that had been used by pastoralists for centuries. All four regions were assessed to be generally similar in terms of density of well groups, soils, landscape, altitude and potential vegetative physiognomy. Aerial surveys during June 1982 indicated that the average stocking rate for the four regions was 24.6 head/km^2 (Milligan, 1983: p 37). Recent grazing history varied as Goff, located to the east, was abandoned by pastoralists for a few years during the late 1970s due to security problems, but was reoccupied by 1980. In contrast, the other regions have been continuously occupied during the past few decades.

The second study, conducted at Medecho and Did Hara, involved regions regarded as generally similar in terms of cattle density (average of 24 head/km^2; Milligan (1983: p 37), annual rainfall (550 to 650 mm), soil parent materials (mixtures of volcanics and granitic materials) and density of water points. They differed principally, however, in recent intensity of use. Over the previous six years (1976 to 1982) Did Hara had endured a doubling of human population in response to the construction of permanent ponds that opened the area to sedentary encampments (some of which began to resemble large permanent villages). Medecho, in contrast, had been occupied for centuries but was in a state of population decline by the early 1980s (some of its residents may have moved 60 km north to Did Hara). Evidence for the different population dynamics of the two regions was inferred (in part) from variation in the proportions of occupied vs unoccupied encampment sites. There will always be some unoccupied sites because encampments move every five to eight years (Cossins and Upton, 1987). However, of 139 sites in Did Hara, 39% were occupied in 1982–83, while at Medecho only 14% of 184 sites were occupied (Billé and Assefa Eshete, 1983b: pp 30–31). Year-round access to permanent ponds in Did Hara probably also encouraged less mobile grazing strategies compared to Medecho. Cattle in Medecho radiate out in wet seasons to access forage near ephemeral ponds and return to graze closer to the central wells in dry seasons.

The 20 x 20-km blocks were initially mapped using aerial photographs from 1965 and 1967 at a scale of 1:50 000 to delineate landscape facets with reference to previous surveys by AGROTEC/CRG/SEDES Associates (1974d; 1974i; 1974j). Ecological units of similar vegetation and soil features were identified using two-colour composite prints from Landsat (ERTS E 2368 070 20501 in bands 5 and 7 of 25 January 1976) and transcribed to a topographic map at a scale of 1:250 000. Ecological units were mapped and described further from ground-truthing during 1982 to 1983. The number of ecological units/block ranged from four to eight. Detailed maps of each block may be found

Figure 3.1. *Location of twelve 20 x 20-km blocks in the southern rangelands used for ecological analyses of pastoral land-use impacts.*



Source: Billé (1982).

in Billé and Assefa Eshete (1983a; 1983b; 1984) and Billé et al (1983).

Quantification of environmental variables in each block was based on an ocular survey method developed by Billé (nd) which employed up to 50 sample points per block, located along a driving route at 1 km intervals. The route was designed to maximise observation of dominant ecological units in each block. At each sampling point a 1-ha site was described in terms of: (1) per cent of canopy cover for herbaceous and woody layers, estimated into one of five classes; (2) density of woody plants; and (3) scores of 1 to 5 for topographic class, slope, degree of erosion, and grazing pressure (Billé, 1982). Random sampling of woody plants was used to obtain age structures of populations. Age class was estimated by measuring circumference of single or central boles and placing them into one of seven categories from 1 to 70 cm in circumference. Plants with a bole circumference of 20 cm were considered to be at least 70 years old (Billé and Assefa Eshete, 1983a: p 7).

Other extensive surveys which documented soil erosion, bush encroachment and incidence of cultivation throughout the study area were conducted using systematic aerial reconnaissance. These methods are described elsewhere (see Section 4.2.6: *Grain cultivation*).

3.2.3 Short-term vegetation change

3.2.3.1 Effects of excluding livestock

The Boran have recently started a system of *kalo* or dry-season grazing reserves for calves (Menwyelet Atsedu, 1990; see Section 7.3.1.2: *Grazing management*). Over 90% of surveyed encampments (*N*=127) now have these reserves (Coppock and Mulugeta Mamo, 1985; Menwyelet Atsedu, 1990), averaging about seven years old and 12 ha in size and protected against open grazing by bush fencing and/or decree. They are typically used by women to collect grass for handfeeding young calves, although some grazing may occur in the dry season. *Kalo* usually occur on sites with deeper soils where grass production is higher and some green biomass persists into the dry season. The presence of similar but unprotected sites adjacent to these reserves gave an opportunity to measure effects of continuous versus restricted use on soil and vegetation characteristics, showing greater cover, diversity and productivity of vegetation and an improved soil nutrient status for *Kalo* compared to unprotected sites (Smoliak et al, 1972; Brand and Goetz, 1986).

Eight pairs of sites (six on red and two on grey soil) were analysed in terms of: (1) per cent cover composition and species diversity of herbaceous and woody plants; (2) net primary production (NPP) of herbaceous functional groups (i.e. grasses, forbs, legumes and total); and (3) nutrient characteristics of top soil. Percentage basal cover was determined for herbaceous plants on 1-ha sites using sixty 0.1-m^2 quadrats (Daubenmire, 1959) placed in a stratified-random fashion. Four 15 x 150-m belt transects were used in parallel for cover of woody plants on 5-ha sites with total counts and crown-diameter measurements taken for intercepted plants. Species diversity was quantified using the Shannon-Wiener index (Shannon, 1948). Net primary production of herbaceous components (grasses, forbs, legumes and total) was estimated over the long wet season (April to May) of 1989 by subtracting the terminal standing crop of the previous dry season (March) from the peak standing crop near the end of the wet season. Biomass of each 1-ha site was estimated from clipping forty 0.25-m^2 quadrats placed in a stratified-random fashion. Sites were protected from grazing in order to allow standing crop data to be used in this fashion. Soil texture and concentrations of organic matter, nitrogen, phosphorus, potassium and exchangeable cations were analysed using standard techniques (Kamara and Haque, 1987: pp 12–14), and compared among paired sites using four samples each. Each sample was a composite of eight cores, 30 cm in depth, collected on a transect that traversed several hectares/site. Statistical analyses for all variables employed a one-way analysis of variance (ANOVA) blocked by soil type. Details are available in Menwyelet Atsedu (1990).

3.2.3.2 Interactions among woody and herbaceous plants

Effects of woody plants on productivity and composition of herbaceous vegetation is significant for interpretating impacts due to bush encroachment. As part of the analysis of Sarite ranch (Figure 3.1), Solomon Kebede (1989) studied effects of *Acacia horrida* and *A. seyal* on the understorey during the long rainy season of 1987. He performed an experiment in which trees were paired and one was cut down with the stump being treated with arboricide to kill the root. Sites were bush fenced to prevent grazing so that herbaceous NPP could be measured in controlled and treated situations up to a radius of 4 m from tree trunks. Sixteen 0.25-m^2 quadrats were clipped to ground level in a stratified design and biomass was separated into various components prior to drying. Production was estimated by subtracting standing crop at the end of the dry season from that at the end of the following long rainy season, sampled 120 days apart. Overall, the analysis was based on 144 trees/species distributed among four size classes and three sites. Data were analysed using a four-way ANOVA with species and site as main factors and size class and distance from trunk as sub-factors. Roots were excavated to assess tree-root morphology (Solomon Kebede, 1989: pp 119–131).

Billé and Corra (nd) investigated effects of five *Acacia* and *Balanites* species on understorey cover during the long rainy season of 1986 at the Dembel Wachu ranch (Figure 3.1). One large tree (with a trunk diameter of 15 to 35 cm) was randomly selected on a level site for each species. Herbaceous cover around each tree was measured using about 500 reflectance readings from a portable radiometer held 1 m above ground level. Each reading measured green reflectance from 4x4-m plots located within a series of concentric circles up to a maximum of 8 m from each tree. These readings, referred to as normalised difference vegetation index (or NDVI), were highly correlated with standing biomass (Billé and Corra, nd) showing that the trees had no effect on understorey cover (Boutton and Tieszen, 1983; Kennedy, 1989).

3.2.4 Population ecology of woody species

Research was directed towards the population ecology of *Acacia brevispica* and *A. drepanolobium*, which are increasing in the study area on upland soils and Vertisols, respectively (Tamene Yigezu, 1990). A laboratory study examined effects of various treatments on germination rates of seeds to determine germination strategy. Seeds with a hard coat have a conservative strategy because they can stay in the soil for years before germination, while those with a soft coat can germinate shortly after deposition (Harper, 1977: p 99). Treatments included a background of constant (28°C) or variable (15/30°C) air temperature, with or without scarification of seed coats using sand paper or by immersion of seeds in hot water (98°C for 7 min). The sandpaper treatment was meant to achieve maximum germination while the hot water was intended to reveal to what extent germination was controlled by a waxy layer. Seeds with waxy layers may be more able to germinate after heat treatment caused by natural phenomena such as fire (J.

Hanson, ILCA, personal communication). Data were collected on per cent of seed germinated over a 21-day period for four replications/species/treatment with 100 seeds/replicate. Data were analysed using a factorial ANOVA to determine effects of species, temperature and scarification method. In addition, there was a one-month trial conducted under nursery conditions where effects of species, soil type (red and black), planting depth (0, 1 or 3 cm below the soil surface) and watering frequency (initially only or weekly) on germination rate were studied. There were eight replicates/treatment. One replicate consisted of 25 seeds in a plastic pot. Data were analysed using an ANOVA for a randomised-block design.

Phenology was characterised in the field at 11 monthly intervals for plants of both species along two replicated transects at three sites. Each replicate consisted of 35 plants distributed among several height classes. Data were analysed using an ANOVA with phenology scores as dependent variables and species, site, height class and month as independent variables. Seed production was estimated from data on numbers of dry dehiscent fruits and seeds/fruit for 35 individuals and 100 fruits/species. An ANOVA on fruit yield/tree utilised species, sites and height class as independent variables. Seed pools were quantified using fifty 30-cm soil cores/site at different seasons. Root morphologies were characterised using excavations. Seedling recruitment in the current year was gauged using random plots associated with line transects. Details are available in Tamene Yigezu (1990: pp 93, 108–114, 147–150, 198–200).

Maps of the extent of *A. drepanolobium* populations in the north-central region of the Borana Plateau were compiled by Tamene Yigezu (TLDP/ILCA postgraduate researcher, unpublished data) based on aerial surveys conducted in 1988.

3.2.5 Use of native vegetation

3.2.5.1 Livestock food habits

Working in the Beke Pond region in the upper semi-arid zone near Gololcha, Woodward (1988) studied feeding ecology of livestock in relation to a local community of trees and shrubs. One objective of the work was to evaluate local browses in terms of development potential by assessing their nutritive value, phenology, abundance, relative use by livestock and population trend. Seasonal feeding habits of cattle, camels, sheep and goats were quantified from observations of eight adults of each species for five hours/animal/day in two wet and two dry seasons during 1985–86. This gave a total of 128 animals observed for 640 hours. Forage consumption was recorded as was the time an animal spent eating each species, bite rates per forage species and bite sizes per forage species. The relative availability of each woody species to different livestock species was estimated by measurements of density, phenology, leaf production and leaf accessibility as a function of height from the ground (Woodward, 1988: p 25). Dietary selectivity was expressed for each browse species as a ratio of intake to abundance. Forage samples were collected for nutritional analyses including kjeldahl nitrogen (AOAC, 1980), fibre (Van Soest and Robertson, 1980) and tannins (Reed et al, 1985; Reed, 1986).

Ruminants are known to select forages of above-average quality, and features of body size and gut anatomy dictate that smaller animals such as goats can be more selective than cattle (Kay et al, 1980). Smaller ruminants will select forages with higher concentrations of crude protein and lower content of fibre or tannins that can reduce palatability and digestive efficiency (Kay et al, 1980; Cooper and Owen-Smith, 1985). Thus, the seasonal influence of forage chemical composition on livestock diet selection was analysed by Woodward and Coppock (1989) by calculating dietary preference indices as in Johnson (1980) and using Kendall's TAU B nonparametric method (Kendall, 1970) to correlate ranked preference of forages in diets with those ranked according to content of available N, neutral-detergent fibre (NDF), *in vitro* dry-matter digestibility (IVDMD), or tannins (e.g. soluble phenolics and insoluble proanthocyanidins; Reed, 1986). Details for feeding ecology studies are available in Woodward (1988: pp 20–27) and Woodward and Coppock (1989).

Belete Dessalegn's (1985) work on the feeding habits of goats and camels in the Beke pond region during 1983 to 1985 used: (1) four camels observed an average of seven hours/day in each of four seasons; and (2) five goats observed for eight hours/day during two months in four seasons. Feeding habits were quantified by recording the forage species eaten by an animal at 5-min intervals (Belete Dessalegn, 1985: pp 9, 43).

3.2.5.2 Household use of plants and pastoral perceptions of range trend

Interviews of rural people can be useful in assessing the value of native vegetation. Such exercises with pastoralists can be enlightening since they often have an excellent knowledge of plant species. A survey of local names and uses of nearly 450 plant species was undertaken by Wilding (1984; 1985b) and subsequently refined and validated by Tesfaye Wogayehu (CARE-Ethiopia, unpublished data) using household interviews in 1988 to 1989. A survey of critical grasses for hand feeding calves in different seasons was conducted by Menwyelet Atsedu (1990). Responses were ranked and analysed using the Friedman's two-way ANOVA (Steel and Torrie, 1980). Opinions of pastoralists on range trends were gathered using: (1) group interviews in 60 encampments throughout the Did Hara, Web, Melbana and Medecho regions by Coppock and Mulugeta Mamo (1985); (2) individual interviews of leaders in four regions (i.e. Did Hara, Did Yabelo, Harwe-U and Gobso) by Solomon Dessalegn (TLDP/ILCA postgraduate researcher, unpublished data); and (3) interviews of 30 leaders of the Did Hara, Melbana, Areri, Dubluk, Medecho and Dilo *madda* by Coppock (ILCA, unpublished data; Coppock, 1992b). All interviews were conducted in an open-ended fashion with sufficient time to gather details from respondents. In all cases questions were asked regarding perceptions of long-term vegetation change and its causes and characteristics.

3.3 Results

3.3.1 Ecological map and land use

An ecological map (scale of 1:500 000) is presented as a fold-out at the back of this volume (see Figure B1, Annex B). It illustrates the ecological diversity of a 26 600-km^2 area in the western region of the Borana Plateau. This is roughly 70% larger than the area for which aerial surveys were conducted for population and land-use studies (see Section 4.2.6: *Grain cultivation*).

Overall, the 26 600-km^2 area is comprised of the following six agro-ecological zones: (1) subhumid (6.5% of the mapped area); (2) upper semi-arid (22.4% of the mapped area); (3) lower semi-arid on basement-complex soil (19.9%); (4) lower semi-arid on other mixed soils, including volcanics (20.4%); (5) arid (19.2%); and (6) bottomlands, dominated by Vertisols (11.6%). It is important to note that both climate and soils are integrated in this classification scheme, with soil type contributing the degree of moisture stress (Assefa Eshete et al, 1986).

The six zones were broadly differentiated on the basis of elevation and rainfall while other aspects of classification were based on vegetation structure as influenced by soil depth and fertility (Assefa Eshete et al, 1986). For example:

(1) subhumid environments (annual rainfall averaging approximately 900 mm) are either currently or formerly densely wooded with juniper (*Juniperus procera*) or mixed associations of trees such as *Olea, Euclea, Dodonea, Tarconanthus and Terminalia* spp;

(2) upper semi-arid environments (annual rainfall averaging around 650 mm) offer the best grazing resources, and are primarily indicated by broad-leaved trees (e.g. *Combretum*, *Euphorbia*, *Terminalia* spp) with *Acacias* also common;

(3) some lower semi-arid environments (with annual rainfall between 450 and 650 mm) occur on basement-complex substrates with enhanced soil-plant-water relations. These are represented by *Acacia–Commiphora* spp associations as well as by patches of open grasslands;

(4) other lower semi-arid environments (also with annual rainfall between 450 and 650 mm) on mixed (granitic, metamorphic and volcanic) soils offer high spatial variability in terms of plant associations. Wooded *Acacia* savannah, open grasslands and bushed grasslands are a few of these associations;

(5) arid environments (with an annual rainfall <450 mm), which are defined by either reduced precipitation at lower elevations to the west, or shallow volcanic soils with a low water-holding capacity that occur throughout the study area. *Acacias* such as *A. mellifera*, *A. reficiens* and *A. horrida* commonly dominate vegetation in arid sites. Sparse grassland on lava is also typical; and

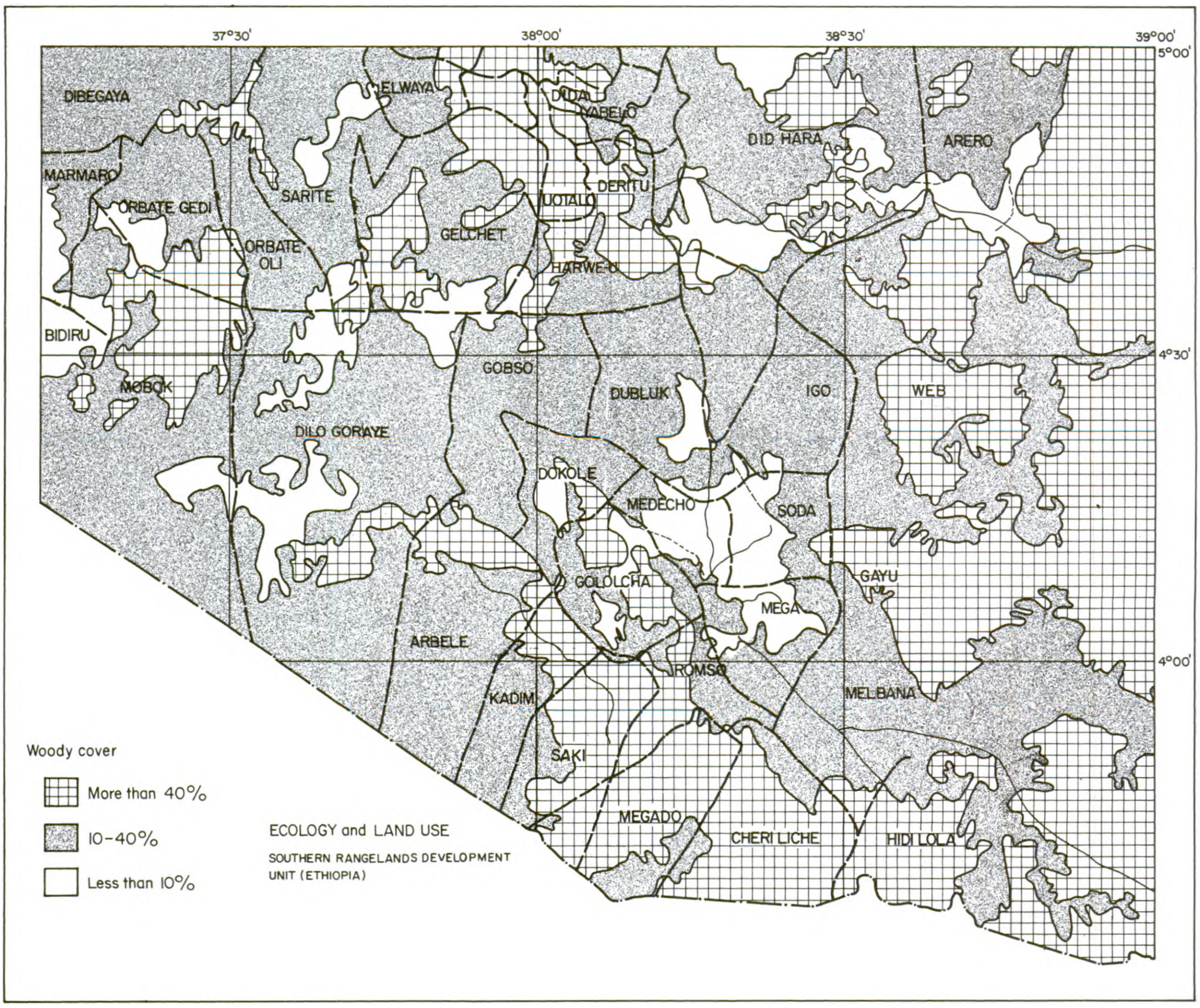
(6) bottomlands, dominated by Vertisols at high and low elevations. *Acacia drepanolobium*, *Pennisetum* spp and *A. seyal* are found where seasonal water-logging occurs. This zone also includes limestone valleys and units of riverine vegetation which are very restricted in occurrence. Landscape features which foster water collection at these sites render the role of annual rainfall less relevant to plant production than in other zones.

Considering the importance of traditional socio-territorial units of the Boran (or *madda*; see Section 2.4.1.7: *Water resources*) for development planning (Hogg, 1990c), a breakdown of agro-ecological zones for 29 *madda* is depicted in Table B1, Annex B. A *madda* map is provided in Figure 2.10. The key finding regarding the distribution of agro-ecological zones is the variation in zonal diversity among *madda*. Bottomlands, regarded as critical for sustainable cultivation and dry-season forage (see Section 2.4.1.3: *Soils*), did not occur in nine of the 29 *madda* but comprised over 10% of the area of seven others (Table B1, Annex B). The high elevation subhumid zone, probably the most stable and predictable in terms of annual forage production (see Section 2.4.1.4: *Climate, primary production and carrying capacity*), did not occur in 12 *madda*, but comprised over 20% of six others. The arid zone, probably the least stable and predictable in terms of annual forage production, was absent in eight *madda* but comprised over 25% of nine others. *Madda* thus vary substantially in terms of zonal diversity. Three *madda* possessed all six zones; 16 possessed four to five and 10 possessed two to three. The most diverse *madda* were Gobso, Harwe-U/Deritu and Orbate Gedi and the least were Dubluk and Kadim.

Variation in types and diversity of ecological zones within *madda* strongly influences development potential, and thus mitigates against having only one resource-intervention strategy (see Chapter 7: Development-intervention concepts). Different properties of zones, ecological units and subunits in terms of suitability for grazing, cultivation and other aspects of sustainable use are reviewed in detail in Annex C and Assefa Eshete et al (1986). In general, these investigators concluded that the subhumid zone has been fairly stable in terms of the conservation of the juniper forest and mixed woodlands since 1970. This is largely a tribute to enforcement of local forestry regulations, since most major towns occur in these areas and demand for wood for fuel and construction is high. The upper semi-arid zone is regarded as the most vulnerable to bush encroachment as a result of heavy grazing. The lower semi-arid zones may require the most flexible herd management strategies for *warra/forra* herds of cattle (see Section 5.3.1: *General aspects of cattle management*) because of the higher annual variability in rainfall and forage production (Assefa Eshete et al, 1986; see Annex C).

Results from satellite imagery and ground surveys revealed a large extent of dense woody cover and a significant degree of soil erosion. Roughly two-fifths of the region had a woody cover exceeding 40% in the mid-1980s, largely in the east, south and north-central sections (Figure 3.2).

Figure 3.2. *Distribution of woody cover on the south-western Borana Plateau during the mid-1980s.*

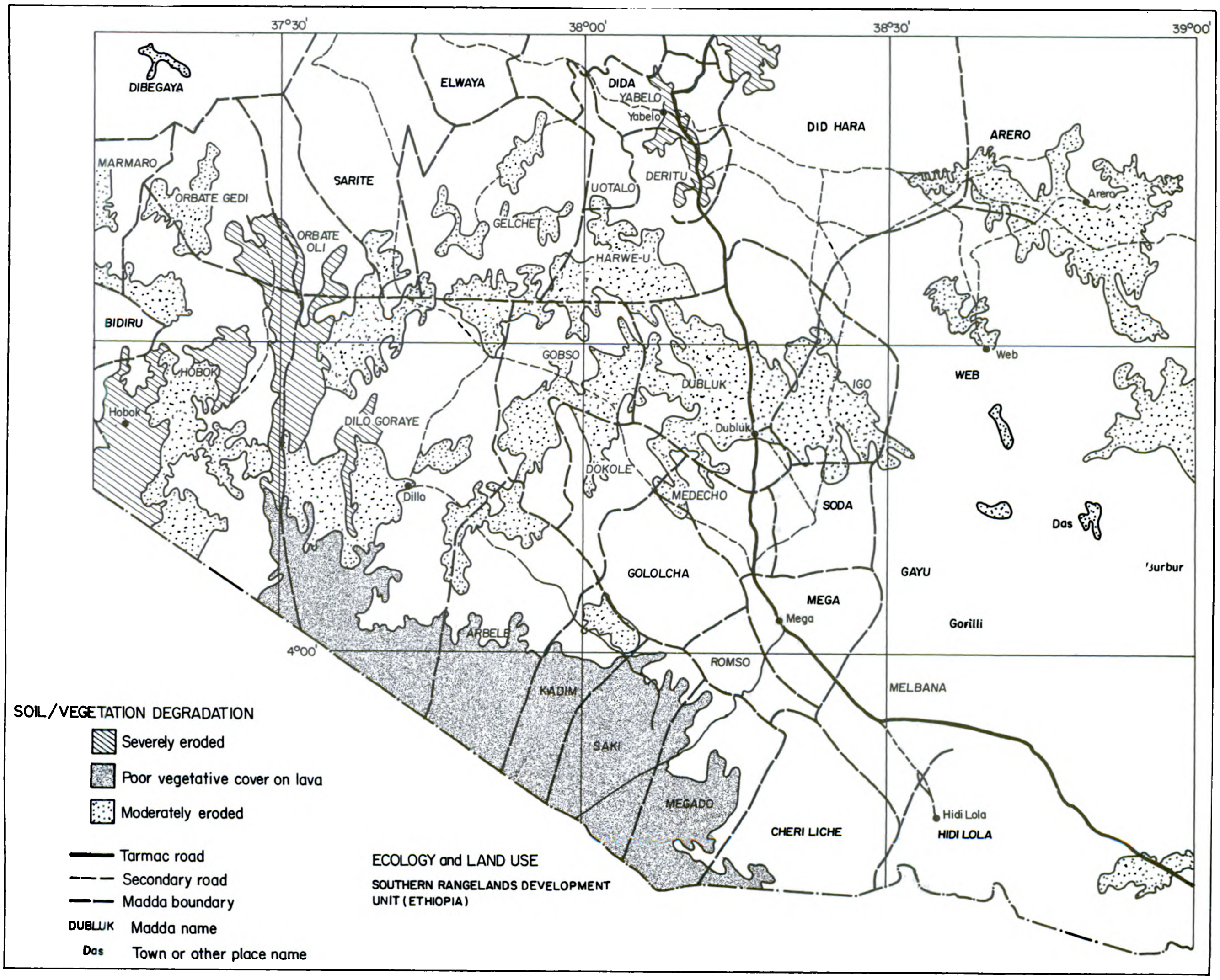


Source: Assefa Eshete et al (1986).

Madda such as Web, Gayu, Hidi Lola, Cheri Liche, Megado, Gololcha, Orbate Gedi, Gelchet, Uotalo, Deritu, Did Yabelo and Did Hara appeared to have the greatest extent of dense woody cover. Severe erosion was observed in the north-central and western portions of the study area (Figure 3.3), amounting to 4% in the mid-1980s. Moderate erosion was observed throughout an east-to-west belt and comprised 15% of the area overall. In total nearly one-third of the study area was assessed as degraded and in need of grazing control (Assefa Eshete et al, 1986). This is important given that degradation was defined by these investigators as instances where perennial plant cover had been "substantially" reduced and erosion occurred as sheets or gullies. These impacts were supposed to have occurred over many generations and largely due to heavy grazing during rainy seasons, with effects magnified on shallow soils (Assefa Eshete et al, 1986: pp 23–24).

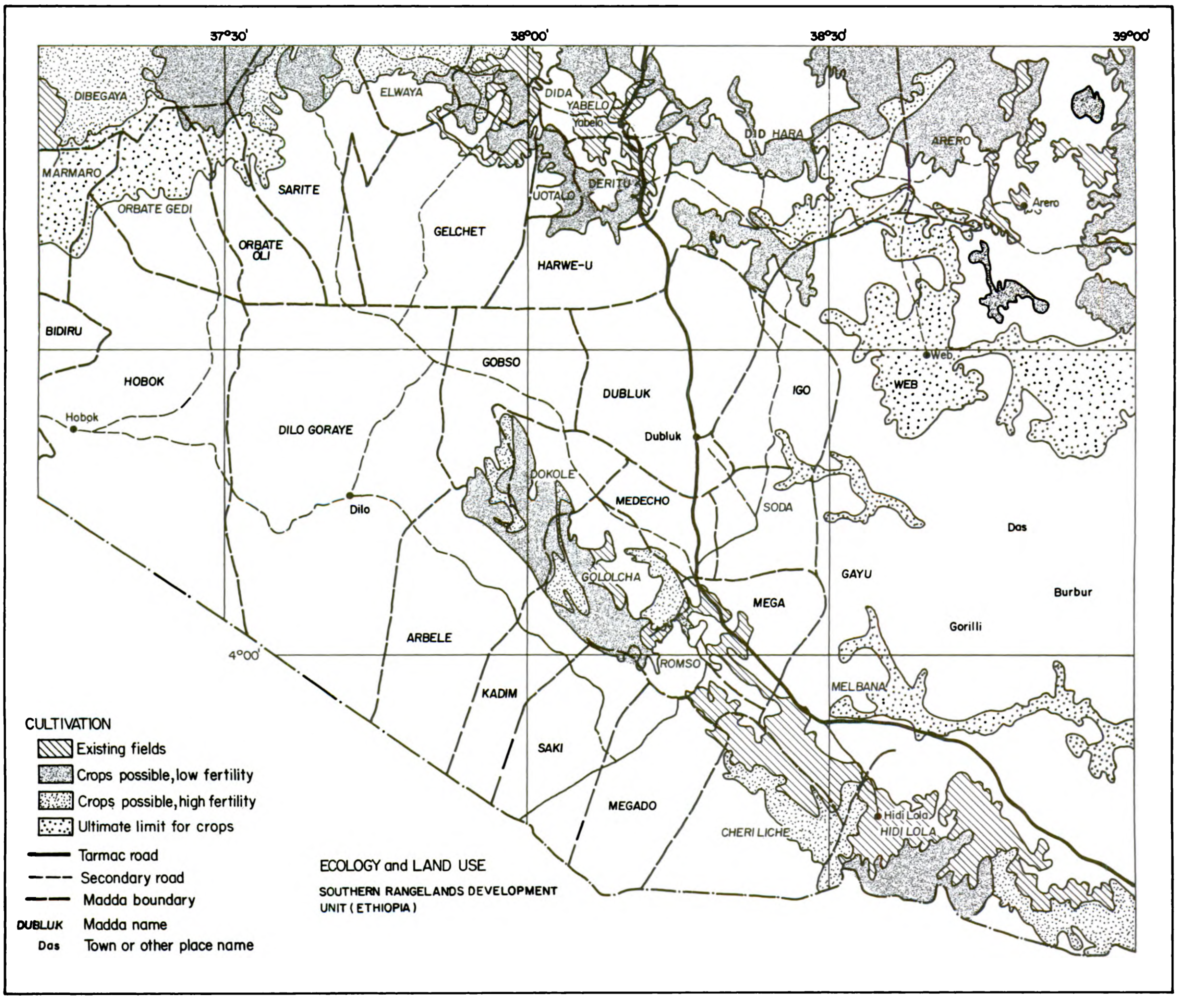
Assefa Eshete et al (1987) reported widespread instances of small cultivated plots in the study area after the 1983 to 1984 drought (see Section 4.3.6: *Cultivation*). In terms of extent, cultivation was most significant at higher elevations near towns such as Yabelo, Mega, Arero, Hidi Lola and in rural areas to the north-central, north-west and north-east and at higher elevations near the Kenya escarpment (Figure 3.4). Roughly 4% of the study area was covered by cultivated fields in the mid-1980s. The ultimate area possible for cultivation, however, may be on the order of 30% overall (Assefa Eshete et al, 1986, 1987). Much of this would occur on slopes at higher elevations and may not be sustainable except under careful management. Note that lower-elevation sites in the semi-arid interior that

Figure 3.3. ***Distribution of soil erosion on the south-western Borana Plateau during the mid-1980s.***



Source: Assefa Eshete et al (1986).

Figure 3.4. *Distribution of cultivation on the south-western Borana Plateau during the mid-1980s.*



Source: Assefa Eshete et al (1986).

offer opportunity for expansion of cultivation are often coincident with Vertisol bottomlands depicted in Figure B1, Annex B. Cultivable sites not located within reasonable reach of wells may also not be utilised. According to the criteria used by Assefa Eshete et al (1986) about half of the *madda* appear unsuitable for cultivation. This suggests that development of sustainable agropastoralism would be highly dependent on site and region-specific features (see Section 7.3.2: *Land-use policy and agronomic interventions*).

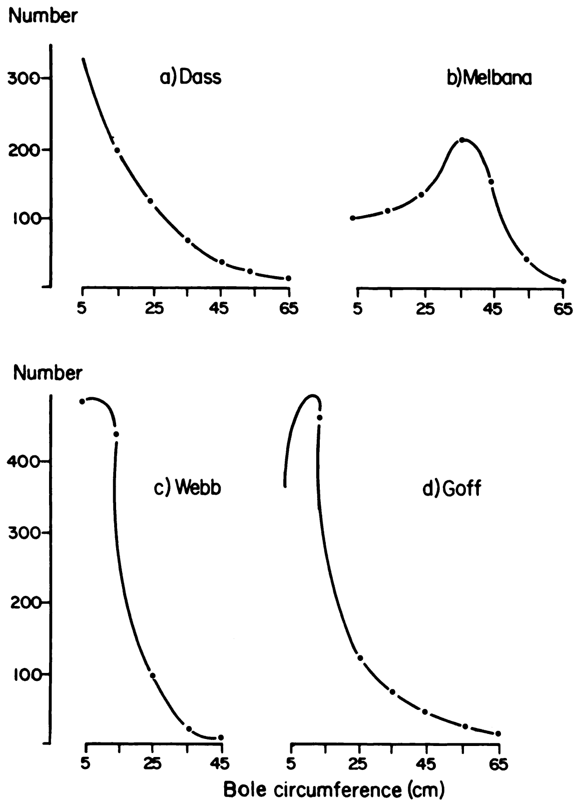
3.3.2 Long-term vegetation change

3.3.2.1 Central semi-arid regions

Highlights of results are presented here. Details may be found elsewhere (Billé and Assefa Eshete, 1983b; Billé et al, 1983, Billé and Assefa Eshete, 1984).

Based on an average of 43 sample points/block, canopy cover of herbaceous plants was similar among blocks and ranged from an average of 20% for Web, Goff and Dass to 29% for Melbana. Blocks were more variable, however, in terms of woody cover. Goff had a woody canopy cover of 70% while the other three blocks were similar and averaged 45%. This difference in woody cover represented variation in density and size of woody plants. Size-class distributions for woody populations are shown in Figure 3.5 (a-d). These data were interpreted to show a relatively mature and stable woody population in Melbana, a more heterogeneous population in Dass and younger populations in Web and Goff. Inspection of areas under the curves in Figure 3.5 (a-d) indicates that the Web population had only 22% of individuals with bole circumferences of over 20 cm (i.e. over 70 years old) while Goff had 24%, Dass 50%, and Melbana 78%. At both Web and Goff woody plants

Figure 3.5 (a–d). *Distribution of various size classes of woody plants in four locations on the central Borana Plateau during the early 1980s.*



Source: Billé et al (1983).

were considered to be reaching maximum densities (i.e. 800/ha). Billé et al (1983: p 24) noted that despite the general similarity of population curves for Web and Goff, there were important differences in the number of very old trees (i.e. those having a bole circumference of over 30 cm). Less than 10% of the trees were in this category at Web, but this increased to about 30% (or 260/ha) in Goff.

Frequency distributions for optimum and observed intensities of grazing pressure and erosion for the four blocks are shown in Figure 3.6 (a-c), and optimum distributions in Figure 3.6b should be compared against those observed in Figure 3.6 (a,c) to visualise trends. Current grazing pressure was skewed towards higher levels for Web and lower levels for Melbana (Figure 3.6a). Erosion appeared more intense for Goff and less so for Melbana (Figure 3.6c). Billé et al (1983) speculated that the data made sense if the four blocks were regarded as different stages in a historical cycle of heavy grazing, woody encroachment, reduced grazing pressure, gradual regeneration of the herbaceous layer and subsequent decline in recruitment of woody plants. Thus:

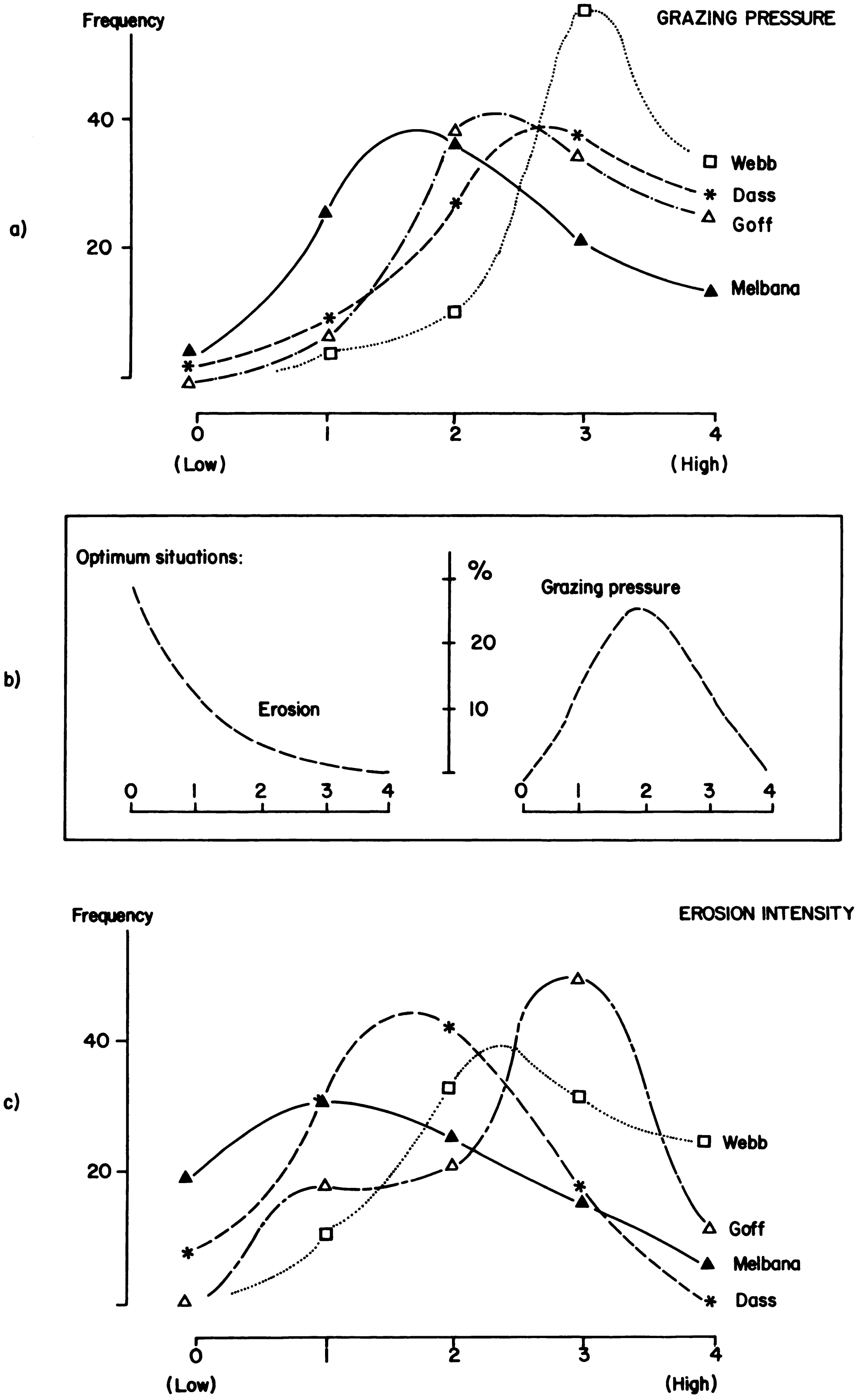
1) Dass was hypothesised to represent an initial stage of impact in which a high intensity of grazing had been occurring for a relatively short period of time. Some grazing-induced erosion had occurred but the scattered woody population had not yet been affected in terms of age structure or density;
2) Web represented the next stage of impact in which the incidence of erosion increased and widespread establishment of young woody plants had occurred;
3) Melbana represented the third stage. Woody plants had increased here many years ago and the pastoralists subsequently abandoned the region (perhaps due in part to heavy utilisation of grasses). The herbaceous layer then recovered in many places, establishment of more woody plants was curtailed and the woody population stabilised and matured. The recovery of the grass layer probably started in the 1960s and was still in progress in the early 1980s; and
4) Goff was hypothesised to be a variant of the third stage. It had apparently been heavily grazed for many decades and a high degree of erosion was noted to have markedly changed the landscape. The mixture of very young and very old trees suggested that successive waves of cattle grazing had not permitted recovery of the grass layer as observed in Melbana.

3.3.2.2 Contrasts of lower and upper semi-arid regions

Based on an average of 39 sample points/block, blocks at Medecho and Did Hara were similar in terms of herbaceous canopy cover (28 to 32%), but less so in terms of woody plant density (460/ha at Medecho versus 640/ha at Did Hara). However, the most interesting differences were in terms of the age structure of woody populations (Figure 3.7). Did Hara had a younger *Commiphora*-dominated community with 64% of the population having a bole circumference of <10 cm while the same-size class at Medecho comprised only 25% of the aggregate population. Conversely, Medecho had a higher percentage (26%) of very old trees (bole circumferences of over 30 cm) compared to Did Hara (2%). Both blocks were being heavily utilised by cattle at the time of the study, with grazing pressure rated from high to very high for an average of 65% of the sample points in both blocks (Billé and Assefa Eshete, 1983b: p 25).

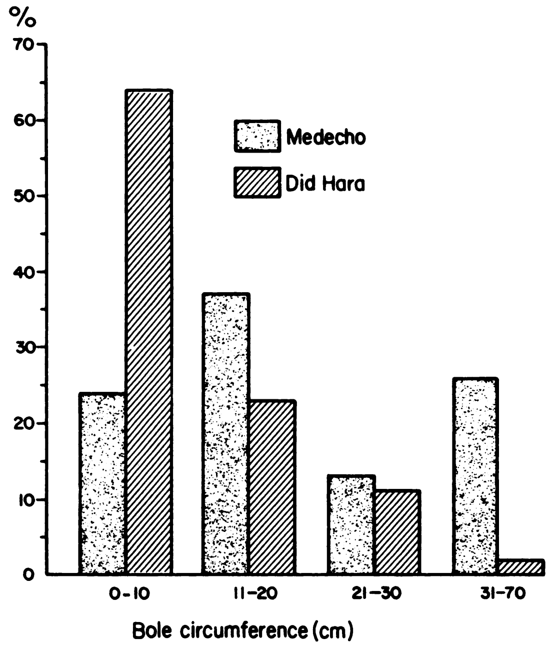
The impacts of recent pond development (especially Beke Pond) on vegetation in Gololcha in the upper semi-arid zone were reported by Billé and

Figure 3.6 (a–c). *Frequency distributions for: (a) grazing pressure and (c) erosion intensity for four locations on the central Borana Plateau during the early 1980s. Optimum situations are shown in (b).*



Source: Billé et al (1983).

Figure 3.7. *Contrast of age structures for woody populations in two locations on the central Borana Plateau. Medecho was a site with a long history of pastoral occupation, while Did Hara had been occupied for about seven years.*



Source: Billé and Assefa Eshete (1983b).

Assefa Eshete (1984: pp 22–27). Based on 47 sample points, average density of woody plants in this block was estimated to be 1170/ha. The age structure of these populations was not assessed because of the density and complexity of the vegetation (Billé and Assefa Eshete, 1984: p 23). Gololcha was thus regarded to be threatened by severe encroachment from species such as *Acacia brevispica* and *Commiphora* spp (Billé and Assefa Eshete, 1984: p 23). Erosion and grazing intensity appeared to be interrelated and both were ranked from high to very high at over half of the sample points, the most for any block. Marked erosion occurred when grass cover was less than 20% (Billé and Assefa Eshete, 1984: p 26). Compared to other blocks, the pronounced impact in Gololcha was probably due to a combination of a higher density of livestock throughout the year (see Section 3.2.2: *Long-term vegetation change*), higher rainfall that favoured faster establishment of woody vegetation and a greater degree of hilliness that predisposes the area to cattle-induced erosion (Billé and Assefa Eshete, 1984; D. L. Coppock, ILCA, personal observation).

Billé and Assefa Eshete suggested (1984) that environmental impacts of livestock at Medecho, Did Hara and Gololcha illustrated the same principles as those inferred from conditions at Dass, Web, Melbana and Goff. Recent and heavy grazing pressure in Did Hara, which had previously been relatively undisturbed by livestock because of poor access to water, elicited a new wave of woody encroachment. Heavy grazing at Medecho in the past was evident in the mature age structure of the woody populations. Gololcha, under the highest rainfall regime, exhibited a particularly strong tendency for woody encroachment from grazing perturbation.

In sum, traditional pastoral exploitation patterns under lower population densities of humans and livestock were hypothesised to consist of the following stages (Billé and Assefa Eshete, 1983b: pp 32–34; Billé and Corra, 1986):

(1) pastoral settlements would be maintained around a given well group until the area was overgrazed to the extent that cattle productivity was compromised. Besides heavy grazing, negative effects on the herbaceous layer could also accrue from a possible reduction in availability of top-soil nutrients (due to nutrient redistribution from forage in grazing areas to corrals at settlements via livestock faeces) and from encroachment of woody vegetation which could limit herbaceous growth through competitive effects for light, moisture and nutrients;

(2) these sites are eventually abandoned, and the grass layer then begins to recover in the absence of grazing. Recruitment in the woody population consequently slows down due to increased competition from grasses, and woody populations mature. To some degree grass recovery could be facilitated by the physical obstruction of woody plants which limit livestock access, and annual leaf litter from deciduous woody plants that could help replenish top-soil nutrients. Nitrogen fixation by woody legumes may also provide important inputs. As the herbaceous layer recovers further, fuel loads would build up and set the stage for fires to thin the woody populations. A fertile, open savannah is thus re-established; and

(3) pastoralists then recolonise the site in a cycle that could take from 60 to 100 years for completion.

3.3.3 Short-term vegetation change

3.3.3.1 Effects of excluding livestock

In terms of soil properties, seven years of protection from continuous grazing only had minor effects ($P<0.05$) on exchangeable cations (Table 3.1). There was also no significant trend ($P>0.05$) among

Table 3.1. *Chemical and physical features of top soils on and off protected calf pastures (kalo) in the southern rangelands.*[1]

Site	Chemical and physical features[2]										
	Texture (%)							Exchangeable cations (meq/100 g)			
	Sand	Silt	Clay	pH	OM (%)	N (%)	P (ppm)	Na	K	Ca	Mg
Protected pasture *(kalo)*	67	16	17	6.9	1.9	0.09	33.7	0.1	1.6	17.4	4.3
Unprotected pasture	65	16	19	7	1.9	0.1	28.8	0.02	1.5	19.9	4.8
Statistics[3]	NS	NS	*	NS	NS	NS	NS	*	NS	*	*

1 Where protected sites had been kept from continuous grazing pressure for at least seven years.

2 Where OM = organic matter, N = total nitrogen, P = phosphorus, Na = sodium, K = potassium, Ca = calcium and Mg = magnesium. Percentages are expressed on an oven-dried basis.

3 Based on paired t-tests for eight pairs of sites. NS denotes not significant with P>0.05. Asterisks denote significant variation for their respective columns at P≤0.05.

Source: Menwyelet Atsedu (1990).

protected *kalo* and unprotected sites in terms of: (1) per cent basal cover of herbaceous vegetation or small shrubs (Table B2, Annex B); (2) density of medium- to large-sized woody plants (an average of 1350/ha within *kalo* versus 1180/ha off *kalo*; (3) crown cover of medium- to large-sized woody plants (an average of 16% within *kalo* versus 13% off *kalo*; and (4) plant species diversity.

More resolution, however, is provided from production data for herbaceous functional groups (Table 3.2). Subtracting standing-crop values before the long rains from those after suggests that total dry-matter production in *kalo* over the wet season was 158 g/m^2 (or 1.58 t/ha), while that for unprotected sites was 83% higher at 299 g/m^2 (or 2.99 t/ha). The composition of production was also markedly different. Production on *kalo* consisted of 62% grasses, 12% legumes and 26% forbs while that for off-*kalo* sites was 38% grasses, 7% legumes and 55% forbs (Table 3.2).

In sum, these findings are interpreted to show that seven years of protection from continuous grazing on these particular sites did not confer notable changes in soil nutrient status or total herbaceous cover. In terms of herbaceous biomass, however, off-*kalo* sites appeared to be more productive overall than *kalo* sites, but this was due to a greater representation of forbs. Forbs probably have lower grazing value for cattle compared to grasses (see Section 3.3.5.1: *Livestock food habits*) and may be regarded as invaders. Similarity in grass production on and off *kalo* suggests that the perennial grasses are somewhat resilient in response to continuous grazing.

3.3.3.2 Interactions among woody and herbaceous plants

Considered across four size classes of two species of woody plants on three sites at the Sarite ranch, herbaceous production over an average 50-m^2 area increased by 58% when woody plants were removed prior to the long rains of 1987 (Table 3.3). Influence of both woody species on the understorey gradually declined up to a distance of 4 m from the

Table 3.2. *Estimated ANPP (g/m^2; ±SD) during the long rainy season of 1988 for herbaceous vegetation on and off protected calf pastures (*kalo*) in the southern rangelands.*[1]

Vegetation component	On *kalo*	Off *kalo*	Statistics[2]
Grass	98.1 ± 36	110.4 ± 40.2	NS
Legume	18.2 ± 5 .7	30.5 ± 6.2	*
Forbs	41.9 ± 11.3	158.8 ± 91.3	*
Total	158.2 ± 37.9	299.7 ± 91.7	*

1 Where protected sites had been kept from continuous grazing pressure for at least seven years. ANPP refers to above-ground net primary production on an oven-dried basis, determined by comparing biomass from exclosure sites between sampling dates before and after the rains of 1989 (i.e. over a period of about 60 days).

2 Asterisks denote significant differences between means in a given row at P≤ 0.05. NS denotes non-significance.

Source: Menwyelet Atsedu (1990).

Table 3.3. *Mean dry weight of herbaceous biomass (kg/ha) produced during the long rainy season of 1987 on 50-m² plots where* A. seyal *or* A. horrida *had been removed or retained.*[1]

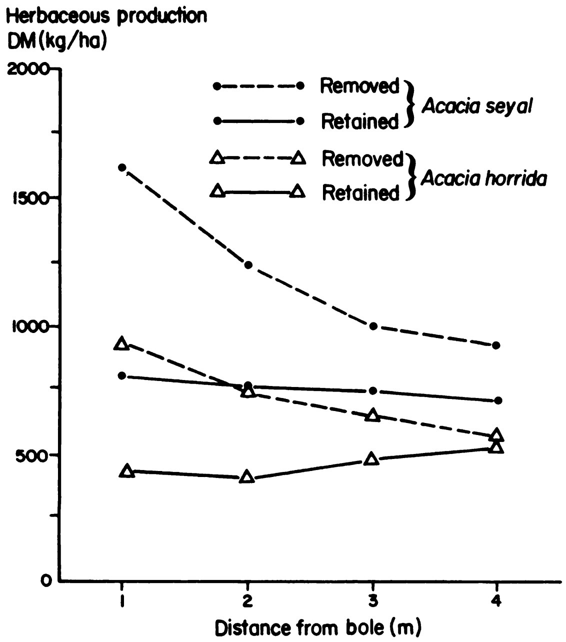
Site	A. seyal		A. horrida	
	Retained	Removed	Retained	Removed
1	1073	1557	425	550
2	586	1055	594	1033
3	540	870	340	504
Mean	759	1194	460	731

1 Where data are based on 16 clipped quadrats (0.25 m²) per tree for 144 trees/species. Means are calculated across four size classes/species at each site.

Source: Solomon Kebede (1989).

central trunk (Figure 3.8). The negative effect of *Acacia seyal* and *A. horrida* on herbaceous production in this locale is understandably large given that they comprised over 60% of a woody community that averaged 337 plants/ha (Solomon Kebede, 1989: p 70). Removal of woody plants also shifted the understorey composition to greater domination by perennial and annual grasses (Solomon Kebede, 1989: pp 182, 188). It was speculated that competition for moisture in the top soil was the critical factor in observed patterns, principally because the influence of woody plants extended beyond their canopies, indicating negative effects on the understorey could not be interpreted just in terms of shading effects. Evidence of competition for water was provided by studies of roots. Excavations showed that a 3-m tall *A. seyal* had lateral roots at a soil depth of only 10 to 15 cm that extended outward over 13 m, but a tap root only 1.2 m in length. An *A. horrida* specimen of similar height had lateral roots up to 7.5 m in length. Even a 20-cm tall seedling of *A. horrida* had a tap root nearly 1 m long (Solomon Kebede, 1989: p 167). *Acacia horrida* may also compete with the understorey for rain water interception; the funnel-shaped crown captures rain water and channels it to the central point of stem emergence (Solomon Kebede, 1989: pp 165, 169).

Figure 3.8. *Total herbaceous production during the 1987 long rains as a function of tree removal and distance from central boles (trunks) at Sarite ranch.*



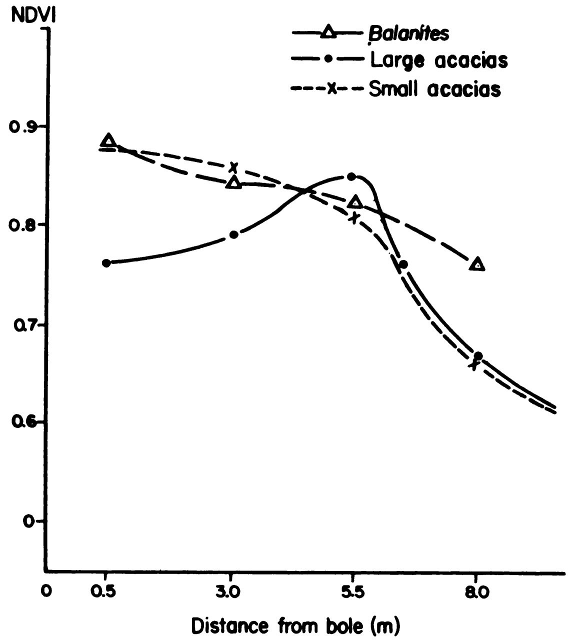
Source: Solomon Kebede (1989).

Billé and Corra (nd) reported different results of effects of trees on understorey cover at the Dembel Wachu ranch. Except for two large specimens of *A. tortilis* and *A. bussei*, NDVI tended to gradually increase in a linear fashion as distance from tree trunks decreased (Figure 3.9). Billé and Corra (nd) noted, however, that herbaceous species composition sometimes changed from grasses to less desirable forbs directly under tree canopies, so the increased NDVI could not be interpreted strictly with regards to grazing potential for cattle.

3.3.4 Population ecology of woody species

Although the laboratory experiment did not reveal an effect of temperature regime on germination rate (P>0.05), there were significant effects (P<0.05) due to species and an interaction among species and seed treatment (Table 3.4). Overall, seeds of *Acacia drepanolobium* germinated to a greater extent (83%) than those of *A. brevispica* (62%). Compared to other treatments, seeds of *A. brevispica* germinated to a higher extent after soaking in hot water. Seeds of *A. drepanolobium* germinated at similar rates regardless of treatment.

Figure 3.9. *Normalised difference vegetation index (NDVI) reading as a function of tree species, tree size and distance from central boles (trunks) at Dembel Wachu ranch in 1986. NDVI values were highly correlated with standing herbaceous biomass.*



Source: Billé and Corra (nd).

In the nursery trial, germination rates were lower overall than in the laboratory experiment with main effects coming from species, watering regime and planting depth (Table 3.5). The only significant species interaction was due to planting depth (Figure 3.10). Other interactions are described in Tamene Yigezu (1990: p 133).

Phenological studies indicated that both species produced fruits starting in October and November (i.e. during the later stages of the short rains) and seed fall occurred between January and April. Specimens at a minimum height of 1 m produced seeds but the largest standing crop of seeds was observed for those over 4 m in height (Tamene Yigezu, 1990: p 153). Standing crop of fruits was influenced (*P*<0.01) by the main effects of height class and site, with evident height class x site interaction (Tamene Yigezu, 1990: p 204). Standing crops of fruits and seeds per tree ranged from around 500 fruits (with 3100 seeds) for trees 1 to 2-m tall in December to over 30 000 fruits (and 180 000 seeds) for trees over 6 m tall in January. Although this seed yield is impressive, about 40% of a random sample of seeds had been damaged by insect larvae (Tamene Yigezu, 1990: pp 202, 206). After seed fall, nearly all seeds were located near the soil surface. Analysis of seed pools

Table 3.4. *Germination percentage of* A. drepanolobium *and* A. brevispica *seeds over 21 days in the laboratory under different seed-scarification treatments.*[1]

Species	Seed-scarification treatments		
	Control	Hot water	Sand paper
A. brevispica	62*y*	73*x*	52*y*
A. drepanolobium	85*x*	83*x*	82*x*

1 See text for description of seed-scarification treatments. Entries in the same row accompanied by the same letter (*x, y*) were not significantly different (P>0.05).

Source: Tamene Yigezu (1990).

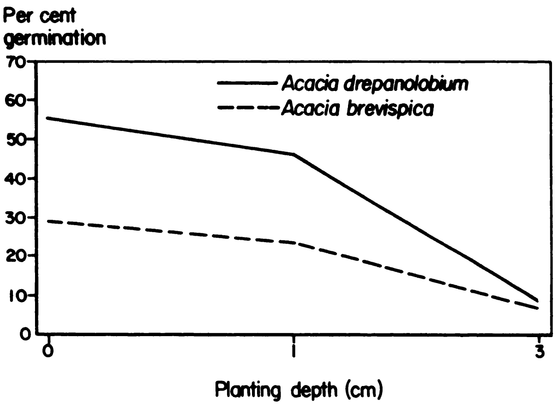
Table 3.5. *Main effects of four experimental factors on germination percentage of* A. drepanolobium *and* A. brevispica *seeds in a four-week trial conducted in a forestry nursery at Yabelo.*[1]

Factor	Per cent germination		
Species	A. drepanolobium		A. brevispica
	37*x*		20*y*
Soil type	Black Vertisol		Red upland
	27*x*		29*x*
Watering frequency	First week only		Weekly
	22*y*		36*x*
Planting depth	Surface	1 cm	3 cm
	42*x*	37*x*	8*y*

1 See text for experimental details. Soils are described in Section 2.4.1.3: *Soils*. Means in the same row accompanied by the same letter (*x, y*) were not significantly different (P>0.05).

Source: Tamene Yigezu (1990: pp 126–133).

Figure 3.10. *Per cent germination of seeds as a function of tree species and planting depth, as determined in a nursery trial in Yabelo during 1988.*



Source: Tamene Yigezu (1990).

indicated that no seeds were below 5 cm in the profile (Tamene Yigezu, 1990: p 170).

Recruitment rates of young plants was low as more mortality occurred before and during the seedling stage. Seasonal dynamics of seedlings in established stands indicated that densities ranged from a maximum of 2 to 4 plants/m^2 within two months after the long rains, but this dropped to <1 plant/m^2 in the following long dry season (Tamene Yigezu, 1990: p 180).

Once established, seedlings grew rapidly. A mature *A. drepanolobium* that was 4 m in height had a tap root 5 to 6 m in length. An *A. brevispica* of similar size also had a 6-m tap root, but in addition had an extensive system of lateral roots (Tamene Yigezu, 1990: pp 17–19). These differences in root morphology may partially explain why the grass understory appears much more reduced in the vicinity of *A. brevispica* compared to that of *A. drepanolobium*; lateral roots may confer greater competition for grasses (D. L. Coppock, ILCA, personal observation).

Acacia drepanolobium presents one of the most visually striking examples of encroachment by woody plants in the southern rangelands (D. L. Coppock, ILCA, personal observation). Maps of populations between Yabelo, Mega and Negele derived from aerial survey in 1988 are provided in Figure B2 a,b, Annex B.

In sum, these studies indicated that seeds were produced in the long dry season, but seed quantity was variable depending on several factors. The seed pool was on or near the soil surface and the majority of these seeds were capable of rapid germination depending on rainfall. A significant percentage of *A. brevispica* seeds, however, may be dormant and depend on other stimuli such as fire for germination. Larger individuals of both dormant and rapid germinating species may produce large quantities of seeds, but annual population recruitment is low due to a variety of factors, the most important of which may be parasitism and predation by insects at the seed-formation stage.

3.3.5 Use of native vegetation

3.3.5.1 Livestock food habits

In the analysis of livestock feeding habits in the Beke pond region, browsing comprised an average of 2, 36, 84 and 100% of the feeding time of cattle, sheep, goats and camels, respectively, when averaged over four seasons (Woodward, 1988: p 40). Camels and goats browsed to a similar degree regardless of season, but sheep appeared to browse more during dry periods. Averaged over four seasons, consumption of *A. brevispica* comprised 39, 29 and 16% of the feeding time of camels, goats and sheep, respectively, and thus was the most important browse (Tables B3, B4 and B5, Annex B). Other commonly used species included *Rhus natalensis, A. tortilis, Grewia tembensis, Cadaba farinosa, Dichrostchyus cinera* and *Ormocarpum mimosoides*. Some of these species (i.e. *A. brevispica, D. cinerea, E. shimperi and R. natalensis*) also elicited high rates of dry-matter intake, usually because their forage was accessible and less protected by physical or chemical defenses (Woodward, 1988). Of 16 dominant species in the study area, 11 were ranked as increasing in the environment and two were ranked as stable. Eight produced preferred forage based on relative occurrence in livestock diets and the environment (Table B6, Annex B).

Chemical composition of 23 important browse forages is shown in Woodward (1988); these data illustrate wide variation in chemical content across species and across seasons within species. Forages were usually higher in nitrogen content and digestibility during wet seasons. During seasonal feeding observations (see Woodward and Coppock, 1989) livestock encountered forages widely ranging in concentrations of polyphenolics (9.6 to 57% of DM), proanthocyanidins (A_{550} absorbance readings from 0.01 to 2.78), total nitrogen (1.4 to 5.9% of DM) and available nitrogen (0.8 to 4.0% of DM). In general, browse with lower nutritive values seem more abundant (Woodward, 1988). Rank correlations of animal dietary preference and chemical attributes of browse indicated that livestock mostly responded to phenolic compounds and nitrogen (Table 3.6). During the long rains, when forage was abundant and animals could afford to be selective, they appeared to avoid those materials having

Table 3.6. *Ranked correlation among animal preference indices and chemical content of forages during two seasons in the Beke Pond Region of the southern rangelands in 1986.*[1]

Season[2] and chemical characteristic[3]	Species		
	Goats	Sheep	Camels
Long rains			
Polyphenols			
Total soluble	-0.429	-0.421	-0.421
	(0.026)*	(0.029)*	(0.026)*
Proanthocyanidins	-0.425	-0.456	-0.418
	(0.029)	(0.19)	(0.032)*
Nitrogen			
Total	0.165	0.41	0.195
	(0.398)	(0.036)	(0.319)
Available	0.107	0.332	0.117
	(0.584)	(0.09)*	(0.550)
Neutral-detergent fibre	0.009	0.038	–
	(0.960)	(0.843)	(1)
In vitro digestibility	0.191	0.163	0.202
	(0.322)	(0.399)	(0.297)
Warm dry season			
Polyphenols			
Total soluble	0.05	–	-0.016
	(0.787)	(1)	(0.945)
Proanthocyanidins	-0.414	-0.386	-0.246
	(0.027)*	(0.041)*	(0.27)
Nitrogen			
Total	0.281	0.286	0.187
	(0.135)	(0.133)	(0.406)
Available	0.393	0.4	0.202
	(0.037)*	(0.036)*	(0.369)
Neutral-detergent fibre	-0.059	-0.129	0.047
	(0.752)	(0.496)	(0.836)
In vitro digestibility	0.084	0.171	0.154
	(0.652)	(0.364)	(0.491)

1 Tabulated entries are Kendall TAU B nonparametric correlation coefficients (Kendall, 1970) with the probability that the coefficient equals zero underneath in brackets. Negative signs preceeding correlation coefficients suggest avoidance. Other entries suggest positive selectivity. Probability values less than 0.1 were considered significant. This is denoted by an asterisk (*).

2 Where the long rains are a time of high forage abundance and diversity and the warm dry season is a time of low forage abundance and diversity.

3 See text for references concerning chemical constituents.

Source: Woodward and Coppock (1989).

higher concentrations of polyphenols and proanthocyanidins. Also at this time, sheep selected for forages higher in total and available nitrogen. In contrast, during the long dry season when forage was scarce, camels were apparently not selective for or against any particular compound, but small ruminants selected forages that had higher available nitrogen and lower levels of proanthocyanidins (Table 3.6). Livestock were not observed to select forages on the basis of fibre content or digestibility (Woodward and Coppock, 1989: p 7).

It was concluded that 29 woody species could be divided into four categories of development potential. Two species provided the mainstay of the browsing system already; 10 species could have greater impact if they were more abundant and the rest were either not feed resources or there was insufficient information on them (Table 3.7). Of the four species that were not feed resources, three (*Acacia drepanolobium, Albizia amara,* and *C. africana*) have been considered as invaders in range trend evaluations (Billé and Assefa Eshete,

Table 3.7. *Categorisation of woody species in the Beke Pond region of the southern rangelands according to development potential based on their relative abundance in diets of camels and small ruminants and in the plant community during 1985–86.*

I.	Current forage resources (i.e. greater than 10% in diets and vegetation)	
	All seasons:	*Acacia brevispica*
	Dry seasons:	*Euclea shimperi*
II.	Forage resources with development potential (i.e. selected for by livestock; greater than 10% in diets but less than 10% in vegetation)	
	All seasons:	*Dichrostachys cinerea*
		Rhus natalensis
	Rainy seasons:	*Acacia etbaica*
		Grewia tembensis
		Ormocarpum mimosoides
	Dry seasons:	*Acacia tortilis*
		Balanites spp
		Cadaba farinosa
		Capparis tomentosa
		Grewia bicolor
III.	Not potential forage resources (i.e. selected against by livestock; greater than 10% in vegetation but less than 10% in diets)	
		Acacia drepanolobium
		Albizia amara
		Commiphora africana
		Lannea flocossa
IV.	Others (i.e. insufficient information; less than 10% in diets or vegetation)	
		Acacia bussei
		Acacia goetzi
		Acacia seyal
		Boscia angustifolia
		Dahlbergia microphylla
		Phyllanthus somalensis
		Caucanthus auriculatus
		Combretum molle
		Commiphora habessinica
		Cordia gharaf
		Plectranthus ctilongipes
		Vernonia cinerascens

Source: Woodward (1988).

1983; Michel Corra, ILCA, personal communication; Tamene Yigezu, 1990). Despite *A. brevispica* being labelled as an encroacher, it is serving an important role as a forage. This was previously noted by Belete Dessalegn (1985).

3.3.5.2 Household use of plants and pastoral perceptions of range trend

A list of 114 plant species used in pastoral households is presented in Table B7, Annex B. These plants have many traditional uses including fencing and firewood (26 species); home construction (16 species); wood and fibres for making household utensils (38 species); medicines for people and livestock (44 species); food for people during years of average or below-average rainfall (49 species); extracts for leather tanning and dyes (10 species); charcoal for incense, fumigation of insects and microbial fumigation of milk-processing containers (15 species); and for spiritual or ceremonial purposes (12 species). On average, each species listed has about two uses but some have over seven to nine uses. Degree of traditional use should influence range management strategies. For example, of the 13 woody species regarded as invaders in the rangelands by Hacker (1990; see Table B8, Annex B), 11 have at least minor uses as food, construction material, medicine and fumigants (Table B7, Annex B). (Readers interested in the vernacular names of native plants throughout Ethiopia should consult Wolde Michael Kelecha, 1987).

Grasses and shrubs mentioned by pastoralists as valuable for calf feeding (grazing or cut and carry) during dry seasons of different degrees of rainfall years are shown in Table B9, Annex B. *Pennisetum* spp were consistently ranked as the most important grasses especially in drier years. Located on deep black soils, *Pennisetum* spp may be the only herbaceous plants with green tissue during dry periods, which explains their utility (Menwyelet Atsedu, 1990). Shrubs were more important in drought years (Table B9, Annex B). The most important fruit-producing trees for livestock were reported to be *A. tortilis* in dry seasons of all years and *A. tortilis* and *A. nilotica* in drought years (Menwyelet Atsedu, 1990).

There was a nearly unanimous opinion in eight of nine *madda* that substantial increases in woody cover had occurred in recent times (*N*=60 group interviews of *olla* residents (Coppock and Mulugeta Mamo, 1985); *N*=5 group interviews of *madda* leaders (Solomon Dessalegn, ILCA/TLDP postgraduate researcher, unpublished data). Increased woody cover reportedly varied from local to regional scales of resolution and trends were attributed to overgrazing and government policy which restricted range burning by pastoralists (Coppock and Mulugeta Mamo, 1985; Solomon Dessalegn, ILCA/TLDP postgraduate researcher, unpublished data). The Boran appreciated, however, that different types and/or stages of woody encroachment can have a variety of effects on the environment (Coppock and Mulugeta Mamo, 1985; see Section 3.3.3.2: *Interactions among woody and herbaceous plants*). At the early stages of encroachment, shading and associated effects of some woody plants are perceived to encourage valuable forage grasses in certain locations. Encroachment also provides easy access to fuelwood and construction materials. Once encroachment becomes pronounced, however, the situation deteriorates in terms of reduced herbaceous cover and hide-out for livestock predators such as lions.

The Boran also report that households are less mobile than in the past and this has contributed to resource-use problems (D. L. Coppock, ILCA, unpublished data; Menwyelet Atsedu, 1990). Reduced mobility by households, as a result of population growth and full occupation of preferred land, has led to changing opinions regarding participation by the Boran in bush-control programmes. This is reported in Section 7.3.1.4: *Site reclamation.*

Solomon Dessalegn (ILCA/TLDP postgraduate researcher, unpublished data) reported a general concern among leaders of five *madda* regarding a declining range condition for grazing over the past 10 years. Coppock (ILCA research scientist, unpublished data) reported similar pastoral perceptions of range trend based on *N*=30 interviews of leaders in six *madda*. Concerns with overpopulation, overgrazing and bush encroachment as consequences of high stocking rates were commonly stated by respondents. Strategies to deal with balancing resource demand and use are forwarded in Chapter 7: *Development-intervention concepts.*

3.4 Discussion

Livestock have been implicated as a major factor in environmental changes whereby 40% of the western Borana Plateau has endured bush encroachment and 19% has significant erosion. This perspective conforms to the mainstream view that pastoralists and their livestock can have widespread negative effects on natural resources, irrespective of climatic factors (see citations in Section 3.1: *Introduction* and Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). Tendencies towards trends such as bush encroachment, however, have also been exacerbated by government policy.

3.4.1 Ecology and land use

Two major findings from the ecological mapping exercise are: (1) documentation of the high spatial diversity in forage resources conferred by the 104 ecological site types and (2) the high variability in access to the six ecological zones by residents of the 29 *madda*. To recap, sustainable rain-fed cultivation may be very viable on suitable landscapes in the subhumid and upper semi-arid zones as well as in bottomlands. Zonal criteria should be reviewed in the formulation of policy providing for cereal cultivation (see Section 7.3.2: *Land-use policy and agronomic interventions*). The subhumid and upper semi-arid zones have conditions that are conducive to woody encroachment and the arid zone requires the most flexibility in pastoral management due to patterns of past degradation as well as its variable availability of forage and water. This all implies that rather than embracing one comprehensive approach for range management and pastoral development, efforts need to be tailored, at minimum, to deal with region-specific issues at the *madda* level of resolution. This would require, however, a level of site-specific research and coordination that greatly exceeds the capabilities of local governmental and nongovernmental organisations. A reasonable compromise could promote collaborative, participatory approaches which involve the Borana leadership and repealing controversial land-use policies (see Chapter 8: *Synthesis and conclusions*).

Despite the diversity in ecological communities, the diversity of readily accessible landscape types with marked seasonal variation in access to strategic production resources (e.g. uplands vs bottomlands or mountain ranges) appears low on the central Borana Plateau compared with other pastoral systems in East Africa for which use of different landscapes is well documented. This is largely because bottomlands occur on <12% of the total area and because mountains are usually inaccessible to livestock because of poor water availability (see Section 2.4.1.7: *Water resources*). Bottomlands are also unevenly distributed. Coppock et al (1986a) and Ellis et al (1986) illustrated the critical role of forested riverine areas and mountain savannahs in promoting livestock species diversity and the perseverance of Turkana pastoral subsystems in arid north-western Kenya. Scoones (1991) noted the increasingly critical role of bottomlands in African pastoral systems. They serve as sources of dry season forage and offer opportunities for the development of agro-pastoralism. As a result, bottomlands are commonly a source of land-use conflicts where population pressure is acute (Scoones, 1991). On the central Borana Plateau bottomlands are exploited mainly for collection of calf forages in dry seasons (Menwyelet Atsedu, 1990) while northern subhumid and upper semi-arid zones at higher elevations are used by cattle during extended dry seasons and drought (see Section 6.3.1.1: *Livestock dispersal and herd composition*). Use of reliable *tula* well systems during drought also leads to herds gathering in "fall-back" *madda* (see Section 2.4.1.7: *Water resources*). Such trans-*madda* movements of cattle reduce the relevance of *madda*-specific estimates of carrying capacity during times of stress. Instead, resource managers need to consider population and resource-use dynamics at a level of resolution which encompasses the entire western half of the Borana Plateau (see Chapter 8: *Synthesis and conclusions*).

3.4.2 Environmental change

As perhaps the most ubiquitous consequence of heavy grazing pressure in the Borana plateau, bush encroachment is not unusual in semi-arid East Africa. Increases in woody vegetation have been commonly reported as a response to heavy grazing elsewhere (Norton-Griffiths, 1979; Cumming, 1982; Sabiiti and Wein, 1988; Belsky, 1989; á Tchie and Gakahu, 1989; Msafiri and Pieper, 1989).

3.4.2.1 Review of ancillary work in Borana

Other investigators in the southern rangelands made similar conclusions regarding impacts of pastoralists on the environment. During the early 1970s when human and livestock numbers were just beginning to increase in the Did Hara region in response to pond development, consultants from AGROTEC/CRG/SEDES Associates (1974d: pp 85–87) noted that woody encroachment was a risk there. They also stated that woody encroachment had already advanced in a number of other semi-arid regions.

Reporting on a brief consulting survey, Pratt (1987a: pp 15, 17) noted that given the favourable rainfall of the region, natural succession would lead to a dominance of woody plants in most communities regardless of grazing. He recognised the heightened soil erosion on slopes at higher elevations and speculated that it was caused by high stocking rates and the trekking of cattle to up-country markets. Pratt (1987a: p 18) also reported extensive bushland and thickets below 1500 m elevation. He hypothesised that the overall increase in woody plants appeared to be due to a gradual thickening of existing stands as a result of seedling recruitment rather than expansion of plants into new sites. Pratt (1987a: pp 17–18) concluded that although woody encroachment was marked, the rangeland was still in "reasonable" condition because: (1) patches of high-quality perennial grasses remained in heavily grazed sites that could respond well to adequate rainfall; and (2) similarity in grass cover between government ranches (managed at lower stocking rates) and adjacent communal rangeland. Pratt (1987a) felt that priority attention should be given to arrest trends toward rapid resource deterioration at higher elevations where population pressure was most acute.

Summarising another consulting survey, Hacker (1990: pp 5–24) also confirmed a high incidence of soil erosion and the presence of young woody plants in 68% of 801 survey sites. He noted that erosion appeared to be greatest on slopes comprised of red soil (i.e. yellow-red Haplic Xerosols) where grass cover was reduced by grazing, but that the amount of grass cover was not strongly associated with abundance of young woody plants. In contrast to the more favourable assessments three years earlier in the same region by Pratt (1987a), Hacker (1990) ranked 43% of his sample sites from poor to very poor grazing condition and felt that the government ranches had markedly higher grass cover than areas outside (note that the discrepancy between the range condition surveys of Pratt,1987a and Hacker, 1990 may be explained by growth in the cattle population during 1987–90; see Section 7.2:

A theory of local system dynamics). From a comparison of 15 sample points near Yabelo town using aerial photos from 1967 and 1984, Hacker (1990: pp 27–37) estimated that woody canopy cover had increased only slightly (from 24.1 to 28.5%) and that cover had increased at only four and decreased at only one of the sites. He concluded that changes in woody cover in this particular region were thus more local than general in nature, which supports Pratt's (1987a) contentions.

In sum, the concensus appears to be that soil erosion and woody encroachment have occurred to varying degrees throughout the study area. While livestock pressure can probably be directly linked to soil erosion along trekking routes and high-elevation slopes, mechanistic ways that link cattle to woody encroachment are less clear. The tendency for woody plants to proliferate under grazing perturbation is greatest in the upper semi-arid and subhumid zones because higher soil moisture increases the likelihood of establishing woody vegetation (Tamene Yigezu, 1990).

In addition, woody encroachment could also be facilitated if grazing modifies the competitive relations among grasses and woody seedlings for soil moisture and nutrients, an interaction which may be most pronounced on fine-textured, rather than sandy, soils (Walker et al, 1981; Walker, 1985; Knoop and Walker, 1985). Most of the soils on the Borana Plateau are relatively fine-textured (Kamara and Haque, 1988).

Another factor that has probably facilitated woody encroachment may be the national policy banning burning of grazing and agricultural lands since the mid-1970s. Prior to this the Boran burned rangeland to improve forage quality and control woody plants and ticks (Coppock, 1990b). This policy constraint has been noted by several investigators (Billé, 1985; Pratt, 1987a: p 18; Hacker, 1990: p 20). However, it is noteworthy that extensive woody encroachment predated the ban (AGROTEC/CRG/SEDES Associates, 1974d: pp 85–87; Billé et al, 1983). This suggests that traditional use of fire was only partially effective in controlling woody vegetation. The local ban on range fires was lifted by government administrators in 1990. This is discussed further in Section 7.3.1.4: *Site reclamation*.

3.4.2.2 Hypothesised cycle of grazing-induced vegetation dynamics

Billé and Assefa Eshete (1983b: p 34) noted the traditional importance of the hypothesised cycle of patch use by cattle and shifts in vegetation composition in maintaining a long-term dynamic stability and diversity of the Borana ecosystem. Factors that could disrupt the cycle, such as higher human and cattle populations that re-use sites before grass recovery has taken place (as at Goff), or higher populations of browsing stock (e.g. goats) that prevent establishment of woody vegetation, could negatively affect the sustainability of pastoral production. The same would hold if fire were too frequent (see Section 7.3.1.4: *Site reclamation*). Woody encroachment could be beneficial in the long run by forcing pastoralists to migrate from overgrazed sites thereby providing the degraded areas with an opportunity to rehabilitate themselves (Billé and Assefa Eshete, 1983b).

In a rigorous sense, the elements that underpin the hypothesis of a cycle of grazing-induced dynamics of woody encroachment remain untested although some of its key elements are supported by other work in Borana and research from similar systems elsewhere:

Migration of pastoralists in response to condition of the local resource base. Observations that the Boran occupy areas until they are severely overgrazed is only supported by the anecdotal reports of Billé and Assefa Eshete (1983b) for Medecho *madda*. Pastoral response to advanced stages of woody encroachment can only be surmised from interviews. Herd owners have said that instead of attempting to control local woody encroachment they would prefer to move elsewhere (D. L. Coppock, ILCA, unpublished data). This is a logical response for households that have considerable labour constraints (Mulugeta Assefa, 1990), as benefits accrued to individuals from implementing difficult tasks such as bush clearing in communal grazing areas are probably only a fraction of the cost. Although the Boran are semi-settled, they can be highly mobile when the need arises. Encampments usually change location once every five to eight years and this is commonly related to the search for better grazing (Donaldson, 1986; Cossins and Upton, 1987). Herd owners have reported that today, however, it is increasingly difficult to relocate to improved grazing sites because of the general increase in the numbers of both people and cattle (see Section 7.1.3: *Review of dynamics and past interventions*). They also think they are becoming more sedentary than in previous generations and this is reportedly due to the attraction of roads, markets and permanent water development that encourage settlement (Menwyelet Atsedu, 1990).

The role of livestock grazing and corralling in relation to nutrient redistribution. Heavy grazing could serve to concentrate a significant quantity of nutrients from surrounding foraging areas because cattle are corralled nightly at encampments, but this has not been quantified. Tonnes of manure are neatly piled into small hills at each Borana encampment and this often represents many years of accumulation (Donaldson, 1986). Elsewhere in pastoral Africa it is well known that corralling confines animals for about 50% of the time and consequently serves to concentrate large quantities of nutrients (Jahnke, 1982: p 35; Powell, 1986; Coppock et al, 1988). In addition to nutrient transport, frequent defoliation of perennial grasses during growing seasons could serve to deplete nutrients in the top soils of foraging areas by stimulating translocation (Botkin et al, 1981).

The role of woody encroachment in facilitating recovery of the herbaceous layer. If nutrient depletion in top soils is a factor in the decline of herbaceous productivity under heavy grazing on the Borana Plateau, there is other evidence that woody encroachment could have some beneficial effects on recovery of herbaceous vegetation by improving soil fertility. First, since woody seedlings can grow deep roots quickly (Gates and Brown, 1988; Solomon Kebede, 1989; Tamene Yigezu, 1990) they could establish and tolerate nutrient-depleted top soils to a higher degree than shallower-rooted grasses. Second, woody plants have been shown to have a potentially significant role in nutrient turnover and the replenishment of soil fertility in semi-arid savannahs. Billé and Corra (1986) made some initial calculations of nutrient budgets for sites on the central Borana Plateau and estimated that leaf litter from at least 200 woody plants/ha could provide roughly 57% and 21% of the annual turnover for nitrogen and phosphorus, respectively.

Hatton and Smart (1984) described the effects of a 24-year exclusion of wild herbivores from a Ugandan savannah. Under natural conditions, elephants prevented the persistence of woody populations through their feeding and clearing activities. Once elephants were excluded, however, an increase in acacias occurred and these extracted nutrients from the soil profile and deposited litter on the soil surface. Compared to unprotected sites, top soils of protected sites showed up to a five-fold increase in exchangeable cations, a 50% increase in nitrogen and up to a 30% increase in organic matter. Similarly, Radwanski and Wickens (1967) in the Sudan and Radwanski (1969) in northern Nigeria found *Acacia albida* and *Azadirachta indica*, respectively, to improve the fertility of top soils. Bosch and Van Wyk (1970), Charley and West (1975) and Weltzin and Coughenour (1990) also found woody plants to improve soils and/or micro-climate for herbaceous plants. Dreyfus and Dommergues (1981) highlighted the potential role of nitrogen fixation by native woody legumes in improving soil fertility when colonising new sites.

It is important to note, however, that whether interactions among woody and herbaceous plants are positive, neutral or negative depends on soil texture (Walker, 1985), soil fertility (P. N. de Leeuw, ILCA, personal communication), harshness of climate (Weltzin and Coughenour, 1990), density and maturity of the woody layer, and potential for species-specific competition based on compatibility of the seeds, juveniles and mature forms of the plants (Harper, 1977). Of particular importance for species-specific interactions are root morphology and distribution (Walker, 1985) and the degree to which woody crowns intercept light from the understorey. Whether plants are adaptable to drought and/or fire would also complicate interactions.

Examples of the diverse interactions among plants on the Borana Plateau include the apparently positive or neutral effects of *A. tortilis* (Billé and Corra, nd) and *A. drepanolobium* (Tamene Yigezu, 1990) on the herbaceous layer as well as negative effects of *A. horrida* and *A. seyal* (Solomon Kebede, 1989). A major hypothesis to explaining these diverse interactions is variation in the root and crown morphologies of the woody plants. The most marked contrasts include those species with lateral roots, short boles and low spreading crowns (i.e. *A. horrida*) having the most negative effects and those with tap roots, tall boles and elevated open crowns (i.e. *A. drepanolobium*) having only minor effects.

3.4.2.3 Short-term grazing effects

Results of Menwyelet Atsedu (1990) on and off *kalo* (traditional reserves) sites were most notable in terms of the lack of significant effects that seven years of protection from continuous grazing had on soil chemistry, woody populations, herbaceous cover and species composition, or grass production. These findings are also striking because off-*kalo* sites occurred in the immediate vicinity of encampments where grazing pressure is expected to be high. Work also was conducted during the high-density phase of the cattle population in the interdrought cycle (see Section 7.2: *A theory of local system dynamics*). This suggests that these particular plant communities are resilient enough to cope with heavy use (as noted by Pratt, 1987a: pp 17–18). This could, in part, be to their being established on deep soils (Menwyelet Atsedu, 1990) and may not be widely generalisable. That forb production markedly increased off-*kalo*, however, suggests that the plant community did respond at least in a minor way to heavy grazing. Forbs have not been observed to be important dietary components for cattle in East African pastoral systems, although they may be more important for small ruminants (Belete Dessalegn, 1985; Coppock et al 1987a). Forbs are low in fibre which is the major dietary constituent for energy for cattle (Kay et al, 1980). The increase in forbs may thus have no effect on cattle in the Borana system as long as grass production is not compromised. Food habits and nutritional studies would be required for an adequate assessment of the situation regarding small ruminants.

3.4.2.4 Population ecology of woody species

There are roughly 16 species of woody plant in the Borana Plateau that are thought to be encroachers (see Table B8, Annex B). Trials conducted by Tamene Yigezu (1990) on two species are thus limited in scope, but offer some potentially important insights. That heat treatment in the laboratory stimulated germination of *A. brevispica* seeds significantly more than other treatments serves as a caution for prescribed burning as a management tool for bush control in the upper semi-arid and subhumid zones. Field research involving heat treatment of *A. brevispica* should be designed to detect effects on seedling emergence. Heat scarification of seeds may well be an important survival strategy for woody plants in zones where plant communities have evolved under frequent fire disturbance.

3.4.3 Use of native plants

Although limited in regional extent, livestock food habits observed on the Borana Plateau are typical of those recorded for the same livestock species elsewhere in East Africa in terms of relative emphasis on grazing or browsing (Migongo-Bake and Hansen, 1987; Coppock et al, 1986a). Our work documents the potentially high degree of dietary overlap between grazing cattle and sheep on a forage-class basis, while browsing goats and camels appear to have more distinctive diets. Although goats and camels share some preferences for certain woody species (Woodward, 1988), differences based on feeding height in the canopy are to be expected.

There were no studies of forage competition *per se* among livestock on the Borana Plateau that should increase in one livestock species leading to production constraints in another as a result of reduced intake of preferred forages. It is speculated, however, that the potential for competition exists between cattle and sheep in some situations. Cattle comprise over 90% of the livestock biomass on the central plateau and cattle productivity may be significantly compromised during average rainfall years when cattle density exceeds 25 head/km^2, creating a situation for possible forage competition (see Section 7.2: *A theory of local system dynamics*).

Given such hypothesised intra-species pressure for cattle, inter-species pressure from cattle to sheep may also be likely during the high-density phases of cattle population. During other times disease may be the most pervasive constraint for sheep production. In contrast, disease may be the most chronic limiting factor for goats and camels given their low population densities and abundant browse resources (see Sections 5.3.7.1: *Sheep and goats* and 5.3.7.2: *Camels*). These perspectives are important given the apparent opportunities for increasing livestock species diversity as a development strategy among the Boran (Section 7.3.3.2: *Camels, donkeys and small ruminants*). While marketing opportunities may best justify promoting them (Section 4.4.3: *Livestock supply to markets*), sheep are the least complementary species to cattle in terms of food habits on a forage-class basis. By virtue of their food habits, the scope to increase goat and camel populations appears greater. Neither, however, are able to control bush encroachment according to Borana informants (see Section 7.3.1.4: *Site reclamation*).

Results from Woodward (1988) and Woodward and Coppock (1989) indicate an abundance and a variety of browse species although not all are suitable forage based on morphological features and/or variable concentrations and types of polyphenolic compounds. Woodward (1988) noted that species higher in polyphenolics tended to be more abundant in this upland study site. While this suggests that past browsing pressure may have led to the persistence of less palatable species, site-specific effects may also be a factor. Coley et al (1985) theorised that plants on nutrient-poor soils have "more to lose" from excessive *herbivory*, and may consequently invest more resources into concentrating defensive secondary compounds. Conversely, plants growing on more fertile sites may tolerate more herbivory because nutrients lost to herbivores may be more readily replaced. These plants may thus invest fewer scarce resources in secondary compounds. This suggests a hypothesis that browse species growing in bottomlands may be more palatable than those growing in uplands (see Section 2.4.1.3: *Soils*).

Importantly, the mere presence of tannins does not indicate that forage has inferior feeding value; nutritional variation occurs with respect to types and concentrations of polyphenolics and the level of intake. Forages therefore need to be tested on a case-by-case basis using feeding trials. It is envisioned that small quantities of various types of tanniferous acacia leaves and dry dehiscent fruits could be useful as protein supplements for calves on grass hay diets (see Section 7.3.1.3: *Forage improvements*). This underscores the claim that, given the generally poor results from numerous establishment trials with exotic forages (Hodgson, 1990), more benefits could accrue from identifying promising indigenous grasses and trees and attempting to promote these more widely in the Borana system. Some valuable grasses are *Pennisetum*, *Chrysopogon*, *Cenchrus*, *Chloris*, *Cynodon* and *Themeda* spp to others (also see Section 2.4.1.5: *Native vegetation*). Valuable woody plants are *A. brevispica*, *Euclea shimperi*, *A. tortilis*, *Dichrostachys cinera*, *Rhus natalensis*, *Pappea capensis*, *A. etbaica*, *Grewia* spp, *Ormocarpum mimosoides*, *Balanites* spp, *Cadaba* spp and *Caparis tomentosa* among others. Those regarded as encroachers and with little apparent value for animals or households include *A. drepanolobium*, *Albizia amare*, *A. horrida* and *A. mellifera*. Strategies to make economic use of encroaching species are reviewed in Section 7.3.1.4: *Site reclamation*.

Not surprisingly, the Boran have an excellent knowledge of native vegetation, a common fact among rural people in Africa that has spurred interest in ethnobotany (Morgan, 1981; Stiles and Kassam, 1984; Marx and Wiegand, 1987; Mathias-Mundy and McCorkle, 1989). In this regard, plants used as traditional medicines for people or animals may have a role in developing more sustainable health practices in situations where imported drugs are expensive or unavailable (Tafesse Mesfin, 1990). Research to confirm stated properties of various plant compounds is thus required. Where range management goals focus on reduction or promotion of certain plant species, information should be solicited regarding household use. Forage value of plants should not be the sole criteria for management objectives. Government policy also impinges on the use of plants for cultural items and/or handicrafts. Blanket bans against taking out certain wooden handicrafts from the Borana Plateau to market in Addis Ababa are based on the premise that the tree species involved are endangered (Hodgson, 1990). While caution is commendable, policy makers need updated information on the abundance and trends of key tree species to guide policy. Pastoral households should not be deprived of needed ancillary income from handicraft sales if the species in question are abundant and increasing.

Chapter 4

Borana household economy

Summary

This chapter reviews aspects of Borana household composition and economy as they pertain to average rainfall years during the 1980s. Related topics include labour allocation, livestock marketing, milk processing, dairy marketing and cultivation. Production units are defined as typically consisting of a male household head, one wife, two to three children and perhaps several other live-in relatives dependent upon the livestock for which the household head assumes management responsibility. Men are largely the decision makers for livestock production, while women carry on day-to-day management and retain primary responsibility for dairy-related activities. Widowed women may comprise 20 to 25% of household heads, especially within 30 km of urban areas. These women probably have greater managerial and strategic roles in the society than married women in general. Labour allocation is profiled on a daily basis for married women in different seasons, as well as for both males and females at the encampment and regional level of resolution. Herding and watering animals dominate labour requirements overall with related manpower shortages common during dry seasons.

The average production unit may include some 15 cattle (with eight milking cows), seven small ruminants, an occasional equine or camel for transport and a few chickens. Marked wealth stratification is evident. Some families have only one or two milk cows while others may have over 40. Fifty-one per cent of a sampled population (N=633) were considered poor in terms of per capita livestock holdings, while 31% and 18% were intermediate and wealthy, respectively. Annual cash income may range from US$ 45 (poor) to US$ 217 (intermediate) and US$ 382 (wealthy), but cash income is not entirely indicative of wealth. Annual gross revenue, commercial plus subsistence production, may average US$ 975 and at least 90% of this is derived from cattle, of which 40% accrues from milk production. Gross revenue is divided between production for marketing (31%) and subsistence (69%).

Probably less than 1% of animal outputs are used as crop inputs, thus the average household retains a pastoral, rather than agropastoral, orientation with little crop–livestock integration. Small agropastoral communities appear to be growing in the wetter parts of the study area and the immigrants include poor people who have dropped out of the pastoral sector. Cultivated plots (<0.5 ha/plot on average) occur throughout the plateau (at an average of 3.2 plots/km^2) and these are largely planted with maize in the long rains and cowpea (*Vigna* spp*)* in the short rains. Increased cultivation is attributable to a declining ratio of livestock:people as exacerbated by human population growth and drought.

Men and women share duties in cultivation and animals are occasionally used for ploughing. About 1.4% of the study area was cultivated in 1986, representing 5% of the arable land.

Going by recent high rates of crop expansion in the post-drought period of 1984–86 (i.e. 90 km^2/year), all arable land could be utilised in the next two generations. This estimate may be conservative if animal traction becomes more pervasive and other assumptions hold untrue. Compared to similar African systems, densities of people and livestock suggest that preconditions now exist to force a widespread shift to agropastoralism on the plateau where the environment permits and in the absence of other development opportunities. The population, however, has been partially dependent on grain purchases for at least the past 25 years. A shift to agropastoralism could allow some Boran to procure more food and still restrict sales of animals for grain purchases so that herd capital can be retained for other purposes.

Analysis of 67 803 records of livestock sales from the early 1980s confirmed that: (1) cattle were by far the dominant species marketed; (2) cattle sales were dominated by mature males (52% of volume) and (3) supply of animals was highly variable among markets and years. Studies of livestock marketing rationale suggest that the Boran: (1) prefer to avoid cattle sales in light of the need for animal accumulation; (2) are increasingly forced to sell cattle to procure food grain; (3) may diversify more into small ruminants as a replacement commodity to reduce prospects of having to sell cattle; (4) tend to sell in dry seasons when they have an acute need for money; and (5) prefer to sell mature male cattle because the income is sufficient to procure goods as well as replacement calves, thus satisfying several objectives. The poor are often forced to sell immature cattle because of a low number and diversity of animals held. This further diminishes their prospects for animal replacement. Increased numbers of immature cattle in markets may thus be an indicator of increasing poverty, and not a sign that the production system

is being transformed in a "progressive" fashion according to Western models of production where cattle are fattened for market. A pastoralist does not plan to sell and when he does it is in response to an acute need for money.

Boran herd owners disclosed that should cattle prices increase, and the prices of consumer goods remain constant, the ultimate result over time would be a lower throughput of cattle through marketing channels. The Boran seek higher prices precisely to reduce the number of cattle households have to sell over the longterm. This is the main incentive for selling cattle on the black market with Kenya. If the same scenario were to occur for small ruminants, the ultimate response would be a higher throughput because these species are perceived to have a lower socio-economic value and greater production risks than cattle. Despite the persistence of such traditional values, younger herd owners in peri-urban locations are becoming more interested in trade. There is also a general and increasing awareness of the necessity for markets to promote the survival of the society at large. Herd owners reported that should Ethiopian prices for livestock become similar to those offered by Kenyan buyers, they would prefer to sell to Ethiopian interests.

Coming to traditional livestock outputs, common products are fresh milk, butter, buttermilk, soured milks and ghee. Butter and fresh milk are commonly sold by households residing within 30 km of market. Butter tends to be sold more by wealthier households further from market while fresh milk is sold relatively more by poorer households living closer to market. Proceeds from dairy sales are controlled by women and are important to all families, averaging around 20% of annual income. Dairy sales decline markedly in dry seasons compared to wet seasons, and families residing within 10 km of market reportedly sold 16 times more products than those residing 21–30 km from market. Dairy sales are often the main source of regular income for the poorest households who have little else to sell. This justifies the settlement of poorer households in peri-urban areas and underscores the importance of local market opportunities generated by small towns. Increased dairy sales by poorer households with easy access to market but with low-producing milk cows may pose health risks for calves because of nutritional stress resulting from reduced milk intake. This could jeopardise calf recruitment, and thus prospects for herd growth for the peri-urban poor.

4.1 Introduction

The organisational structure of a pastoral society can be described in terms of a hierarchy which includes households, extended families, encampments or villages, neighbourhoods containing encampments and regional associations of neighbourhoods. Functional aspects of pastoral society include decision making and allocation of responsibilities and resources in support of its production and management systems. Material in this chapter focuses on structure and function of the Borana household and the relationship of households to the encampment (or *olla*). Relationships of encampments to each other and the roles of neighbourhoods and regional units of resource allocation are respectively reviewed in Section 7.3.1.2: *Grazing management* and Section 2.4.1.7: *Water resources.* The objective of this chapter is to provide a synthesis of studies conducted largely during average rainfall years in the 1980s. Specific topics of investigation included household composition and livestock holdings, marketing behaviour principally involving livestock and dairy products, labour allocation, patterns of cash income and expenditure, allocation of animal production to subsistence and commercial purposes and degree of crop–livestock integration and patterns of emergent agropastoralism.

These topics were prioritised in a series of independent investigations.

4.2 Methods

4.2.1 Household economy in average rainfall years

A profile of Borana households during average rainfall years in the 1980s was primarily developed using results of three independent surveys that involved a total of 247 households (i.e. Negussie Tilahun, 1984; Holden, 1988; and Mulugeta Assefa, 1990) and one preliminary synthesis (Cossins and Upton, 1987). In sum, the objectives of these studies were to: (1) define production units and describe households in terms of people and livestock holdings; (2) characterise contributions of livestock production, cultivation and trade to food procurement; (3) derive indicators of household wealth and depict wealth stratification; and (4) enumerate important sources of cash income and expenditure.

The first survey entailed a baseline survey of 49 Borana households within nine encampments *(olla).* Throughout nine *madda* were surveyed from June 1981 to July 1983. This was a period of average rainfall and a high population density of cattle (see Section 2.4.1.4: *Climate, primary production and carrying capacity* and Section 7.2: *A theory of local system dynamics*). *Madda* included Marmaro, Orbati, Hobok, Dilo Goraye, Dokole, Melbana, Web and Did Hara (Negussie Tilahun, 1984: p 4; see Figure 2.10). Enumerators lived in encampments and interviewed men and women in each household at monthly intervals to record dynamics of family composition, cash income and expenditure as well as sales and exchange of animals and other possessions. Production units were largely defined on the basis of households managed by married couples in association with live-in relatives. Livestock units were scaled as: Calf=0.25; other cattle=0.75; sheep and goats=0.15; and camels=1.4. African Adult Male Equivalents (AAME; see Cossins and Upton, 1987) were scaled as: Males aged 16 years and over=1; females 16 and over=0.8; and children less than 16=0.6. One-way ANOVAs were employed to assess effects of region on response variables.

In a second survey, Holden (1988) selected 108 households on a stratified-random basis for interview from encampments located within 30 km of the towns of Dubluk and Mega during 1987. This was a year of average rainfall and moderate population density of cattle (Section 7.2: *A theory of local system dynamics*). Her study primarily dealt with dairy marketing and the methods are reported in full later in this section. Selected data pertaining to household structure and cash income from Holden (1988) are compared and contrasted to those in Negussie Tilahun (1984).

In a third survey, Mulugeta Assefa (1990) profiled 633 households in terms of per capita cattle holdings and conducted detailed interviews with 90 households concerning cattle production and management during 1988 in the Did Hara and Dubluk *madda*. This was a year of average rainfall and a higher population density of cattle compared to 1987. Selected data pertaining to wealth stratification in Mulugeta Assefa (1990) will be presented here. His main body of results are presented in full elsewhere (see Section 5.3.3: *Cattle production and pastoral wealth* and Section 7.3.3.5: *Calf mortality mitigation*).

Conceptual models for resource use and food production and demand for an average Borana household (i.e. one that managed eight breeding cows plus followers) were analysed by Donaldson (1986) and Cossins and Upton (1987, 1988b). They calculated average numbers of stock/household based on aerial survey data (Milligan, 1983; Assefa Eshete et al, 1987; for methods see Section 4.2.6: *Grain cultivation*). Estimates of numbers of people and households/encampment were based on hut counts from the air (Milligan, 1983; Assefa Eshete et al, 1987) supplemented with ground surveys (Negussie Tilahun, 1984; Donaldson, 1986; Coppock and Mulugeta Mamo, 1985). Human diets were collated from survey data in 1982 (Negussie Tilahun, 1984; Donaldson, 1986) in which 20 families reported daily intakes of common foods that were standardised on a gross energy (GE) basis.

4.2.2 Labour

Profiles of labour supply and demand at the encampment level of resolution were compiled from data presented in Cossins and Upton (1987) and Negussie Tilahun (1984). This mainly focused on labour required to raise water from the deep wells and that needed for herding. Descriptions of how labour is organised at the deep wells is described elsewhere (see Section 2.4.1.7: *Water resources*).

A preliminary study of seasonal time budgets for married women was carried out by Mulugeta Assefa (1990: pp 62–64) to clarify implications of labour constraints for interventions related to improved calf management (see Section 7.3.3.5: *Calf mortality mitigation*). A total of 30 Borana women were interviewed from Dubluk and Did Hara *madda* (15 in each) and asked to estimate the frequency and average duration/event in which some 20 independent activities were carried out in each of four seasons (i.e. long rains, cool dry, short rains and warm dry; see Section 2.4.1.4: *Climate, primary production and carrying capacity*). Composited labour profiles were calculated based on mean values. Each activity was scored as more or less important against others using Friedman's nonparametric ranking test (Steel and Torrie, 1980). This provided a means to value seasonal priorities independent of time allocation. Details are in Mulugeta Assefa (1990: pp 62–64).

4.2.3 Livestock marketing

Monitoring of livestock markets was conducted from 1981 to 1984 in the following locations: Moyale (for 27 months); Hidi Lola (34 months); Mega (26 months); Yabelo (27 months); Teltele (23 months); Negele (24 months); Agere Mariam (28 months); Kera (9 months); and Finchewha (5 months). The last two sites varied with regards to year of observation, but otherwise data roughly covered the same period elsewhere. More details can be found in Dyce (1987: p 33) and Negussie Tilahun (nd).

The objectives of this work were to characterise: (1) who supplied animals to markets and why; (2) who purchased animals and why; (3) volume and composition of throughput in terms of species, age and sex; and (4) sources of variation in supply of livestock over time. On market days the following information was collected (Dyce, 1987: pp 33–34): (1) number of animals brought to market, reasons for sale, type of supplier and time taken to reach market; (2) livestock species, age, sex, colour, body condition and live weight or heart girth; (3) number of animals purchased, prices paid, reasons for purchase, and type and origin of buyers; and (4) opinions of buyers and suppliers as to market prices, price expectations and reasons for unsold animals. Data analysis involved collation of nearly 70 000 records (Negussie Tilahun, nd). Simple linear regressions were used to correlate relationships between: (1) monthly rainfall and number of cattle marketed for two locations; and (2) prices for mature cattle/unit of live weight at five markets over 21 months from August 1981 to April 1983. Prices were determined by assuming the average live weight for mature males and females to be 318 and 225 kg, respectively (Alberro, 1986), and summing recorded prices on a monthly basis (Dyce, 1987: p 73). Selected results from these studies are presented here.

Coppock (1992b) conducted extensive interviews with 30 leaders of Borana society to examine hypotheses concerning the traditional rationale for animal production. Topics investigated included cultural constraints on livestock sales, motivations for retaining or selling livestock, perceived changes in Borana society in terms of livestock marketing behaviour and to what degree perverse supply factors could be expected to operate (Doran et al, 1979; Sandford, 1983a). Perverse supply response is the concept that throughput of marketed animals could decline over time in response to higher prices. This considers that pastoralists only need a certain amount of cash income per year and manage herd assets in a manner which minimises sales. This is because herd assets have other traditional social and economic functions besides income generation. Sandford (1983a) contends that the evidence to support or refute the perverse supply hypotheses for pastoral systems is equivocal. Some 100 logic questions were formulated. Respondents were selected nonrandomly and ranged from 35 to 60 years of age. Interviews were open-ended to adequately solicit unstructured responses and were carried out for several hours over two consecutive days per person. Respondents were widely distributed throughout a 10 000 km^2 region on the central plateau.

4.2.4 Dairy processing and marketing

Studies of household milk allocation and processing were conducted during 1986–88 and are summarised in Coppock et al (1992) and Coppock et al (in press). Seasonal patterns of milk production and use were quantified for two households at each of four encampments in the Melbana, Medecho and Did Hara *madda*. One enumerator lived in each encampment and collected data for the two households for seven consecutive days during each of four main seasons (long rains, cool dry, short rains and warm dry) during 1987–88. Daily data collection consisted of interviews and measurements to establish major pathways of milk allocation. This primarily included use of fresh milk for consumption, sale or storage and fermentation. Milk was typically stored to produce: (1) milk fermented for a short term (stored for ≤5 days) for family consumption or butter-making; or (2) milk fermented for a longer term (typically stored for up to 30 days, but reportedly as long as 60 days), as *ititu* (a special food commonly reserved for guests). Data were also collected on use of stored products including production and use of butter and buttermilk. Seasonal allocation patterns were standardised on a gross energy (GE) basis (i.e. where 1 kg of fresh whole milk = 3.3 MJ GE; 1 kg of fermented milk = 3.9 MJ GE and 1 kg of butter = 29.8 MJ GE (ENI, 1980; Nicholson, 1983a)).

The role of dairy marketing in the household economy and its possible consequences for animal production was the focus of several studies (Holden, 1988; Holden et al, 1991; Coppock et al, in press; Holden and Coppock, 1992). Wealth stratification of households evident in Negussie Tilahun (1984) served as a basis for work designed to analyse effects of per capita livestock wealth, distance to market and season on quantity of dairy products sold/person/day and the role of dairy income in the household economy. A sample of households was drawn within a 30-km radius of the market towns of Dubluk (population 500) and Mega (population 3000), located within 40 km of each other on the main tarmac road that runs south from Addis Ababa to Moyale. Demand for dairy products in these towns is a combination of local demand plus a demand for butter for export to the southern highlands via traders on the public transport system (Holden, 1988). The 2800-km^2 study area surrounding each market town was divided up into three concentric sub-areas (i.e. 0 to 10, 11 to 20 and 21 to 30 km from market). Six encampments were randomly selected within each sub-area using compass coordinates. One family from each of the wealthy, intermediate and poor wealth classes was selected by the senior male leader (*aba olla*) in each encampment and interviewed for a total of 108, or 54 from each market area.

Although similar scalars were used to quantify livestock units and people as used in Negussie Tilahun (1984), they were amended in the dairy study to be lactating livestock units (LLU) while people were scored as African adult male equivalents (AAME) as in ILCA (1981). This is reviewed in Holden (1988: p 20).

Data for different seasons that influenced milk production were collected from all families using a one-time questionnaire that recorded reported dairy sales for the current dry period of August/September 1987 and for the rainy and transition (or post-rainy) seasons in the previous 12 months. The senior woman (i.e. the key person for dairy marketing) in each household was asked to recall: (1) maximum and minimum sale volumes/market trip/season (calibrated using local containers); (2) frequency of market trips; (3) number and type of livestock milked/day in each season; (4) daily milk offtake (also calibrated using local containers; and (5) income from dairy sales and uses of the money.

Income from livestock sales and other domains controlled by men was reported by husbands. Dependent variables were calculated on a seasonal or time-weighted annual basis and included daily quantity of dairy products sold per AAME and per LLU, and dairy income as a per cent of reported total income. Dairy products were expressed in litres of fresh milk equivalents derived from GE content (above). Independent variables were distance class to market (km), wealth class, season and market site. A four-way ANOVA calculating least-squares means with repeated measures was used to analyse the data (SAS, 1987). The ANOVA of dairy income as a per cent of seasonal cash income had to employ two, rather than three, distance categories because of empty cells due to some reports of zero income. Simple linear regressions were used to analyse marketing behaviour by correlating: (1) frequency of marketing or (2) quantity of dairy products sold/market trip with: (1) annual dairy sales/AAME, (2) wealth or (3) distance to market. Details are available in Holden (1988: pp 17–21) and Holden and Coppock (1992).

4.2.5 Dairy marketing and calf management

Data from 15 encampments in the Dubluk marketing area in Holden (1988) were combined with information on calf morbidity and mortality (Mulugeta Assefa, 1990) to analyse risks of milk marketing to calf management in households of varying wealth (Holden et al, 1991). The hypothesis was that poorer families living closer to a market would be affected by the opportunity to sell dairy products and that this would intensify competition between people and calves for milk, with negative implications for the vigour and health of calves. In addition to the data collection and scaling reported in Section 4.2.4, one woman/household was asked to report amounts of milk and grain consumed by themselves and one child under the age of four during the previous 24 hours and these were converted to metabolisable energy equivalents (see appendix 3 in Holden, 1988). Quantities were estimated by calibrating local containers. As part of another questionnaire on livestock production that was similarly set up to measure variability due to distance from market and wealth, the perceived daily milk yield, daily milk offtake and calf performance (births, deaths and morbidity) were recorded for offsprings of up to six randomly selected lactating cows in each of the 45 households (or five per wealth and distance class). The 233 cows were evenly divided into "good", "average" and "poor" milking classes (as defined by the respondents) with milk offtakes ranging from 2.3 litres/day over nine months for the highest-producing cows to 1.5 litres/day over seven months for the lowest-producing cows (Mulugeta Assefa, 1990: p 19).

Calf morbidity and mortality were reported only for animals prior to weaning and rates were calculated based on two samples of calves born in three years previous to the survey (i.e. 1985–87). These years had average rainfall (see Section 2.4.1.4: *Climate, primary production and carrying capacity*). A calf was considered to have experienced morbidity if it had recovered at least once from a life-threatening ailment related to nutrition management. Respondents apparently had no difficulty reporting such information and data were cross-checked with other family members.

Effects of wealth class and distance to market on human food intake were analysed using a two-way ANOVA. Milk offtake/lactating cow was analysed using a split-plot three-factor design with families as the main plot with the two factors of wealth and distance to market. Cows were sub-plots within the factor cow class. Binomial data for calf mortality and morbidity were analysed using a "maximum likelihood" logistic analysis for the same three factors using PROC CATMOD procedures in SAS (1987). Details are available in Holden et al (1991).

4.2.6 Grain cultivation

Cereal cultivation has important implications for change in the Borana System. Incidence of cultivation and pastoral opinions concerning farming among the Boran and Gabra were assessed from a series of household surveys (Coppock and Mulugeta Mamo, 1985; EWWCA, 1987; D. L. Coppock, ILCA, unpublished data; R. J. Hodgson, CARE-Ethiopia, unpublished data; Coppock, 1988; Webb et al, 1992). The extent of cultivation before and after the 1983–84 drought was determined by Assefa Eshete et al (1987) using aerial survey methods.

The 15 475-km^2 study area was divided into a 10x10-km UTM (Universal Transverse Mercator) grid which was further sub-divided into 619 (5x5 km) sampling cells. Forty parallel flight lines, 5 km apart and running north to south, were sampled along the midline of each cell. The sampled area was limited to a fixed width along each side of the flight line using a sighting device composed of parallel rods. At a flying height of 180 m the projected sighting strip at ground level was 300 m wide, which gave a sampling intensity of 12% (Assefa Eshete et al, 1987: p 4). Counts of huts, farming plots and livestock in the sampling strips were supplemented by photography if numbers were high (i.e. above 10) and validated in the office.

4.3 Results

The following results attempt to profile various aspects of Borana household economy. The attempt to convey information in a straightforward way, however, sometimes erroneously infers that household features are relatively static. In reality, the Borana system is exceedingly dynamic and household attributes vary from year to year. This dynamic nature of the system is profiled in Section 7.2: *A theory of local system dynamics*.

4.3.1 General household structure and economy in average rainfall years

Production units were defined by Negussie Tilahun (1984) as households consisting of a male herd owner, his wife, two to three children and up to four other relatives who lived and ate with the herd owner's family, for an average of 8.5 people/household (*N*=49 households). These persons shared management duties for the family's livestock and were the prime recipients of the products from these animals.

A Borana man could have more than one spouse if he is wealthy enough. However, the vast majority of them today have only one wife (Cossins and Upton, 1987). One major exception to the household leadership and composition noted above are widows who had typically married much older men and now preside over households in the intermediate or poor economic strata. Negussie Tilahun (1984: pp 6, 9–10) reported 20% (*N*=49) of households headed by women, while Holden (1988) found 25% (*N*=105) headed by women in peri-urban locations. These women apparently controlled their livestock and other household resources as male heads of households do, but may seek advice or help from senior male relatives when necessary (D. L. Coppock, ILCA, personal observation).

The first survey by Negussie Tilahun (1984) revealed a wide range in household statistics (Table D1, Annex D). His average sample household in the early 1980s had 5.6 AAME, 77 LSU and a ratio of LSU:AAME of 13.8:1. A high degree of wealth stratification was also evident: 3 of 49 households reported over 300 head of livestock. Annual reported income averaged EB 803 (US$ 392).

Subsequent research which incorporated wealth stratification into the study design suggests that reported annual income levels in Negussie Tilahun (1984) may be biased on the high side in favour of wealthier households. Mulugeta Assefa (1990) surveyed 633 households in the Did Hara and Dubluk *madda* and considered 51% as poor, 31% as intermediate and 18% as wealthy. These categories corresponded to 0.8, 2.9 and 6.0 milk cows per family member, or 2.3, 7.3 and 14.2 head per family member when the entire inventory was considered for a subsample (see Table 5.5 in Section 5.3.3: *Cattle production and pastoral wealth*). Holden and Coppock (1992) reported annual income ranging from EB 93 to 445 and 784 for poor, intermediate and wealthy households, respectively, based on stratified random sampling in the vicinity of Dubluk and Mega towns. When results of Mulugeta Assefa (1990) and Holden and Coppock (1992) are combined, a weighted mean annual income of EB 326 is obtained, which is 40% of the figure from Negussie Tilahun (1984).

The grand total of reported income for the 49 families during 1981–82 was EB 78 694. Sources of income detailed in Negussie Tilahun (1984: p 15) were: (1) cattle (90.9% of annual income); (2) other livestock products (milk, butter, hides, etc) at 5.3% of annual income; (3) small ruminants (1.2%); and (4) camels and camel products (0.9%).

An average of 52% of total income was accounted for in detailed expenditures, with high variability (17 to 93%) among locations (Table D1, Annex D). On average, 39% of documented expenses were on food, with nearly half of this (17%) for grain and the remainder for sugar, tea, coffee and miscellaneous items. The remaining 61% was spent on replacement livestock and household items with clothing making up nearly three-fourths of this total (Negussie Tilahun, 1984: p 16). There was significant ($P \leq 0.05$) regional variation among households in absolute monthly expenditure on clothing, grain and other foodstuffs. This was speculated to be due to regional variation in cultivation and proximity to markets: Families able to cultivate likely spent less on grain while those closer to market spent more on consumer goods (Negussie Tilahun, 1984: pp 17–19). A pie chart of dietary patterns for years of average rainfall is contrasted with that which occurred during the

1983–84 drought in Figure 6.2a,b. Diets in average rainfall years were dominated by milk (55%) and cereal grains (32%) on a gross-energy (GE) basis, most of the latter was inferred to have been purchased and not home grown. Milk was almost exclusively from cows.

Negussie Tilahun (1984) found a significant and positive correlation (N=49; r^2=0.54; P=0.01) between the size of the household in AAME (x) and reported herd size in LSU (y):

$$\text{Log } y = 2.59 + 0.18x$$

This was interpreted to illustrate a positive relationship between herd size and labour requirements: If well endowed with cattle, a herd owner can marry additional women and/or recruit relatives to improve his management capability (Negussie Tilahun, 1984: pp 12–13).

In contrast to findings of Negussie Tilahun (1984), a combination of aerial survey and more extensive household data collected from 1982–85 revealed that the average Borana family in the study area consisted of only three AAME, dependent upon 14.6 cattle (with eight milk cows) and seven small ruminants for food and income generation plus an occasional camel or equine for transport (Cossins and Upton, 1987). This roughly translates into 66 000 people (4.3/km^2), 325 000 cattle (21/km^2), 100 000 small ruminants (6.5/km^2), 7500 camels (0.5/km^2), and 2500 equines (0.2/km^2) for the 15 475-km^2 study area in 1981–82. Population dynamics are reported elsewhere (Section 6.3.1.1: *Livestock dispersal and herd composition* and Section 7.2: *A theory of local system dynamics*).

Donaldson (1986: pp 13–14) and Cossins and Upton (1987: pp 131, 212–213) compiled an annual energy budget for an eight-cow household for an average rainfall year. Given a live weight of an adult Borana male as 55 kg, and considering additional energy expenditure for work, the daily energy demand for such a person is on the order of 10.6 MJ GE based on nutritional costs in FAO (1973). Assuming this person represents 1 AAME, the model household with 3 AAME would require 11 607 MJ GE per year. Domestic production, dominated by cow milk, would account for 64% of this requirement based on 75% of cows in milk and production levels determined by Nicholson (1983a; see Section 5.3.2: *Calf growth and milk offtake*). Most of the remaining energy (4178 MJ GE) would have to be obtained from cultivation and/or bought grain because other livestock sources of food production are nominal. Assuming that the balance was obtained from grain purchases (Cossins and Upton, 1987), this means that 278 kg of maize grain would be required with an energy content of 15 MJ GE/kg (Cossins and Upton, 1987). One kilogram of cattle live weight was exchanged for 2.5 kg of grain in an average rainfall year in the early 1980s (Cossins and Upton, 1987); so this implies that each household would have to sell at least 111 kg of live weight. On a TLU per household basis, this represents an offtake of 3% per year, or 9750 head out of 325 000 head for the study area. While this rate agrees with estimates of 5% per annum by FLDP (nd), it is less than one-sixth of the rate of 19% estimated by Donaldson (1986) for 1981–82 from herd monitoring. One source of variation is that additional offtake is required for purchases of other goods besides food, but at most this would probably double the offtake estimate to 6%. This discrepancy is explored further in Section 4.4.2: *Economic comparisons among pastoral systems*.

4.3.2 The encampment and the role of cooperative labour

Cossins and Upton (1987: pp 209–210, 213) reviewed some general aspects of labour allocation and relationships of labour to the organisation of households into encampments (*olla*). A typical *olla* is depicted in Figure 4.1.

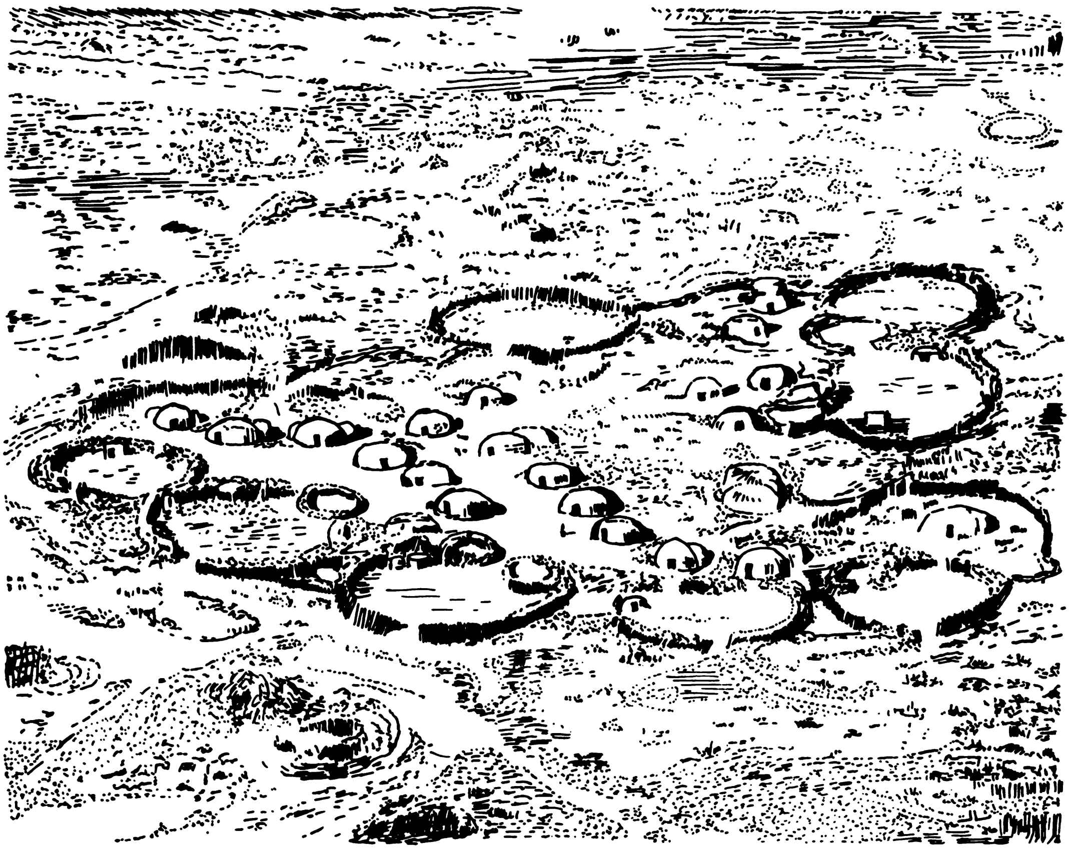
Although the household is the basic unit of production and consumption, some types of work are carried out cooperatively by households. These labour-sharing activities include herding, watering animals, marketing dairy products and constructing corrals and fences. Advantages in terms of social activities, group security and information sharing are likely to have played important role in the development of the encampment as the next level of social organisation after the household.

Herding may involve males and females from 6 to 25 years of age. Younger children, and females in general, do most of the tending of small ruminants and calf herds near encampments while young men and older boys are more responsible for *warra* (resident milking cattle) and *forra* (dry cattle that are far-ranging; see Section 5.3.1: *General aspects of cattle management*). Older girls (in their late teens) may herd *warra* animals if labour is in short supply (Cossins and Upton, 1987: p 209).

Watering animals from the deep wells (see Section 2.4.1.7: *Water resources*) is an arduous dry-season activity which is the responsibility of mainly young men, but it is also common to see older youths of both sexes involved. Labour allocation and watering schedules are complicated schemes committed to memory by leaders who regulate and coordinate water access. This is a major form of labour sharing in an encampment.

Women share marketing duties especially if they reside far from market and thus have a large opportunity cost in terms of the time needed to walk

Figure 4.1. *Schematic depiction of a Borana encampment or olla with huts and corrals.*



Drawing: Courtesy of Jill Last.

to market (Holden, 1988: p 22). Women rotate market duty and the designated woman will take dairy products and other items to sell on behalf of friends. Cooperation among women and youths in the construction of communal corrals and bush fence to protect encampments and cultivated plots is also important (Mulugeta Assefa, 1990).

Encampments are named for a wealthy and/or influential male individual called the *aba olla* (see Section 2.4.2.2: *Some cultural and organisational features*) who may have herds large enough that he requires labour beyond the capability of his immediate family. Recruitment of families, poor in livestock but able to work, into an encampment is thus related to whether they could provide labour to wealthier households in return for food or other compensation. For example, a poorer neighbour may take care of a milk cow for a wealthier family and receive the milk offtake and a future male calf in return (Cossins and Upton, 1987: p 210). Cash remuneration for labour is rare but small payments have been reported (Mulugeta Assefa, 1990). Poor families are taken into an encampment undoubtedly because of other considerations such as kinship. Clan networks offer possibilities that allow access to different resources that reduce vulnerabilities (see Section 2.4.2.2: *Some cultural and organisational features*).

A general labour budget for the major cooperative tasks of herding and watering animals can be crudely estimated for an encampment to illustrate the potential labour constraints. A typical encampment may contain from 10 to 30 households (Cossins and Upton, 1987: p 209; Coppock and Mulugeta Mamo, 1985). Taking the larger number as an example, the total work force for one encampment could thus consist of about 30 adult males, 30 adult females and around 75 youths, based on demographic data in Negussie Tilahun (1984: p 8). Of the youths (defined as less than 25 years old) about 20 would be under six years of age. This leaves 55 available for substantive work.

This typical encampment could have two to three resident *forra* herds and five to seven far-ranging *warra* herds with a maximum of 70 head/herd (Milligan, 1983, cited in Cossins and Upton, 1987:

p 210). This gives a grand total of 630 head over one year old and about 250 nursing calves. About 70% of these calves would be old enough to require herding (see Section 5.3.1: *General aspects of cattle management*) and could be grouped into about three herds of 60 animals each. This estimate of calf numbers is based on 55% of all cattle over one year of age being mature cows and 75% of these having a calf in an average rainfall year (Cossins and Upton, 1987: p 207). The ratio of lactating cows to AAME would be 2.3:1. The total small ruminants would be about 200 (Cossins and Upton, 1987: p 213) herded perhaps as two flocks. The few camels and equines (see below) may not require herding except when they go to water. Camels may be hobbled so they browse near the encampment and equines seem to stay in the vicinity without much supervision (D. L. Coppock, ILCA, personal observation). Cattle herding for the typical encampment would thus require about 20 young men and boys for all the *warra* and *forra* herds, with two to three per herd on a rotating basis (Cossins and Upton, 1987: p 209). Tending calves and small ruminants, respectively, requires another six and four young boys or older girls.

In sum, a minimum of 30 persons are required only for herding, which is nearly 60% of the youth work force. If it is further assumed that females over the age of 11, and comprising 28% of all youths between the ages of 6 to 25 (Negussie Tilahun, 1984: p 8), then herding could fully occupy 75% of the available pool of 40. Labour allocation for herding would thus be consistently demanding regardless of season, but the need to look for adequate grazing in dry periods would heighten labour requirements then (see Section 5.3.1: *General aspects of cattle management*).

During the later stages of the cool dry season (August through September) and throughout most of the warm dry season (December to March), the high demands of watering livestock at the wells are superimposed upon routine duties of herding and household chores. Cossins and Upton (1987: p 210) noted that the number of livestock watered at the wells per man-day worked ranged from 15 to 155 livestock units. This high variation is due to differing flow rates of water in wells, variable efficiency of raising water to the surface and well depth which determines the number of people required to do the job. Data concerning animals watered at wells and regional labour allocation to well operations are shown in Tables 2.2 and 2.3.

If the average family owns about 12 livestock units Cossins and Upton, 1987: p 213) and on average these are watered once every three days (see Section 5.3.4: *Water restriction and cattle productivity*), the family needs at most to supply about one man-day of labour twice/week based on a minimal watering rate of 15 head/man/day. For an entire encampment of 500 livestock units, the labour force required would be about 67 man-day/week. The 10 youths remaining after herding needs are filled (see above) could provide a maximum of 70 man-day/week, assuming they worked in the wells every day (but they do not; Cossins, 1983c). A key factor in these calculations is the watering rate/man-day. If an average of 85 livestock units/man-day is assumed (as the mean of 15 and 155), then the 500 livestock units only require about 12 man-day of labour/week for watering. This stipulation giving 35 man-day week is more consistent with the capability of the 10 youths working on an alternate-day basis. Such calculations also reveal the labour-saving advantages of watering once every three days versus once daily or once every other day (Nicholson, 1987a). Using the 500 livestock units with 85 watered/man-day, the once-every-third-day watering regime requires, respectively, only 28 and 58% of the labour needed for a daily or alternate-day watering.

In sum, this analysis is interpreted to show that encampment labour schedules in dry seasons are likely to be tight. As will be shown, married women may have the most demanding work schedules and thus are unable to assist in most of the tasks described thus far. Senior men spend more time dealing with herding strategies, cattle marketing and related issues and usually do not perform menial labour unless they are poor (D. L. Coppock, ILCA, personal observation).

4.3.3 The labour of married women

Married women are critical to the household economy. They have the major role in determining milk offtake (Holden, 1988: p 66), carry on the home-based forage feeding and health management of nursing calves (Mulugeta Assefa, 1990: p 65; D. L. Coppock, ILCA, personal observation). They may also be increasingly important as herd managers and decision makers in the society (see Section 4.3.1: *General household structure and economy in average rainfall years*).

Composited activity budgets reported by women in two locations are shown in Tables D2 and D3, Annex D, for the long rains and warm dry seasons, respectively. Time budgets were similar across locations in terms of seasonal work priorities and total worked hours reported for each season. On average, over 14 important activities were reported for each season. When averaged across all rainy periods women reportedly worked 10.7 hours/day, increasing to an average of 14.1 hours/day in dry seasons. The warm dry season required the greatest reported work commitment at 15.8 hours/day, while work priorities were similar for both locations within seasons. Not surprisingly, milking cattle was ranked as the most important activity in nearly all instances, but the absolute time required for milking varied seasonally. The highest time needed for milking was reported in the long rainy season and the least in the warm dry season.

Other dominant activities in wet seasons included collecting fuelwood (more fires being needed due to cooler air temperatures) and churning milk to make butter (due to a higher milk volume). In contrast, priorities during dry periods commonly involved the more time-consuming and arduous tasks of collecting water for people and calves, getting forage for calves and taking other animals to water. Food preparation, going to market and cleaning and repairing pond catchments, corrals and huts were apparently common throughout the year.

4.3.4 Livestock marketing

4.3.4.1 Suppliers

The following categorisations of livestock supply were based on a sample of 67 803 animals marketed from 1981 to 1984. Much of the information was originally compiled by Negussie Tilahun (nd) but was later consolidated and analysed by Dyce (1987: pp 35–57).

The dominant ethnic group supplying livestock to market were the Boran, with 48% of the total (32 545 head). They were followed by the Gujji agropastoralists with 12% (8136 head) which were mostly marketed at northern centres in the periphery of the study area such as Agere Mariam. Other local groups supplying much smaller numbers were the urban Amhara (6%) and Konso, Burji and Gabra with 2% each. Most of the remainder were supplied by Somali, Arsi and Walayita groups (Negussie Tilahun, nd: p 2).

Nearly all of the Boran and Gujji suppliers were breeders producing stock under low-input range conditions. Breeders supplied 46% of the 26 991 animals brought to primary collection markets in Teltele, Yabelo and Negele and 82% of 17 538 animals brought to primary collection markets at Hidi Lola and Mega.

Traders, people dealing in livestock exclusively for business purposes, were more common among the Amhara and other local urban minorities. Traders supplied 59% of the 28 306 animals brought to secondary collection markets that bordered the rangelands such as Moyale and Agere Mariam. Sixteen per cent of the 7109 animals supplied to Moyale were from Borana breeders. Many of the suppliers to Moyale markets were traders from Somalia and Kenya. The highest concentration of traders was in Agere Mariam (Negussie Tilahun, nd: pp 2, 6).

Overall, the most common reason for breeders selling an animal was to engage in animal trading (34% of 67 803 responses). This was followed by the need to acquire money to purchase clothing (26%) or food grain (17%). Payment of taxes, purchase of breeding stock and household items or other nonessential commodities were the other minor reasons for selling stock. At Hidi Lola and Mega the Borana suppliers of marketed livestock reported purchase of clothing (43%) and grain (15%) as the most important reasons for animal sales, out of 35 181 responses.

Based on a sample of 25 312 head 60% traveled for less than one day to reach market (most of the immatures were in this category), 11% traveled one day and the rest took from 1.5 to 4 days (nearly all matures). In an extreme case for Agere Mariam (to the north of the rangelands), 60% of mature cattle had to travel four days or more to reach market.

4.3.4.2 Buyers

The Boran were the leading ethnic group buying all types of livestock (21% of a sample of 98 213 purchases) followed closely by the Amhara (17%). Thirty-eight per cent of all purchased stock were bought by traders, followed by breeders seeking replacements (19%) with the remainder by butchers and others (Negussie Tilahun, nd: pp 6–7). Breeders and traders were the most prevalent at primary collection markets while traders and urban con- sumers were more prevalent at secondary markets. Traders bought the highest proportions of animals in the primary markets of Yabelo (40% of 5112 observed), Negele (40% of 6993 observed), Mega (64% of 6680 observed) and Teltele (37% of 2330 observed). Breeders bought a high percentage of the animals in the primary markets at Hidi Lola (45% of 6225 observed), Teltele (28% of 1794 observed) and Moyale (23% of 1710 observed).

Purchases for butchering were the most common at secondary markets such as Agere Mariam (50% of 12045 observed), Moyale (15% of 1109 observed) and Negele (14% of 2502 observed). Most of the animals bought by butchers in Agere Mariam were slaughtered in Dilla, a large urban centre 200 km further north (Negussie Tilahun, nd: p 15). About 5% (5000) of all marketed animals (namely cattle) made it to a terminal market in Addis Ababa for slaughter (Negussie Tilahun, nd: pp 10, 15). In summary, for animals headed northwards, markets such as Yabelo, Mega and Hidi Lola serve as collection centres from smaller local markets in the interior of the southern rangelands.

These intermediate markets then channel animals to secondary markets such as Agere Mariam (Negussie Tilahun, nd: p 18).

4.3.4.3 Composition of animals purchased

Cattle purchases (69% of all animal purchases or 67 767 observations) were dominated by mature males over four years of age (52% or 35 238) bought primarily for trading (54% of transactions). They were followed by mature females (39% or 2678) which were usually cull cows procured for slaughter. Immature males came next (8% or 5431) with immature females the most rare (1% or 680). Immature cattle were usually purchased by breeders for herd building or to bring up for resale (91% or 5561).

Goats comprised 25% of total animal sales (24 553 observed), sheep 5% (4910 observed) and camels negligible at less than 1% (558 observed). Mature male goats were purchased for trading while others were for breeding and growing out. Mature male sheep were mainly purchased for direct consumption while other sheep were bought for breeding and growing out. The small number of camel transactions were not analysed. More details are available in Negussie Tilahun (nd) and Dyce (1987).

4.3.4.4 Other features of livestock market supply

Summary of the relative contribution of each livestock species to the seven markets with about 23 months of data collection is provided in Table 4.1. The monthly average flow of recorded animals ranged from 847 (Agere Mariam) and 731 (Negele) to 401 to 475 for Mega, Hidi Lola and Yabelo (401 to 475) with Moyale and Teltele less than 300 each. Except for Moyale, Mega and Hidi Lola where both cattle and goats were equally dominant, cattle were typically by far the dominant species marketed.

Detailed analyses of animal trade only used data from the six markets at Negele, Moyale, Mega, Hidi Lola, Agere Mariam and Yabelo (Dyce,1987: p 41). Time series of livestock supply at these markets are shown in Figure 4.2 a–c. Although cattle were usually supplied in the greatest numbers, they showed the most fluctuation. Maximum monthly variation in throughput calculated across the six markets indicated that cattle numbers fluctuated almost eightfold, followed distantly by sheep (tenfold) and goats or camels (sixfold). The average monthly supply was 4076 head and coefficients of variation varied nearly 13 percentage points (Table 4.2).

Except for Hidi Lola where immatures commonly comprised up to 50% of the monthly cattle market supply, immatures usually made up a small proportion of the cattle, although patterns were variable (Dyce, 1987: pp 50–53). Moyale consistently received the lowest proportion of immature cattle of all markets (<1%). The supply of immature cattle to Negele was also consistent and low (5 to 10%) while that for Mega was low and more variable (usually less than 5%, but sometimes 20 to 40%). The number of immature male cattle was always greater than that of immature females. The overall ratio of male to female immatures was 7.6:1 (Dyce, 1987: p 54). In contrast, while males usually outnumbered females in the market supply of immature small ruminants, the ratios of males to females were typically 1.3:1 (goats) and 3:1 (sheep) (Dyce, 1987: p 71).

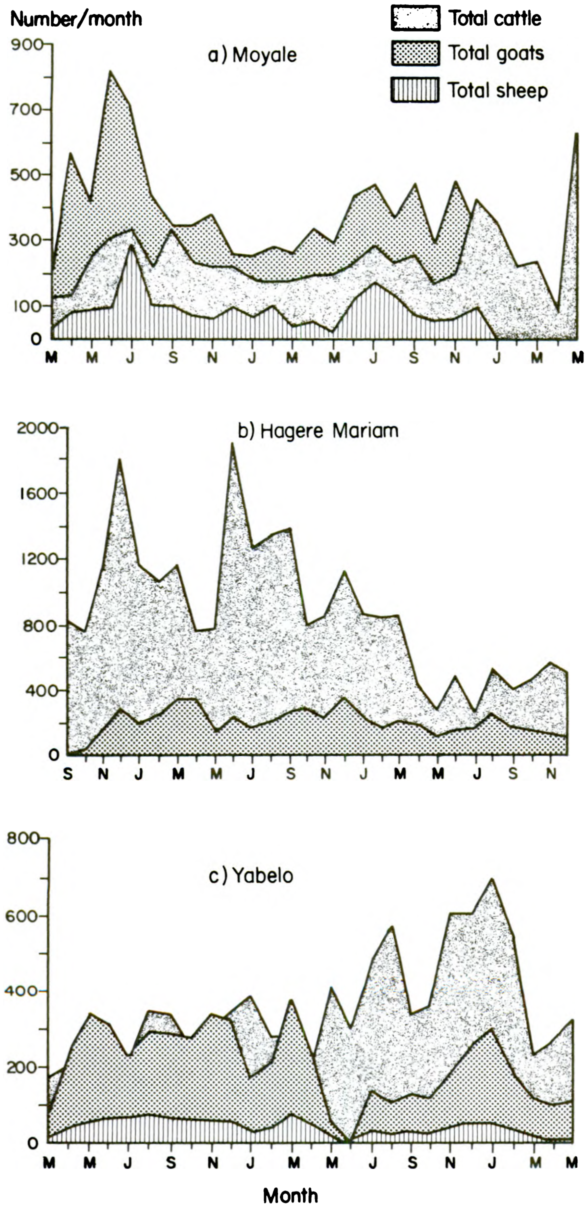
The average price for mature cattle was calculated for Moyale, Hidi Lola, Mega, Yabelo and Agere Mariam where suitable data were obtained from August 1981 to April 1983. Twenty-five correlations ($N = 21$ each) were conducted to test for intermarket price relationships (Dyce, 1987: pp 56–57). The highest correlation coefficient was r=0.5 (for Mega and Hidi Lola), which was significant (P<0.05) (Steel and Torrie, 1980: p 597).

Table 4.1. *Relative contributions (%) of livestock species on a numerical basis for seven markets in the southern rangelands during 1981–82.*

Market	Species				Number
	Cattle	Sheep	Goat	Camel	
Negele	70.7	6.8	21.1	1.3	17 549
Moyale	36.9	11.1	48.7	3.3	7345
Mega	46.1	16.8	36.6	0.5	10 443
Hidi Lola	49.7	11.7	38.6		13 918
Agere Mariam	81.1	0.5	18.4		23 730
Yabelo	59.4	6.6	34.o		12 851
Teltele	57.9	11.5	30.5		6374

Source: Dyce (1987).

Figure 4.2 (a–c). *Temporal dynamics of monthly livestock supply to markets at: (a) Moyale; (b) Hagere Mariam; and (c) Yabelo during 1981–82.*



Source: Dyce (1981).

4.3.4.5 Traders

The types of traders operating in the southern rangelands are reviewed by Negussie Tilahun (nd: pp 28–34). He distinguished between part-time and full-time (i.e. small, medium and large-scale) traders. The scale of trading was associated with the time invested, amount of working capital and the number of buying agents employed.

Investment was increased to enable operation in remote primary or secondary markets. A medium-scale trader in a secondary market like Agere Mariam is one that can deliver from 30 to 50 head of cattle at one time. The large-scale traders may also operate butcher shops and may also lend operating funds to medium and small-scale traders. Traders may sell inventories on credit depending on the uncertainties of the market and scarcity of forage or water along trekking routes or at holding grounds. More details on traders are provided in Negussie Tilahun (nd: pp 28–34).

4.3.4.6 Prices

Negussie Tilahun (nd: pp 72–79) gives average monthly price estimates for various age and sex classes of livestock purchased at seven markets from March 1981 to January 1984. Immature males and females were sold for an average of EB 106 and 129, respectively; mature males and females sold for an average of EB 251 and 205, respectively. These price patterns were related to the higher value of immature females than males and the greater demand for mature males (as slaughter stock) than cull cows (Negussie Tilahun, nd: pp 49–50). Average prices for sheep or goats ranged from about EB 12 for immatures to EB 32 for matures. Camel prices ranged from EB 198 to 412 for immature males and mature females, respectively. There appeared to be a gradual increase in the price/head of all livestock (EB 7.30), cattle (EB 6.44) and small ruminants (EB 0.43) during the study period. This was interpreted as resulting from an increased demand due to favourable rainfall and production conditions

Table 4.2. *Statistics of monthly supply of livestock to nine markets in the southern rangelands during 1981–82.*

Species	Statistics				
	Maximum	Minimum	Mean	CV (%)[1]	Months
Cattle	5610	71	2466	54.6	35
Sheep	680	70	323	51.2	35
Goats	2034	315	1248	42.1	35
Camels	69	12	39	45.5	28

1 Coefficient of variation.

Source: Dyce (1987).

throughout the Borana Plateau at this time (Negussie Tilahun, nd: p 46).

Seasonality in cattle prices, given a general upward trend across years, are also described in Negussie Tilahun (nd: pp 46–47) and they showed a rise at the beginning of the long rains (April) until the middle of the cool dry season (June or July) followed by a variable decline from July until the middle of the warm dry season (February). This was interpreted as a tendency for demand for cattle to rise during favourable rainfall periods and decline during dry periods. Deviations from this general pattern could be related to variation in rainfall during the long and short rains. Different patterns among some markets are discussed by Negussie Tilahun (nd: pp 47–48).

4.3.4.7 Marketing attitudes

Marketing attitude study results are detailed in Coppock (1992b). Only highlights will be presented here with conclusions based on a sample of Borana leaders who were independently interviewed.

Cattle production objectives: The prevailing view of respondents was that Borana herd owners seek to accumulate cattle as social and economic assets rather than to generate cash income. They realise, however, that herd building is becoming increasingly difficult under today's conditions of higher population and restricted resources in the southern rangelands, while increasing food deficits force them to dispose more of their herd to buy food (see Section 7.2: *A theory of local system dynamics*). Despite this situation, increasing herd size is still seen by most herd owners as the main means available to generate wealth and attain prestige. A far less important reason is to have large numbers of animals to endure drought; respondents stated that a household doesn't actually need many animals to purchase grain to last it through a two-year drought (see Section 7.3.3.7: *Mitigation of drought impact*) so that the primary reason for selling an animal is to meet an acute need of money in general. This usually arises when milk production drops and food is needed, and is why herd owners always wait until a dry period to sell animals even though they realise terms of trade are less favourable than compared to other times of the year (see Section 6.4.3: *Decline in terms of trade*). Their attitude may be best described as "optimistic gambling": hope that the unfavourable weather or economic straits will break before they have to sell an animal (Coppock, 1992b). Households will thus undergo great deprivation before they succumb to selling cattle (see Section 6.3.2.2: *Human welfare)*

Priority ranking of animals for sale: A compiled ranking by 30 herd owners was as follows: (a) As long as cash demands are modest (less than US$ 40), the top priority is to sell a sheep or goat. These species are valued because they can substitute for sales of cattle and there are fewer social regulations that constrain their sale; (b) when cash demands are higher then cattle can be sold. The sale of cattle usually requires deliberations within the extended family before it can proceed. Priority sale cattle were as follows (from highest to lowest): (i) cull cows (10+ years old); (ii) mature males in descending order of age (from 10 to 5 years old); (iii) immature males (1 to 4 years old); (iv) male calves (<1 year old); (v) female calves (<1 year old); (vi) immature females (1 to 4 years old); (vii) heifers (4 to 5 years old); and (viii) prime cows (5 to 9 years old). Wealthy herd owners would have all these classes of cattle at their disposal. The poor, however, may only have a few cows and immatures (see Section 5.3.3: *Cattle production and pastoral wealth*). Animals are thus reportedly sold in reverse order of their importance to herd generating capacity. Larger males tend to be sold as a priority because the price received is the highest and permits the purchase of the needed goods plus one or more replacement calves thereby attaining two objectives simultaneously. The poor, in contrast, may often be forced to selling immatures to buy commodities only.

Perceptions of perverse supply: If cattle prices were to double and the prices of goods were to remain constant, the 30 leaders concurred that the net result over time would be for marketed throughput of cattle to decrease. They felt that this was largely because poor and intermediate households seek to build their herds and would sell cattle only to meet their acute needs for money. The wealthy, however, may move more animals to market initially in the hope that they could buy up more immatures per adult animal sold and build their herds. For small ruminants in contrast, all respondents said that under the same scenario the net result would be a higher marketed throughput. The Boran would move these animals to market because they are riskier to produce (because of disease susceptibility), lack the social and economic utility of cattle in the culture and do not require family negotiations to approve a sale. Despite the view that market throughput would decline over the long term, this does not imply that producers do not seek higher prices; they do, to reduce the numbers they have to sell. That is reportedly why a thriving black market exists for Ethiopian cattle in northern Kenya (FLDP, nd; Hodgson, 1990). The herd owners noted, however, that should Ethiopian prices become similar to those offered from Kenya, they would prefer to sell to Ethiopian buyers because of lower marketing risks. Ethiopian prices have been held to below-market levels in the past (FLDP, nd; Hodgson, 1990).

Animal condition and sale: The herd owners all appreciated that better conditioned animals bring higher prices. Most agreed that they would sell a bull in an excellent condition in a dry season to obtain more money; this would reduce the chance of having to sell more. Herd owners attempt to fatten bulls in an opportunistic fashion depending on rainfall. Calves and other immatures are not fattened for marketing as everyone wants to avoid their sale.

Social and economic change: Despite the traditional "barriers" to commercialisation reported above, the 30 leaders unanimously attested to the effects of markets and a changing generation in altering traditional attitudes. They felt that younger herd owners within a day's walk to a market did not "behave" like Boran anymore: they use money more freely, are more aware of prices and tend to be more active livestock traders.

4.3.5 Dairy processing and marketing

Aspects of traditional milk processing by the Boran are reviewed in Ephraim Bekele and Tarik Kassaye (1987), Coppock et al (1992) and Coppock et al (in press). Results of studies of peri-urban dairy marketing on the Borana Plateau are reviewed in Holden (1988), ILCA (1990: pp 12–14), Coppock et al (in press), and Holden and Coppock (1992). Some of the main findings are summarised here.

4.3.5.1 Milk processing procedures

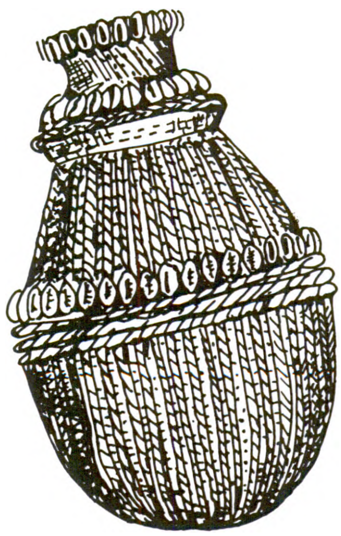
The Borana system for milk processing was first described by Ephraim Bekele and Tarik Kassaye (1987). Cows are the main source of milk and it is cow's milk that is the focus of processing. Milk from other livestock species plays little or no role in processing here. Milk from small ruminants or camels may occasionally be added to top-up a larger volume of cow's milk when it is to be sold or consumed (S. J. Holden, ILCA, personal communication) and thus some of this milk probably gets processed. Although camels produce large quantities of milk, this is considered unsuitable for making butter (see Section 7.3.3.3: *Dairy processing and marketing*).

The Boran use four types of milk containers that are illustrated in Ephraim Bekele and Tarik Kassaye (1987). These include the *okole*, *gorfa*, *golondi* and *amuyou* and are described as follows:

The *okole* is used for collecting milk. These are traditionally made from the skin of buffalo, giraffe or the neck hide of oxen. They are sturdy and stout "buckets", roughly cylindrical, around two litres capacity, and have a large mouth and finger holes at one of two pinched corners surrounding the mouth. *Okoles* serve "double duty" as they are also commonly used for lifting water from the deep wells. Before being used, Okole are rinsed with milk and smoked with wood chips from *Balanites aegyptica*. This likely has a sterilisation effect and coats the inside of the *okole* with a charcoal sealant, which also flavours the milk.

The *gorfa* is a pear-shaped, lidded container woven from root fibres of *Asparagus* sp. *Gorfa* also have an average capacity of about two litres and are used for storing (souring) and churning milk (Figure 4.3). They are smoked using a variety of charcoals (from *Acacia nilotica*, *Cordia gharaf*, *Cordia ovalis*, and *Combretum molle*). This also probably serves to sterilise and seal the container and burns off loose fibres on the inside to create a smooth surface. Smoking and rinsing the *gorfa* with milk occurs just prior to adding fresh milk that is to be stored for several days. The process of smoking and rinsing is repeated prior to pouring the next batch of fresh milk.

Figure 4.3. *Depiction of a* gorfa, *a traditional container for churning and short-term storage of cow's milk.*



Drawing: Courtesy of Jill Last.

The *golondi* is a vase-shaped vessel made by carving trunk sections of *Erythrina abyssinica*. It has a lid and is enclosed in fresh animal skin. It can also be smoked and rinsed prior to receiving up to five litres of fresh milk. These are primarily carried by herders to provide milk during their time away from the encampment.

The *amuyou* is a larger bottle-shaped vessel with a lid that is used for souring and churning milk, and it is also carved from *E. abyssinica*. These hold up to 15 litres of milk and are found most often in households that have a large number of milk cows.

Milk is consumed fresh in the household daily. Surplus milk may be given to relatives and neighbours or be stored as the first step in processing (Ephraim Bekele and Tarik Kassaye, 1987). Soured milk is referred to as *ititu* in the Borana vernacular and refers to all milk that is soured. Information on the microbiological and biochemical aspects of the souring process is available (Tarik Kassaye, 1990). General observations of milk processing reported by Ephraim Bekele and Tarik Kassaye (1987) suggest that the pastoralists are very skilled in milk processing and able to manipulate efficiently a variety of subtle factors despite their lack of sophisticated technology.

After a minimum of one day of fermentation, milk is churned to make butter. Milk is usually churned in the morning during warm weather, as the Boran appreciate the role of cooler temperatures in butter production. The *gorfa* is filled to 50–70% capacity with fermented milk and is cradled by a woman who gently rocks it back and forth. Pressure in the *gorfa* is occasionally released by removing a small wooden plug in the centre of the lid. This also releases a small drop of milk, which when rubbed between the fingers indicates whether butter grains have formed. The presence of butter is also indicated by a change in the pitch of the churning sound. Churning takes less than one hour (also see Section 7.3.3.3: *Dairy processing and marketing*). Butter is removed from the *gorfa* using a wooden spoon. The butter is used as a cosmetic for the skin and hair of both sexes, for roasting coffee beans, as food, or sold. The low-fat buttermilk that remains may be consumed by children or adults, used for rinsing milk containers, or given to animals. A small quantity of buttermilk that remains in the *gorfa* acts as a "starter" for the next batch of soured milk. The process is repeated about every 15 days, during which time four to five batches of butter prepared. After this the *gorfa* is washed with hot water, dried and smoked before being used for another cycle.

Butter may also be melted in a clay saucepan over fire, with fresh leaves and stems of *Ocimum basilicum* added for flavour, to make a dehydrated butter (ghee). The moisture is driven off and before the liquid clarifies a handful of maize, sorghum or other cereal flour is added along with some clean fresh grass and a pinch of salt. The mixture is then poured into a cattle horn or a small wooden container with a tight lid. This product is reported to keep up to three years. The long shelf life may be due to the hygienic handling of the milk, absence of moisture and/or the addition of salt (Ephraim Bekele and Tarik Kassaye, 1987). Ghee can be used in the dry season to prepare porridge or is consumed alone or as a supplement to coffee or tea.

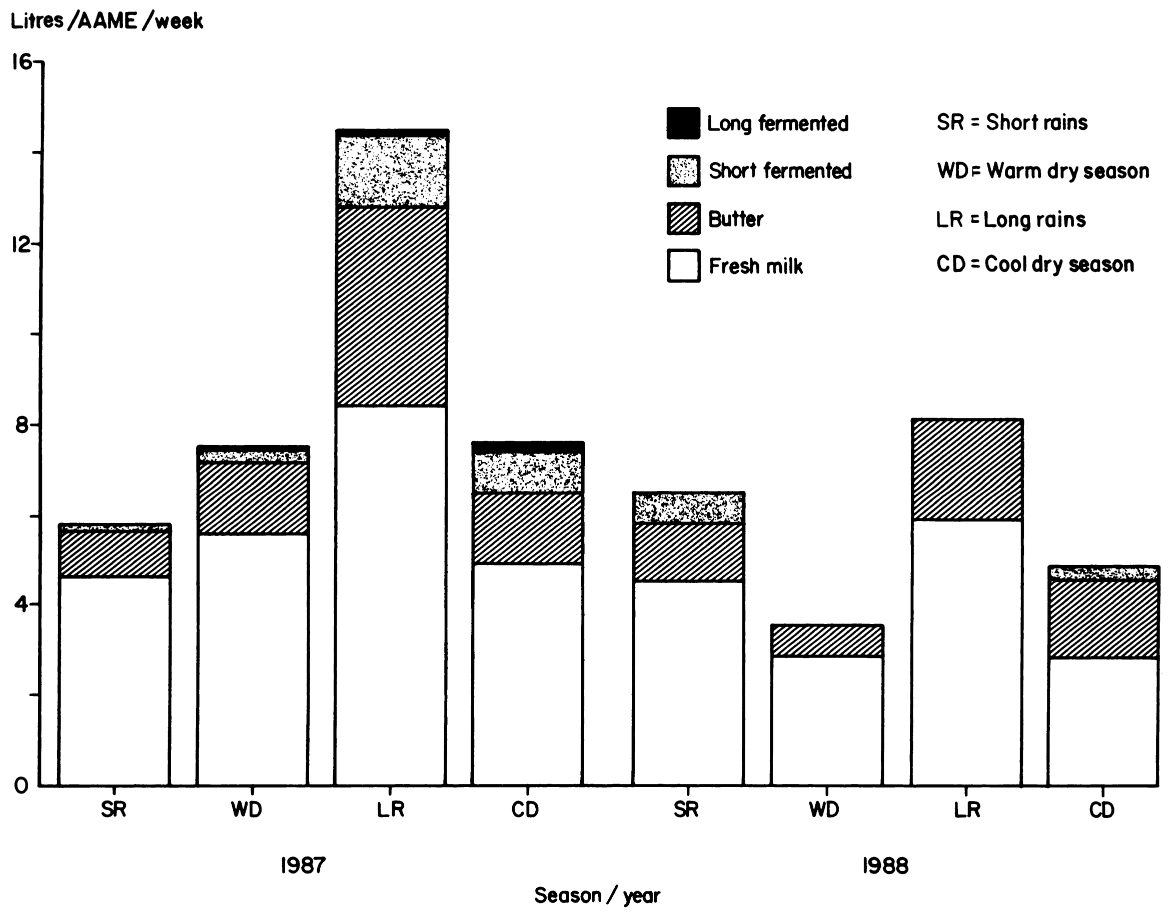
For milk fermented from 5 to 60 days, surplus fresh milk is added to a designated *gorfa* or *amuyou* each day. As the curd coagulates, serum is removed by women using a wooden pipette (Ephraim Bekele and Tarik Kassaye, 1987). The serum is drunk. This process is repeated until the container is full of curds and all of the serum has been removed. The curds are then occasionally checked for mould. When mould forms the surface of the curd is removed and the lid is washed with hot water and cleaned with the leaves and stems of *O. basilicum*. When the lid is replaced some smoke from a charred piece of wood is captured in the container; this is repeated once in a while to help keep the surface of the curds free from undesirable microbes. Before consumption, the curd must be stirred to liquify it.

4.3.5.2 Seasonality and milk allocation for processing

Milk allocation patterns were analysed for eight households over two years (1987–88) of average rainfall. Details of this study are reported in Coppock et al (1992) and Coppock et al (in press). The average milk offtake in litre/AAME/week ranged from 5.5 in the warm dry seasons to 11.5 during the long rains (Figure 4.4). Over eight consecutive seasons the average offtake was 7.3 litres/AAME/week. Sixty-nine per cent of total offtake was variously used as fresh milk, 24% stored and soured to make butter, 6% used otherwise as short-term soured milk and 1% was used as long-term soured milk (>5 days of fermentation). Seasonal means indicated that the amount of milk allocated for fermentation and processing (y) was positively related to milk offtake and thus to potential surplus (x) by the equation: $y=0.484(x)+1.152$ ($r^2=0.91$; $P<0.01$; $df=6$). Seasonal patterns suggested that when there was surplus milk, butter making took precedence over other uses of short-term fermented milk, which in turn took priority over the production of long-term fermented milk (Coppock et al, in press).

The long rains and warm dry periods of 1987 provided the best contrast of seasonal quantities and uses of milk products (Table 4.3). Daily milk offtake ranged from 14.7 litres/AAME/week in the long rains to 7.5 litres/AAME/week during the preceding warm dry season. Although absolute quantities of products varied by season, the relative allocation tended to be consistent for a given product across seasons. Fresh milk was usually consumed and sold/gifted; long-term fermented milk was consumed; short-term fermented milk was mostly processed to make butter; and buttermilk was consumed by children in both seasons but also given to calves during the long rains. Respondents

Figure 4.4. *Allocation of fresh cow's milk to various processing objectives for eight households during 1987–88.*



Source: Coppock et al (in press).

also indicated that in times of plenty, buttermilk may be given to dogs and cats. Butter allocation was poorly documented in the study, but interviews confirmed that butter is used as a hair dressing and skin cosmetic by both sexes, for roasting coffee beans, direct consumption or sale (D. L. Coppock, ILCA, unpublished data).

4.3.5.3 Effects of distance to market, wealth and season on dairy marketing

The 108 sample families surveyed in Holden (1988) and Holden and Coppock (1992) averaged 3.6 AAME/family and the mean annual ratio ($\bar{x} \pm$ SE) of LLU:AAME ranged from 2 ± 0.1 (wealthy) to 1.1 ± 0.1 (intermediate) and 0.5 ± 0.1 (poor) overall, with the ratio increasing during the wet and transition periods compared to dry periods. Over 90% of LLUs were cows.

The ANOVA for daily dairy sales/AAME revealed a significant (P=0.002) three-way interaction with no influence of market site. The interaction is shown in Figure 4.5 (a–c) and was caused by differences in supply by the different wealth classes in connection with interrelated effects of season on milk production and distance on marketing behaviour. Averaged across all distances to market, wealthy households sold six times more products than poor households in the wet season (0.56 vs 0.09 litre/AAME/day), but this difference increased another eightfold in the dry season. When distance to market was reduced from 21 to 30 km to <10 km, the dry-season effect ranged from nil within poor households to plus fourfold and 18-fold within middle-class or wealthy households, respectively.

Calculated across seasons and distances, wealthy families marketed about two to seven times more dairy products (0.26 litre/AAME/day) than the middle-class (0.14 litre/AAME/day) or poor (0.04 litre/AAME/day) ones, respectively. Across all wealth classes and distances, sales in wet periods ($\bar{x}$=0.28 litre/AAME/day) were over two to five times greater than those of transition ($\bar{x}$=0.12) or dry

Table 4.3. *Milk allocation patterns for eight Borana households during 1987—88 in the southern rangelands.*

Product[1]	Long rains					Warm dry season				
	Volume (ml/AAME/wk)	Consumed (%)	Sold/given[2] (%)	Calf (%)	Other[3] (%)	Volume (ml/AAME/wk)	Consumed (%)	Sold/given[2] (%)	Calf (%)	Other[3] (%)
Fresh milk	8541	66	24	0	10	5428	69	20		11
Short-term										
Fermented milk	5869	11	12	0	77	1871	6	1	7	86
Buttermilk	4170	85	0	12	3	1485	93			7
Butter	336					120				
Long-term										
Fermented milk	219					39				

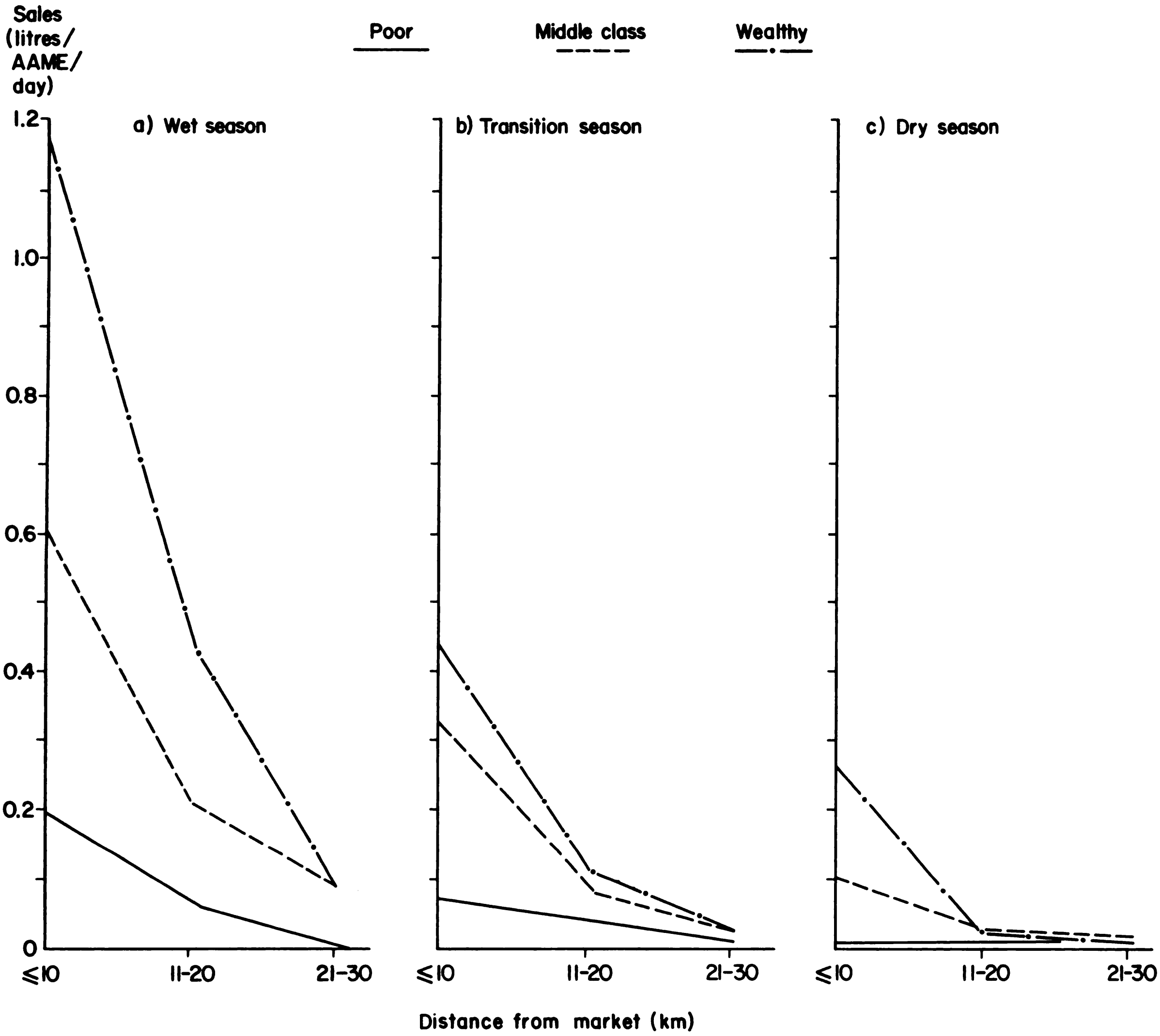
1 Sold/gift could not be adequately segregated in the data. Fresh milk, however, tended to be sold or gifted to relatives and neighbours while short-term fermented milk was gifted only.

2 "Other" was poorly documented for most milk products. Other uses of short-term fermented milk, however, were largely comprised of milk churning for butter production.

3 Where buttermilk and butter (i.e. milk volume "lost" in the production of butter) were componenets of other uses for short-term fermented milk. See the text for descriptions of different milk products.

Source: Coppock et al (in press).

Figure 4.5 (a–c). *Reported daily sales of dairy products (in milk-energy equivalents) by 95 Borana households for two market centres (Dubluk and Mega) for 1987.*



Source: Coppock and Holden (1992).

($\bar{x}$=0.05 litre/AAME/day) seasons, respectively. Dairy sales within a market radius of 10 km averaged 0.32 litre/AAME/day overall, which was over 3 to 16 times greater than that for the distance class of 11 to 20 km ($\bar{x}$=0.10 litre/AAME/day) or 21 to 30 km ($\bar{x}$=0.02 litre/AAME/day). These main effects were highly significant (P<0.001) and are reported in detail in Holden and Coppock (1992).

Linear correlations revealed several important features of marketing behaviour (Holden and Coppock, 1992). Considered across all households, total annual quantity of dairy products sold was positively correlated with total annual frequency of sales (r^2 =0.90; P<0.0001; N=95). The total annual frequency of dairy sales was negatively correlated with distance from market (r^2 =–0.60; P<0.0001; N=95). On an annual basis, households within 10 km of market sold dairy products twice/week on average, whereas those beyond 20 km only sold once/month. The quantity of products sold appeared to remain constant across distance overall, but as families became wealthier they tended to sell more/market trip (r^2 =0.60; P=0.0001; N=95; Holden and Coppock, 1992).

Dairy income as a per cent of annual income was highly variable. Total average income reportedly ranged from EB 93 445 and 784 for poor (N=37), intermediate (N=39) and wealthy families (N=19), respectively. Distribution of results for poor and middle-class households was sharply divided into those who derived a minor (<10%) or major (>80%) proportion of their income from dairy marketing. The

ANOVA revealed only a significant (*P*=0.002) main effect of distance on dairy income as a per cent of total income; the proportion increased from 10% (21 to 30 km) to 17% (11 to 20 km) and 30% (<10 km) across all wealth classes throughout the year. Although not significantly different (*P*>0.05), calculations were interpreted to suggest that the different wealth classes derived varied proportions of their annual income from dairy sales. The poor derived 24% over all seasons while the wealthy and middle class derived 16% and 17%, respectively.

The contribution of dairy sales to seasonal cash income showed a significant (*P*=0.007) interaction of wealth and season that occurred only because the poor and middle class appeared to rely more on dairy sales throughout the year compared to the wealthy. The poor derived 58, 56 and 24% of their income from dairy sales in the wet, transition and dry seasons, respectively. For the same sequence the middle class derived 67, 21 and 12%, while the wealthy derived 38, 24 and 11%. Across all households dairy sales contributed 57, 35 and 16% to total income in the wet, transition and dry seasons, respectively (Holden and Coppock, 1992).

Income from dairy sales belonged to the women and appeared to be their only regular source of money (Holden and Coppock, 1992). All women, but especially the poor, used some of this money to buy grain. Overall, purchase of grain tended to increase in the dry season relative to other times of the year. Purchase of non-food items was more common among the wealthy or middle-class women than the poor ones as higher milk supply allowed the former more discretionary use of dairy income (Holden and Coppock, 1992).

Wealth and distance to market also influenced the types of dairy products sold (Coppock et al, in press). To illustrate the overall pattern using some extreme examples, poorer households closer to market tended to sell relatively more fresh milk while wealthier households far from market tended to sell relatively more butter. This is because of product shelf life and household surplus. Families tend to sell more butter if they live over 20 km from market because it doesn't spoil during the two-hour walk to town. So butter has a low marketing risk and is easy to sell at a good price. This is not the case with fresh milk. Because butter-making requires the accumulation and storage of about two litres of soured milk for up to five days, the production and sale of butter is done more by wealthy and middle-class families who have daily surpluses. In contrast, the poor may be forced to sell fresh milk because their milk supply can be insufficient for subsistence and must be traded for a greater supply of energy as grain. Holden et al (1991) noted that about 3.5 kg of grain (52.5 MJ GE) can be purchased from the sale of 1 litre of milk equivalent (3.3 MJ GE) in the dry season. Poor families close to town can sell fresh milk every day if necessary; this may be an important reason for the poor to reside closer to market centres (Coppock et al, in press).

4.3.5.4 Dairy marketing, human welfare and calf management

The implications of dairy marketing for the welfare of humans and calves were illustrated by Holden et al (1991). The main points are summarised here.

Milk offtake and calf welfare

Across all families the average rate ($\bar{x}\pm$ SE) of milk offtake/cow was 4 litre2.5% (*N*=45) with 5.2 cows documented for each household. Significant ($P\leq$ 0.02) main effects on milk offtake rate were revealed for wealth class (N=15 each), cow class (N=77 each) and distance to market (N=15 each). The poor took a higher rate (53%) than the middle class (36%) or wealthy (34%). The best-producing cows had higher rates of offtake (54%) than average cows (49%), which in turn had higher rates than cows that were poor producers (20%). Across all wealth strata and cow classes, offtake rates were highest within 5 km of market (44%) compared to within 6 to 10 km (40%) or 11 to 15 km (37%).

There were no significant effects of any factors on rates of calf mortality ($P\geq0.56$) with annual mortality averaging 18%. In contrast, there were significant ($P\leq0.05$) main effects of wealth and distance to market on calf morbidity rates which were based on an average of 17 calves/family over three years for a total of 750 observations. Morbidity rates were higher in: (1) wealthy (28%) and poor (25%) households than the middle class ones (16%) and (2) households ≤10 km from market (24% morbidity) versus those between 11 to 15 km (17%).

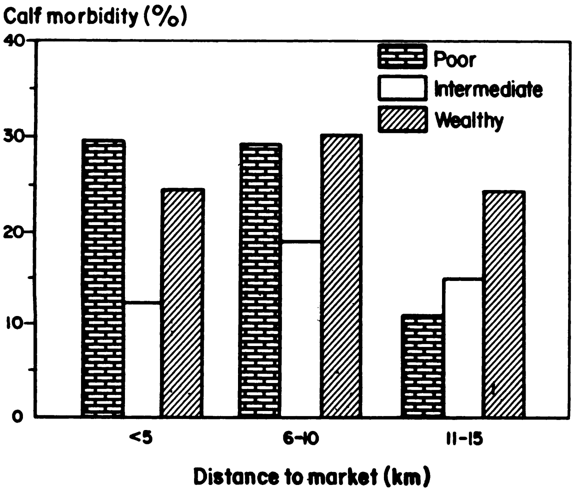
The three-way interaction of wealth x cow class x distance was significant (P=0.01) which indicated that the incidence of morbidity increased among calves of lower-producing cows held by poorer households as distance to market decreased to less than 10 km (Figure 4.6). Overall morbidity rates averaged 23%.

Dairy marketing and human welfare

The reported daily intakes of dairy products by women or young children were not significantly affected by distance to market (P >0.05), but they were affected by wealth class ($P\leq0.03$). With each increase in wealth level (*N*=18 each) intake of dairy products rose 120% for women and 45% for children but only wealthy families were significantly different ($P\leq0.05$) from the others (Holden et al, 1991).

In contrast, grain intake for women was significantly affected (P = 0.001) by distance to

Figure 4.6. *Per cent incidence of reported calf morbidity for Borana households as affected by distance to market and family wealth.*



Source: Holden et al (1991).

market, as women residing within 5 km of town reportedly consumed about 50% more grain than those living further away. Intake of grain energy as a proportion of total energy intake showed no significant effects among children ($\bar{x}$=16%; $P \geq 0.56$) and only the main effect of wealth was significant among the women (P=0.035). Poor, middle-class and wealthy women got 97, 92 and 87% of their energy intake as grain, respectively, and only the poor and wealthy differed significantly (P=0.01).

4.3.6 Cultivation

The general pattern of cultivation by pastoralists on the Borana Plateau suggests a relatively recent increase in cropping activities. Apparently the pastoralists learn rapidly what crops are more appropriate for long or short rainy seasons, and adopt new methods such as animal traction (Hodgson, 1990).

EWWCA (1987) conducted some preliminary surveys with ILCA and CARE- Ethiopia concerning farming practices around the towns of Yabelo and Mega in the upper semi-arid and subhumid zones (see Section 3.3.1: Ecological map and land use). Towns such as these provide the focal point for the introduction of cultivation into the rangelands. From a sample of 38 peri-urban farmers, 21 were Boran, 10 Burji and the rest Amhara, Somali, Konso and Oromo. The mean duration of their farming activity was 32 years. They all worked plots about one hectare in size and held an average of six cattle and four small ruminants. Six of these farmers relied on handtools for land preparation while the rest used draft oxen for ploughing. Preferred crops were maize, teff (*Eragrostis tef*) and wheat.

In their field survey of 60 *olla* in four *madda* during November 1985, Coppock and Mulugeta Mamo (1985) found 49 *olla* had some area under cultivation. Maize, cowpea (*Vigna unguiculata*), haricot bean, sorghum and teff were commonly observed. Informants reported that cultivation had been going on for two years. Seed was purchased from markets and ground preparation was done with sticks and hoes. Crops were frequently seen on heavily manured corrals that were recently made available because of dispersal and the high mortality of cattle during the 1983–84 drought (see Section 6.3.1.1: *Livestock dispersal and herd composition*). Despite the unanimous appreciation of the beneficial effects of fertilisation on crop yields, none of the respondents took the trouble to use manure on their fields even though every encampment had tonnes of manure piled next to corrals from years of corral cleaning. Regional variation in cultivation was indicated because nearly all of the encampments in Did Hara, Web and Melbana were farming, but only 7 of 15 were doing so in drier Medecho. Out of the 49 encampments farming, 10 reported feeding crop residues to calves.

Holden and Coppock (1992) reported from their survey of peri-urban dairy marketing that 33% of 108 households were involved in grain cultivation in 1987. These were mainly middle-class and poor households.

Other cropping surveys were conducted by CARE-Ethiopia and ILCA in Web, Medecho, Melbana and Did Hara *madda* during the long and short rains of 1986 (D. L. Coppock, ILCA, unpublished data; R. J. Hodgson, CARE-Ethiopia, unpublished data). Questionnaires on farming practices were conducted on a larger sample of families while a subset of households were randomly selected to measure the size of their fields and estimate maize production using counts of cobs/stalk and stalk density.

In sum, the questionnaires during the long rainy season (*N*=50) indicated that most sites had been cultivated from one to four years. All family members participated in land clearing, seedbed preparation, weeding and harvest. Men commonly took the lead in these activities. Women constructed elevated storage bins for maize. Manual work was usually done with digging sticks and hoes (66% of respondents) with the remainder using oxen or camels for ploughing. Harnesses were locally designed. Eight *olla* in four *madda* were selected for detailed analysis. In these, 35 of 77 families were farming. Plot size averaged 0.42 ha and over 95% of the area under cultivation was planted with maize, with traces of cowpea, haricot bean, sorghum and teff. Seed was procured from markets, neighbours and Pastoral Associations (PAs; see Section 1.4.3: *The SERP and the Pilot Project*). Crop residues were fed to young calves. Like in the 1985 survey, crops were planted in abandoned corrals when possible, but no effort was made to add manure to fields. Crude estimates of maize density and cobs/stalk suggested that grain production was low and on the order of 1100 kg/ha on an air-dried basis (D. L. Coppock, ILCA, unpublished data).

Surveys in the same eight *olla* during the short rains of 1986 indicated that 53 of 60 families were farming and the average plot size was about 0.15 ha. Crop composition of cultivated area shifted to 82% cowpea, 15% maize, and 3% other minor crops. Increases in the proportion of legume was apparently due to the perception that probability of a successful harvest being greater for these species during the less predictable short rains (D. L. Coppock, ILCA, personal observation). Crop yields were not measured.

In the upper semi-arid zone near Beke Pond, Coppock (1988: pp 19–20) found that 17 out of 24 Gabra and 19 of 23 Borana households were farming and these represented all wealth strata. Fourteen of the Borana households reported that they had farmed for an average of 10 years (range: 1 to 27 years). They started either out of the necessity for food (8 of 13) or by seeing others (5 of 13). Fifteen Gabra households reported that they had farmed for an average of five years (range: 1 to 7 years). Six reported that they started to farm because of famine and nine because they had learned it from the Pastoral Association. Three of 18 Gabra families said that they hoped to stop farming when their herds build to a satisfactory level. The rest of the Gabra and all of the Borana respondents (20) indicated they would continue to farm regardless of the status of their livestock holdings.

On a regional scale, there is evidence that the area under cultivation had increased during the 1980s, it being speculated that this is directly related to impacts of the 1983–84 drought (see Section 3.3.1: *Ecological map and land use*). Citing aerial survey data collected from the 15 475-km^2 study area, Cossins and Upton (1988b: pp 272–273) noted that cultivated area increased fivefold (from 44 to 220 km^2, or from 0.3 to 1.4% of the total land area) between pre-drought 1982 and post-drought 1986. Seventy per cent of the total 220 km^2 under cultivation in 1986 was associated with towns and villages, while the remainder consisted of about 5300 plots scattered throughout the rangelands at an average of 3.2 plots/km^2 (Assefa Eshete et al, 1987: pp 12–13).

4.4 Discussion

4.4.1 General aspects of household economy

4.4.1.1 Pastoralism and cultivation

Gross income of household is the sum of subsistence plus marketed production as derived from the eight-cow production unit of Cossins and Upton (1987). Hence the annual gross income of an average Borana household in an average rainfall year in the early 1980s was about EB 2000. Except for trace amounts of income from sales of things like firewood, incense or handicrafts, virtually all of this income is from livestock, specifically cattle. The calculations considered the values of marketed animals (EB 552), marketed milk (EB 71), consumed milk (EB 721), six new calves (EB 600) plus other useful animal products such as hides (EB 50) for a grand total of EB 1994. Roughly 40% of gross revenue is derived from milk and the remainder from live animals or meat.

It is likely that less than 1% of animal outputs are used as crop inputs. For example, there is apparently no effort made to manually apply the large quantities of manure that have accumulated at encampments, which is a common practice with other low-input extensive farming systems (Massey, 1987: p 93). The main interactions between crops and livestock in Borana occur when oxen or camels are sometimes used to plough fields (direct linkage), when crop residues are fed to calves in dry seasons (direct linkage) and when small amounts of cash from sales of livestock products are used to purchase seeds (indirect linkage).

In sum, this is all interpreted to show that the vast majority of the Boran still operate a largely pastoral, rather than agropastoral economy (considering the criteria of McIntire and Gryseels, 1987; R. T. Wilson, ILCA, unpublished data). Nearly all of their food and income is ultimately derived from livestock. Cash remittances from relatives outside the system were virtually nonexistent in average rainfall years during the early 1980s (Cossins and Upton, 1987: p 212). The preliminary findings of AGROTEC/CRG/SEDES Associates (1974f: pp 70–74) are similar to many reported here with other details provided. However, it is interesting to note that the mean cash income of Borana households in 1972 (EB 86) reported by AGROTEC/CRG/SEDES Associates (1974f: p 67) is only 14% of the mean of (EB 623) for 1983. Assuming the data are accurate, this may reflect changes in the prices of commodities as well as a previously lower need for market involvement (see Section 7.2: *A theory of local system dynamics*). To this day the majority of Boran have apparently little need or opportunity for integrating livestock and crops. Such integration is commonly considered to be slow and uncertain under semi-arid conditions (McIntire and Gryseels, 1987: p 239). Possible development opportunities to facilitate future crop/livestock integration in Borana are presented in Chapter 7: *Development-intervention concepts*.

There are conflicting reports as to whether cultivation has been an important aspect of the Borana economy traditionally. On one hand, Asmarom Legesse (1973) reported that the Boran during the early 1960s had only negative feeling towards farmers and farming and this implied that the Boran would never engage in cultivation unless faced with no other alternative. In contrast, Negussie Tilahun (1984: p 6) noted that cultivation has occurred in the Borana Plateau for over 40 years and that farmed acreage expanded after a drought in the mid-1970s.

The widespread potential of cultivation in the Borana Plateau was first reported by AGROTEC/CRG/SEDES Associates (1974e: pp 24, 27) where it was stated that "one third of the breeders practice cultivation, but only on a very small scale." It is likely, however, that this estimate was biased on the high side since their surveys focused on households residing near roads and towns. Even today these areas remain the dominant centres for cultivation due to favourable local environments and proximity to influences of migrant highland farmers (Hodgson, 1990; Assefa Eshete et al, 1987). A drought in the early 1970s was cited as a factor in the spread of farming on the Borana Plateau (AGROTEC/CRG/SEDES Associates, 1974e).

Assefa Eshete et al (1987: p 12) noted that it may be possible to cultivate about 30% (4600 km^2) of the study area with 21% of this taking place in valleys and the remainder above 1650 m elevation. Given this figure of 4600 km^2 as the maximum possible to cultivate, about 5% of this total may have been cultivated during 1986. Assuming estimates of Cossins and Upton (1988b: pp 272–273) to be correct, the increase of 176 km^2 in cropped area during the mid-1980s was actually achieved in only two years after the 1983–84 drought. If it is assumed that another 90 km^2 could be brought under cultivation each year, it would still take about 48 years to use all the arable land. This is, of course, highly speculative and would vary depending on population growth (in towns as well as the rangelands), cultural commitment and the economic need to farm, uptake of animal traction which could double the rate of cropland expansion (Pingali, 1987: p 11), land use and agricultural policies, the creation of other nonagrarian economic options for people and long-term rainfall patterns.

It is also assumed in this scenario that all arable land is accessible for cultivation, which is not likely to be the case. Since crops need supervision to reduce losses from wildlife and thievery and encampments must be located within 16 km of the deep wells (Cossins and Upton, 1987: p 203), arable sites outside such radii would probably not be used. While the long-term trend in the rangelands may be towards increases in cultivated area, over the short-term farming intensity would probably ebb and flow, largely depending on rainfall.

In more mesic situations where cropping carries less risk, pockets of agropastoralism have developed and will continue to expand. An example of such an area may be Dadim (10 km north of Yabelo), where a settled community of negligible numbers in 1973 had grown to over 4000 persons by 1990 (I. De Lange, Dadim Mission, personal communication). Local informants have speculated that poor pastoralists make up the majority of the new farmers that populate such villages on the edge of the rangelands today (D. L. Coppock, ILCA, personal observation).

Drought has been found to elicit at least a temporary reliance on cultivation by pastoralists until livestock productivity and numbers recover (Hogg, 1980; Toulmin, 1986: p 2; Moris, 1988: p 276). However, whether or not farming persists and is intensified may depend to a large degree on population pressure (Boserup, 1965: pp 63–64). Under recent conditions of restricted resources farming can persist in a pastoral society because a mixed system has greater proven flexibility and resilience (Campbell, 1984: p 55; Massey, 1987: p 83; Johnson et al, 1989). Droughts todate in the Borana system usually kill far more livestock than people (see Chapter 6: *Effects of drought and traditional tactics for drought mitigation*) and thus should accelerate a decline in pastoral production and welfare in the face of increasing population density. Opportunistic cultivation is one of the few alternatives that pastoralists have to partially compensate for such a long-term trend (Evangelou, 1984: p 258). It may be illustrative that there were 3.2 TLU/person and 10 people/km^2 in semi-arid Maasailand during 1980, a time when cultivation was considered to be a growing and permanent feature in the economic diversification of that society (Evangelou, 1984: pp 17–38).

Estimates for the entire 95 000-km^2 SORDU project area showed 4.1 TLU/person and 5.6 people/km^2 in 1988 (Solomon Desta, nd; see Section 7.2: *A theory of local system dynamics*). In an aerial survey of the 15 475 km^2 central plateau, Milligan (1983) estimated about 2.3 TLU/person and 7.3 person/km^2. The uneven distribution of water and the location of most encampments within 16 km of the deep wells (Cossins and Upton, 1987: p 203) indicates that local densities of livestock and people are considerably higher than the overall mean. If about 50% of the potential grazing area is actually used in the dry season (Milligan, 1983: p 28), then population pressure could be more on the order of 15 persons/km^2. In other words, preconditions for a general shift to agropastoralism do in fact exist on the Borana Plateau today.

Drought can permanently turn poor pastoralists into farmers by the unfortunate depletion of their smaller herds; and can at least turn wealthier pastoralists into temporary or part-time farmers by reducing milk production and killing milk cows and their replacements. In such cases households would be forced to cultivate for a few years until herds recover their milk-production potential. This is the hypothesis behind the observation that several pastoral groups have abandoned cultivation a few years after a drought has ended (Hogg, 1980: Toulmin, 1986). It is believed that while cultivation used to be a sporadic response to drought for the Boran, it will now persist, even in average rainfall years. The agropastoral Gujji represent a neighbouring group that were once pure pastoralists (Asmarom Legesse, 1973).

4.4.1.2 Gender

Borana men are the heads of households and make the major decisions regarding production strategies and disposal of ruminant and equine livestock. Most of the money from the sale of these livestock apparently goes to men. Inheritance of livestock follows along male lines of descent also (Asmarom Legesse, 1973). Women, on the other hand, make the day-to-day decisions regarding milk offtake, management of calves, goat kids and lambs, and derive their cash income from sales of dairy products and possibily poultry (D. L. Coppock, ILCA, personal observation). Socio-economic patterns reported elsewhere in Africa support this generally inferior economic status of pastoral and agropastoral women but it has also been noted that these women may have more subtle rights and claims to livestock than is immediately apparent (Broch-Due et al, 1981; Wienpahl, 1984; Massey, 1987: pp 111, 171). This has not been studied in detail among the Boran to verify, so general conclusions need to be qualified. The picture is complicated by the fact that a significant proportion (perhaps 20%) of household heads among the Boran are now women. Many of the female household heads in the survey of Holden (1988) were in the poorest wealth class (S. J. Holden, ILCA, personal communication). It is reasonable to speculate that the incidence of female household heads may increase in peri-urban settings as a reflection of their frequent poverty status and thus their need to sell milk to purchase grain (Holden et al, 1991).

4.4.2 Economic comparisons among pastoral systems

Some useful contrasts can be made between the Borana system and the Maasai System in Kenya because they are both in semi-arid environments, with the Maasai being considered further along a continuum of pastoral change (Evangelou, 1984: Solomon Bekure et al, 1991). Income wise the Borana cash budget is based on a 40:60 split between milk and meat, respectively, similar to the 46:54 split for Maasai families on group ranches (Evangelou, 1984: p 187). Compared to the Maasai system, however, the relative contribution of small ruminants to the household economy among the Boran seems very small (Evangelou, 1984: p 105). The Maasai have a higher population density and as a result appear to be shifting to various forms of livestock diversification and agropastoralism (Campbell, 1984; Evangelou, 1984).

Although livestock production forms the basis for the Borana economy, the opportunity to sell livestock and livestock products in order to purchase grain at favourable terms of trade is critical in providing the food that enables a higher density of people to live on the Borana Plateau. Over 35% of the annual energy requirements of households are met by purchasing nonpastoral foods (Cossins and Upton, 1987: p 213). Similarly, Upton (1986a: pp 21–22) estimated from data in Milligan (1983) that the 14.3 LSU/km^2 on the central plateau yield 11 154 MJ GE/year, which could support a human population density of 4.8/km^2. This is only 68% of the measured density of 7/km^2 in 1983. Considering information in Milligan (1983) and Upton (1986a) and assuming an annual growth rate of 2.5% in the human population (see Section 2.4.3: *Human population growth*) the Boran may have numbered 4.8/km^2 back in 1966. Assuming that livestock productivity and density have been similar over the years of average rainfall, this suggests that the population has become dependent on imported grain for about 24 years or one generation. Maize was reported in the Borana diet in 1972 (AGROTEC/CRG/SEDES Associates, 1974f: p 73). Other population perspectives related to dietary shifts are reviewed in Section 7.2.1: *Empirical modeling.*

The combination of a higher density of people and increasing flows of grain at present means that dependence on grain will continue (and increase) as a permanent and growing feature of the Borana economy, depending on climate, population dynamics and related factors. Trade for grain has probably been going on in the area for centuries and may have fluctuated with the fortunes and size of the human population (Wilding, 1985a). In one sense, while recent population growth may be viewed as a linear process, it is likely that there has been a high degree of flactuation historically as a result of climate changes, migration, warfare and disease (Wilding, 1985a; see Section 7.2: *A theory of local system dynamics*). Various degrees of agropastoralism have probably come and gone over time. It is unclear if the present density of people in the study area has ever been equalled in the past, or whether the current trajectory of the production system is indeed unique.

Upton (1986a: pp 31–33) noted the key role of trade in providing subsistence as well as surplus in average rainfall years, and calculated that even if grain prices rose (or livestock prices fell) by up to 470%, trade would still be beneficial to the Boran. However, higher population densities of people become more vulnerable to less favourable terms of trade (Upton, 1986a: p 33). The subsidy effect of grain on pastoral population density has been noted elsewhere (Dahl and Hjort, 1976: p 155; Bates and Lees, 1977). Dahl and Hjort (1976: p 155–156) and Evangelou (1984: p 108) cited examples of a gradual increase in the proportion of agricultural produce in the Maasai diet over the past 40 years as one result of population pressure. In a 1990 survey of Borana elders, it was found that they believed regular grain consumption to be a relatively new aspect of their society (D. L. Coppock, ILCA, unpublished data).

Offtake rates (largely sales to few slaughters) were estimated to be 19% for cattle on the Borana Plateau in a normal rainfall year (Donaldson, 1986: pp 13, 57; Cossins and Upton, 1987: p 211). Cattle offtake rates were apparently higher during the drought as markets were saturated, but no reliable regional figures were obtained (see Section 6.3.1.1: *Livestock dispersal and herd composition*). An offtake rate of 19% appears high in relation to some long-term estimates for other pastoral systems under conditions of average rainfall and traditional production objectives. Although the Borana system exhibits some symptoms of range degradation (see Section 3.3: *Results*) and the people are increasingly dependent on grain, during years of average rainfall grazing is still regarded as adequate (Cossins and Upton, 1987). Dahl and Hjort (1976: p 181) cited Morgan (1972) as saying that pastoral herds in overgrazed areas had higher offtake of 10–12% versus those in moderately grazed areas (4–9%). Dahl and Hjort (1976: p 181) noted that such a shift in offtake does not reflect "progressiveness", but rather a reaction to low per capita productivity in the traditional system.

Evangelou (1984: p 109) quoted an average of 10% offtake for cattle by pastoralists versus 25% for commercial ranchers in Kenya. He also noted that cattle offtake for the Maasai system could vary from 10% (at times of post-drought herd building) to an average of 13 to 17% once recovery is well underway or complete. The higher rate (17%) is thus similar to estimates for Borana (19%) before the 1983–84 drought. During the 1973–74 drought in Maasailand cattle offtake rates jumped to 38% (Evangelou, 1984: p 109). Meadows and White (1979) saw this as an increased demand for cash that had to be met by the Maasai in order to buy nonpastoral food. Coppock (1992b) found that Borana elders expected livestock offtake to increase among them because of a growing need to buy grain and the changing attitudes among the younger generation towards buying consumer goods. Although sampling methods were unclear, the observation of AGROTEC/CRG/SEDES Associates (1974f: p 67) that the annual marketed offtake of livestock averaged 5.2% on the Borana Plateau in 1972 lends some credence to the stipulation that offtake rates have gone up (see Section 7.2: *A theory local system dynamics*).

Negussie Tilahun (1984) found a high correlation between income and purchase of food and dry goods such as clothes. Income was derived from the sale of cattle and this increased with higher absolute holdings of animals. In one sense these findings are paradoxical: While it could be anticipated that increased wealth would result in a higher demand for some nonfood items, on the other hand wealthier families would be expected to have a higher ratio of milk cows per person and hence less of a need to purchase grain, regardless of season. Grandin and Solomon Bekure (1982) also noted that wealthier Maasai households sold a larger absolute number of animals, but that the rate of herd offtake was lower compared to poorer households. It is possible that some of the grain obtained through cattle sales by the wealthy is for impoverished relatives or friends, as redistribution of food is reportedly common among the Boran (Cossins and Upton, 1987).

Although the households studied by Negussie Tilahun (1984) on average showed a wide range of income and livestock holdings, compared to subsequent surveys (Donaldson, 1986; Holden, 1988) the sample appeared wealthier. Families were larger (over eight persons), several men had two wives and the ratio of 13.8 livestock unit/AAME is nearly three times the mean from more extensive work (Milligan, 1983). It is common that initial household studies in a pastoral society may be associated with the wealthier or more influential persons (D. L. Coppock, ILCA, personal observation), so that if more very poor families had been included in the survey, correlation relationships may have been stronger. Negussie Tilahun (1984) speculated that offtake rate could be stimulated if the flow of appropriate consumer goods was increased to the southern rangelands. This was mentioned previously as a constraint by AGROTEC/ CRG/SEDES Associates (1974f: p 70) and UNDP/ RRC (1984: p 46). This topic is reviewed further in Section 7.3.3.6: *Cattle marketing*.

4.4.3 Livestock supply to markets

The market supply analysis confirmed the supreme role of cattle in the Borana cash economy (Dyce, 1987: pp 58–59): the number of cattle marketed was roughly double that for goats, eight times that for sheep and 80 times that for camels. The dominance of cattle was most pronounced at Negele and Agere Mariam to the north, which reflects the highland demand and the ability of cattle to be trekked long distances out of the system. Except for Moyale, where the supply of goats was greatest, all markets conformed to this species pattern. The location of Moyale on the Kenya border, where there may be a higher demand for goats as well as a "loss" of cattle to cross-border black-market trade, may best explain this pattern. In addition, the environment around Moyale may be more ecologically conducive to rearing small ruminants (Dyce, 1987: p 58).

Although the data base for the Boran only covered 35 months, there were some features that can be compared to other pastoral areas. Sandford (1983a: pp 208–210) asserted that compared to other systems, pastoral systems are more commonly characterised by high seasonal and annual fluctuations in the number of livestock marketed. Data were cited from Kenya (18 years) and Upper Volta (nine years) that showed annual coefficients of variation of 51% and 31%, respectively. Sandford also noted that a higher proportion of the cattle sold in pastoral systems consists of immature males and older females, and that less emphasis is placed on selling mature males ready for slaughter, although this may vary with environmental conditions. For example, if forage is abundant young stock may not be marketed. An example was shown from Herman (1983) who compared pastoral and nonpastoral systems in Upper Volta in 1976–77. Both systems were similar in that about three-fourths of all sales were male cattle, but they differed in that 46% of all sales in the pastoral system were males less than two years old. For the nonpastoral system the same group accounted for only 4% of all sales (Sandford, 1983a: p 210).

Dyce (1987: p 60) calculated an annual coefficient of variation for the Borana markets of 54%, which is in agreement with Sandford (1983a). There was no clear overall pattern, suggesting that the Borana marketing flows varied by season or rainfall pattern; arguably the data set may have been too limited to address this question (Dyce, 1987: p 61). However, information from other re- searchers (Negussie Tilahun, 1984; Holden, 1988; Mulugeta Assefa, 1990), local informants (Coppock, 1992b) and government agents (Solomon Desta, TLDP economist, personal communication) and non-government purchasing agents (R. J. Hodgson, CARE-Ethiopia, personal communication) all indicate that the tendency is for the Boran to try to avoid selling cattle in wet periods when forage (and thus milk) production is high and to sell during dry periods of stress when they are forced to purchase grain. This supports the general observations that pastoralists principally sell animals to remedy a specific cash need that usually appears in a dry season or drought (Dahl and Hjort, 1976: p 180; Meadows and White, 1979; Cossins and Upton, 1988b: p 255).

In terms of the sex and age composition of marketed stock, Dyce (1987: p 61) noted that the most frequently marketed cattle on the Borana Plateau were mature males; this was consistent with patterns in the Sahel reported by Herman (1983) who said that the typical marketed animal was a male four to seven years old (note the contrast to the earlier citation of Herman (1983) by Sandford (1983a)). Data from a small sample collected by Evangelou (1984: pp 216, 228) showed mature males made up 56% (*N*=203) and 67% (*N*=177) of cattle marketed in Maasailand during 1980. Likewise except for one market at Hidi Lola, there was no indication in the southern rangelands to suggest that immature cattle played a significant role in the supply of cattle to formal markets. This is in contrast to speculation by Sandford (1983a: p 210), although sale of young calves may have been greater among producers at innermost bush markets far from town; (Cossins and Upton, 1987: p 211). Their under-representation at larger market centers may have been due to their lower ability to walk long distances. Other factors contravening the sale of immatures may include: (1) a low per kilogram price; (2) the need for milk by delaying weaning for over a year in many cases; and (3) maximising income by selling a mature animal. Nicholson (1983b: pp 27, 37) noted the highest price/kilogram was achieved for animals over 282 kg.

Wealth differences also affect livestock-marketing patterns. Informants reported that a poor herd owner does not have the choice to wait for an animal to reach optimum weight before marketing if he has to buy grain to survive (Coppock, 1992b). Thus, it is usually the poor herd owner who must sell an immature animal. If more immature cattle appear on local markets, it is assumed that this is caused by more households becoming poorer (Coppock, 1992b). As first noted by Jahnke (1982: p 92), Dyce (1987: p 61) mentioned that the low and variable market supply of immature cattle in Borana would be a major constraint to the development of an appropriately stratified beef industry in which, for example, immatures are taken off and fattened in higher potential environments (von Kaufmann, 1976: pp 273–274; Pratt and Gwynne, 1977: p 140; Jahnke, 1982: p 91; UNDP/RRC, 1984: p 46). This perspective fits the Boran especially in light of their resistance to sell younger stock (see next section).

Although sales of goats and sheep were secondary to the Borana economy in the early 1980s, they may have become more important recently because of the increased activity of government buyers collecting animals for export starting in 1984 (Cossins and Upton, 1987: p 211). This can quadruple the price of mature male sheep, although variation in foreign demand greatly alters local marketing opportunities (D. L. Coppock, ILCA, personal observation). It has been suggested that the Boran are diversifying their holdings to include more small ruminants (Belete Dessalegn, 1985: p 26). Although this hypothesis remains untested, it would be consistent with a stress response manifest when cattle pastoralists are increasingly pauperised by high population densities and/or drought (Evangelou, 1984: p 35). The diversification into small ruminants may also indicate an interest to use the latter as saleable substitutes for cattle in light of possible increased pressure to purchase grain. The sale of small ruminants does not cut into the herd capital as deeply as would the sale of cattle, nor does it require the concensus of relatives as is the case with cattle (Coppock, 1992b).

Camels were almost negligible in the market analysis of Dyce (1987). The only reliable markets to find a few camels for sale are to the south at Moyale and to the east at Negele (Hodgson, 1990: p 123). Facilitating development of camels among the Boran is discussed in Section 7.3.3.2: *Camels, donkeys and small ruminants.*

4.4.4 Traditional marketing rationale

The interview data used to interpret pastoral rationale are limited in that they may reveal how people think they behave rather than how they actually behave (S. Sandford, ILCA, personal communication). The results are interpreted, however, as offering important explanatory insights into herd accumulation and animal marketing behaviour that would be very difficult to obtain in a more objective fashion. That the Boran sell animals to satisfy acute cash needs, do so at sub-optimal times of the year in light of the seasonal terms of trade, and prefer to sell certain classes of cattle (older males) that tend to be different from those sold in developed animal production systems (immature males) are important findings consistent with empirical observations (Doran et al, 1979: see reviews in Sandford, 1983a; Dyce, 1987). This preference of the Boran to sell males that have completed growth explains the difficulties purchasing agents have had over the years attempting to buy younger males for ranching and stocker/feeder programmes (Solomon Desta, TLDP economist, personal communication). If more immature cattle are seen in markets in the future, it implies that the people are becoming poorer and have fewer mature males for sale (see Section 7.2: *A theory of local system dynamics*) and should not be erroneously interpreted as a shift towards "more progressive" marketing behaviour by the Boran consistent with Western production concepts. It also undermines concepts such as a stratified regional production systems in which immatures are taken off the rangelands and grown out in higher potential areas (von Kaufmann, 1976).

That the Boran seek to accumulate animals to promote prestige and protect themselves from perturbations have been long recognised as important elements of pastoral behaviour (Pratt and Gwynne, 1977). That the Boran attempt to avoid cattle sales by diversification into small ruminants and cultivation to help them endure increasing population pressure is another important side effect of their behaviour with implications for system transformation (see Section 7.2: *A theory of local system dynamics*).

The "perverse supply concept" is controversial (Doran et al, 1979; Jarvis, 1980; Low et al, 1980; Sandford, 1983a). Results suggest that perverse supply factors operate here, but vary according to the wealth class of the seller and the species of livestock. The hypothesis is thus very difficult to test using aggregated empirical data. It is also often misinterpreted (D. L. Coppock, ILCA, personal observation). Perverse supply in this context implies that marketed throughput of animals over a given period of time would be lower in response to higher prices; this would be true in situations where accumulation of animals is a traditional value and cash needs are limited. It is not to say that pastoralists will not respond in general to a market offering higher prices; in the southern rangelands the black market with Kenya thrives because the Boran seek higher prices for their cattle. The prediction, however, is that the throughput per household would be lower over a specified time interval as a result of higher prices. Marketing patterns over time are also confounded by increasing pauperisation of the Boran as a result of population growth and drought (see Section 7.2: *A theory of local system dynamics*).

This suggests that, with traditional values held relatively constant, perverse supply behaviour would occur more acutely in the future than it does today as a result of a change in the wealth structure of the society. A change in marketing values over time, however, would confound patterns. At least in the peri-urban areas, values reportedly are changing among younger herd owners towards increased monetisation and market involvement and all respondents noted the increasing importance of markets to the survival of the Borana system (Coppock, 1992b). It is important to emphasise, however, that a transition to increased livestock marketing is only welcome if the desired commodities are regularly available at reasonable prices since market dependence has its own risks. In summary, this framework may offer a basis for understanding system-level variation in perverse supply responses due to culture and/or livestock wealth. Such a framework is needed to help elucidate why research on perverse supply phenomena has yielded such equivocal interpretations (Sandford, 1983a).

The idea that the Boran act like "optimistic gamblers" and delay cattle sales until they apparently have no other choice, has large implications for system stability and food security. These topics are explored in Section 6.4.4: *Traditional drought mitigation tactics* and Section 7.3.3.7: *Mitigation of drought impact.*

4.4.5 Marketing efficiency

Cossins and Upton (1988b: pp 254–256) reviewed marketing concepts relevant to the southern rangelands. They noted that marketing strategies to increase offtake through provision of infrastructure assume that the existing marketing system is inefficient and that pastoralists will increase offtake if prices are increased. They stated that without radical changes in the traditional system there is little scope for increasing offtake, making the supply of marketable stock rather inelastic. They argued from the work of Negussie Tilahun (nd) that the structure and performance of the Borana market system to be "reasonably good" because of the ready access of primary markets and the presence of large numbers of buyers and sellers; the latter feature discounts the notion that price fixing or excessive marketing margins apply. They stated the major marketing constraint to be the decline in the terms of trade of livestock for grain during drought, which reflects problems in national policies for food production and distribution rather than deficiencies in the local characteristics of local markets.

In his review, Sandford (1983a: pp 199–229) concluded that the available evidence did not consistently support or reject the notion that pastoralists respond positively to price increases by increasing the supply of animals to market, pointing out the improbability that a single generalisation could explain response in such a diversity of pastoral situations. The second point about pastoral markets being dificient in their terms of trade during drought was contrary to evidence found for Africa by Sandford (1983a).

4.4.6 Market evolution

Evangelou (1984: p 239) cited Johnston and Clark (1982) as stating that the distinctive feature of the development process is the expansion and evolution of markets. Market systems are therefore not static but in a continuing process of change. There has not been any testing of hypotheses regarding market evolution in the southern rangelands, but looking into some of the experiences and speculation of local traders and others is useful in defining some likely elements of change.

Local informants feel (D. L. Coppock, ILCA, personal observation) that markets on the Borana Plateau in 1990 are more organised and diverse compared to the early 1980s. According to these informants, government efforts were initiated in 1983 to organise large-scale purchases of sheep and cattle for export. This served to train a cadre of local traders that reportedly dominated marketing in 1990. These men are often Boran who have strong ties to local urban centres. Some reportedly attained their initial wealth dealing in sheep during years of average rainfall while others did so by buying up cheap cattle during the 1983–84 drought, securing the grazing and water to keep many of them alive and subsequently making windfall profits two years later when normal weather conditions resumed. These traders allegedly maintain large herds of mature males managed as *forra* animals. They purchase animals during dry seasons when prices are low and fill a seasonal marketing gap by selling animals at high prices during the rainy seasons when the traditional pastoralists are apparently less willing to do so (Coppock, 1992b). Thus, there are probably now distinct groups of sellers in the rangelands that have different seasonal strategies.

Data of Negussie Tilahun (nd) collected for 35 months prior to the 1983–84 drought, suggested that livestock prices were slowly rising. Cattle prices in 1990 for mature and immature males increased (Solomon Desta, TLDP economist, personal communication) on the order of 30% compared to those recorded by Negussie Tilahun (nd). Local informants (D. L. Coppock, ILCA, personal observation) have speculated that this increase in price may be due to a greater diversity of outside buyers (government and private operators) and local traders since 1985. This reflects higher demand from the Ethiopian highlands as well as for export (FLDP, nd), a continuing strong black market trade to Kenya and the relaxation of regional controls on commodity movements within Ethiopia starting in 1990 (Ethiopian Herald, 1990).

AGROTEC/CRG/SEDES Associates (1974f: p 67) reported that in October 1972 the "farm-gate" prices on the Borana Plateau averaged from EB 30 (cull cows) to EB 70 (heifers), EB 50 (four-year-old bulls) and EB 95 (six-year-old steers). Prices for purchased commodities were not reported. It was also stated that even in 1972 about 60% of all marketed Boran cattle entered Kenyan markets. This trade remains very active today. Based on estimates from informants, Hodgson (1990: p 77) stipulated that around 17 000 head of Borana cattle crossed to Kenyan markets in 1988. It is not clear to what extent the early 1970s and late 1980s are comparable in terms of climate and livestock population dynamics in relation to drought impact, which complicates direct price comparisons. However, it is likely that a general inflation has occurred and the true value of cattle has increased (R. Brokken, ILCA, personal communication).

4.4.7 Productivity comparisons among systems

Cossins (1985) and Cossins and Upton (1987: p 216) contrasted the secondary productivity of the Borana system with that of Kenya commercial ranches (Laikipia) and three Australian cattle stations. All were considered to have grossly similar environments in terms of rainfall and net primary production. Secondary productivity was expressed per hectare. In the pastoral systems secondary productivity was variously composed of offtake of milk, meat and offal while in the ranching systems offtake was limited to meat. It was concluded that the Borana pastoral system yielded 119 MJ GE of offtake/ha/year (based largely on 6.25 kg of meat and 21 kg of milk) and thus outperformed both the average Laikipia Ranch by 24% (96 MJ GE based on 19 kg of meat) and the cattle stations by over fivefold (22 MJ GE based on 4.3 kg of meat).

Similar perspectives were previously forwarded by de Ridder and Wagenaar (1986a,b) in their analyses of production systems in eastern Botswana. They concluded from a preliminary analysis that the traditional systems were 95% more productive than ranching systems on a per hectare basis. This calculation reflected higher stocking rates, milk offtake and the use of draft power in the traditional sector, which offset their lower cattle productivity per head compared to ranching (de Ridder and Wagenaar, 1986a). They followed this up with a more complete analysis of how efficiently forage energy (GE) and crude protein (CP) are harvested and assimilated in the two systems. For example, in terms of the net energy in animal products as a per cent of total maintenance energy, they found ranching to average 110% more efficient. This primarily occurred because of differences in the age and sex structure of herds in each system. However, the traditional systems were from 119 to 233% more efficient in terms of energy consumed as a per cent of plant energy produced, and 6 to 61% more efficient in terms of net energy in animal products per unit of plant energy produced. Similar results were obtained for CP efficiencies (de Ridder and Wagenaar, 1986b: pp 10–11). They concluded that although ranching systems were more efficient on a per animal basis, a shift from traditional production to ranching results in serious losses of efficiency and productivity per hectare. The higher stocking rates in traditional production systems, however, could pose a higher risk of pasture degradation in years of low rainfall (de Ridder and Wagenaar, 1986b: p 14). Other crucial biological, social and economic transformations required to convert a pastoral system into a ranching system are reviewed in Behnke (1984).

Cossins and Upton (1987: p 217) also compared annual outputs of energy and cash income between a mixed crop–livestock system in the Ethiopian highlands at 845 mm of annual rainfall (Gryseels and Anderson, 1983) with that in the Borana system. Compared to the pastoral system, the mixed system yielded about 63, 2 and 1.75 times more energy per hectare, household and person, respectively. The mixed system also yielded nearly 12 times more cash income per hectare than the pastoral one. However, the Borana system yields about three times more cash income per household and per person. It was concluded that although the pastoralists have an energy-deficit situation in terms of food production, they do receive more cash income. Cossins and Upton (1987: p 217) concluded that the Borana system is productive and efficient and most viable as long as livestock products can be sold to purchase energy at reasonable terms of trade.

4.4.8 Labour and the encampment

4.4.8.1 Labour coordination

Labour coordination is likely a major reason why the encampment-level of organisation has evolved on the Borana Plateau. Certain forms of labour sharing also are probably more important in this process than others. Helland (1980b: p 23) considered labour for watering animals from the wells as far more important than that used for herding, for example. He speculated that the increase in herd size is primarily limited by labour availability for well watering. This may imply that coordination of watering from the wells in dry seasons constitutes the major cohesive function of the encampment.

AGROTEC/CRG/SEDES Associates (1974f: p 25) reported that family heads within each encampment meet each morning at a breakfast ceremony to decide on matters of household concern (this presumably includes labour coordination). They also noted that the association of families within a Borana encampment (*olla*) shows a remarkable stability over time, characterised by much cooperation. Other social and production factors are obviously also important in the cohesion of the encampment throughout the year, otherwise encampment would disband in the wet season with families going in different directions. There are regular seasonal shifts of a few families in some regions that are typically caused by forage shortages and/or the need to minimise distance to water in dry periods (Hodgson, 1990: p 30). In contrast, it should be noted that extensive seasonal gathering and dispersing of families characterise some pastoral groups in more arid regions of East Africa (McCabe, 1983).

If the labour organisation for working wells is a fundamental influence on the size and composition of encampments, it might be expected that those that are found outside of well areas would differ from those within. However, this hypothesis is not substantiated by general observations of Somali encampments immediately to the east (AGROTEC/CRG/SEDES Associates, 1974g: p 21) or of Borana or Gabra encampments to the north served by the large ponds. More differences in social organisation and labour coordination between the Boran and Somali in SORDU may be expected at the level of grazing resource allocation.

The strict allocation of tasks to various age and sex groups in Borana encampments is typical of pastoral systems in general (Evangelou, 1984: pp 99–101: Fratkin, 1987). AGROTEC/CRG/SEDES Associates (1974f: pp 52–53) describing these task in 1972 noted that farming was a distinct activity of males, in contrast to observations in this study that showed both males and females participating in cultivation. This latter point is consistent with the idea that newer activities such as farming may be somewhat more flexible in relation to gender roles, as has been observed in agropastoral societies (Massey, 1987: p 65).

The relatively precise allocation of duties within the Borana household means that technical interventions to improve labour efficiency in performing certain tasks would have to be targeted at particular age and sex groups. Examples include improvements to well systems (largely to the benefit of young men), construction of water cisterns near encampments (benefit to women) and hay making for dry-season calf feed (benefit to women). These concepts are reviewed further in Chapter 7: *Development-intervention concepts*.

4.4.8.2 The labour of women

Although the important and arduous roles of women in mixed farming systems in Africa has received more recent attention (Lowe, 1986: pp 19–21; Gladwin and McMillan, 1989; Kumar, 1989; Webb, 1989), relatively less attention has been given to the study of gender issues in the pastoral sector (Broch-Due et al, 1981). However, Fratkin (1989) lists some references dating back to 1965 that deal with gender inequality in the rights and ownership of pastoral livestock.

Detailed studies dealing with the allocation of time and labour of pastoral women are rare. Massey (1987: pp 66–67) described general duties of women in agropastoral Somalia. He noted that after tending to food preparation and child care, women in the dry season spent nearly all of their time hauling water (on a daily or semi-daily basis). At other times of the year the women divided their time mostly among domestic chores, care of livestock and cultivation. While Somali men shared milking of the camels, the women always milked the cows and goats by themselves. Other domestic tasks of Somali women included managing chickens, processing milk, collecting firewood, fodder collection for young stock (shared sometimes with men), making mats and vessels and erecting and taking down the camp.

Fratkin (1989) cited Dahl (1987) as noting that pastoral women are commonly responsible for running the household as well as herding and other aspects of livestock care. Field studies of Fratkin (1989) of 39 Ariaal households in northern Kenya revealed that married women worked harder (65% of the time between 0530 and 2000 hrs) than married men (43% of the time), and consequently had about two-thirds of the leisure and rest time enjoyed by men (35 vs 52%). Wealthier men and women worked less than their poorer counterparts.

In sum the woman's active day of 14.7 hrs was composed of domestic tasks (37%), livestock tasks (14%), manufacturing (such as weaving) tasks (14%) and others (35%).

The general findings of the above studies are consistent with patterns observed among the Boran. Women's work days are reportedly long and dominated by numerous household-support tasks and care of livestock. Verbal data also indicated significant seasonal shifts in work loads and types of activities prioritised. Alleviation of women's labour burdens has been identified as a priority for development interventions described in Section 7.1.2: *Development philosophy for the Boran.* Observational studies on wet and dry-season labour budgets of women in experimental formats were conducted by Coppock (1992a) in support of development concepts. One finding of these studies is that the verbally reported work load of individual women in the long dry season was probably exaggerated (for details see Section 7.3.1.1: *Water-development activities* and 7.3.1.3: *Forage improvements*).

4.4.9 Milk processing

On the Borana Plateau the processing and marketing of dairy products is under the control of the women. This has been commonly reported elsewhere in African pastoral and agropastoral systems (Dahl and Hjort, 1976: p 159; Kerven, 1987a,b; Grandin, 1988; Waters-Bayer, 1988). However, as pastoralists become more linked to peri-urban markets and milk sales become more important, it has been noted that women lose control of milk marketing activities to men. Waters-Bayer (1988) noted among settled Fulani that men began to milk animals out of concern that women would take too much from calves. Likewise Salih (1985) noted among peri-urban Sudanese pastoralists that men had usurped the traditional role of women in milk marketing leaving the women only with control over poultry production and sales.

Milk available for processing in Borana households is seasonally influenced by the total milk supply. When milk supply exceeds daily household demand such as during and soon after extended rainy periods, secondary products such as butter, ghee or long-term fermented milk are most likely to be produced. This principle also applies when considering wealth differentiation in the society. Wealthier families having a higher ratio of lactating cows/person will more commonly have a larger surplus throughout the year. This means that wealthier families could produce products like butter or ghee for a longer period each year than poorer families. Kerven (1987b: p 20) reported from work in the Sudan that poorer pastoral women processed and sold milk for about five months from when the rains started, while wealthier women were able to do so for an additional three months. It follows that wealthier households should more offen have surpluses that allow them to make and sell butter and store ghee for the dry season.

The basic patterns of milk processing observed here such as churning soured milk to make butter, dehydrating butter to make ghee and removing whey to better regulate milk fermentation are all common traditional practices in the pastoral, agropastoral and mixed farming systems of Africa (O'Mahony, 1988: p 1). In addition to these products, farmers in the Ethiopian highlands make a cottage cheese (*ayib*) by heating skimmed milk, which precipitates casein and some of the remaining fat. This is not produced by the Boran nor do they express interest in doing so; they stated that they don't like the taste of *ayib* (Tarik Kassaye and C. O'Connor, ILCA, unpublished data). *Ayib* may also be inappropriate for the Boran enviroment because of its short shelf-life owing to its high moisture content (O'Mahony, 1988: p 48) that precludes storage and marketing. Perhaps for some of the same reasons, making of soft cheeses by pastoralists is apparently uncommon in northern Kenya (Dahl and Hjort, 1976: p 160; Galvin, 1985) or in the Sudan (Kerven, 1987b: p 19). For a review of the biological principles involved in milk processing and their applicability to the African rural producer the reader should consult O'Mahony (1988).

Ghee provides the Boran with a high-energy food with an excellent shelf-life of seven months to one year (Tarik Kassaye and C. O'Connor, ILCA, unpublished data; D. L. Coppock, ILCA, unpublished data). However, quantities of stored ghee per household are likely small and relatively unimportant for food security during dry seasons (D. L. Coppock, ILCA, personal observation). Ghee may have been more important in the past when according to informants milk surpluses were more common as a result of a lower density of people (see below; Section 7.2: *A theory of local system dynamics*).

Butter has important uses in the preparation of local coffee and porridge, as a cosmetic and for cooking. The storage stability of butter, while not comparable to ghee, is still on the order of four to six weeks (D. L. Coppock, ILCA, personal observation). Hence butter has a distinct advantage over fresh milk in terms of more temporal flexibility for household use and marketing. Butter collected in Borana markets such as Yabelo, Dubluk and Mega can even be taken by traders to the southern highlands via the public transport system.

Furthermore, even when slightly rancid, butter still has market value in Ethiopia. Most urban consumers all over Ethiopia and highland peasants use butter for making traditional *wot* that is eaten with a bread-like *injera* made from teff. A degree of rancidity of the butter is actually desired to improve the flavour of *wot* (D. L. Coppock, ILCA, personal observation). In sum, it is apparent that butter has outstanding features as a marketable commodity even in semi-arid Ethiopia.

In contrast to butter, fresh milk may become rancid within one day. Consequently, it can only be sold by families within a close proximity to markets. These are usually poor families that cannot store enough sour milk to make butter. Tittarelli (1990: pp 54–57), in his study of dairy marketing in the Ethiopian highlands at Selale, also found an effect of marketing distance on the sale of various types of dairy products. He found that smallholders within 5 km of collection centres or roads sold fresh milk more often, while those further away processed and sold more butter.

Besides being easier to sell in terms of spoilage risk, butter also commands a higher price than milk per kilogram throughout the year (see appendix 4 in Holden, 1988). Averaged for two markets, butter varied from EB 6.26/kg (wet season) to EB 7.36/kg (transition) and EB 9.00/kg (dry season). In contrast, fresh milk varied from EB 0.68/kg (wet season), to EB 1.04/kg (transition) and EB 1.11/kg (dry season). All seasonal means within each commodity were significantly ($P \leq 0.05$) different (Holden, 1988). However, Holden (1988) also noted that on an energy basis fresh milk (3.34 MJ GE/kg) was a bit more expensive than butter (29.8 MJ GE/kg) with annual means from EB 0.25/MJ GE (butter) to EB 0.28/MJ GE (fresh milk).

As practised by the Boran and others, the souring of milk offers several practical advantages over fresh milk. The acidity retards the growth of undesirable microbes and to a certain point improves efficiency of milk churning (O'Mahony, 1988: pp 19, 46). Smoking of containers prior to use for milk storage likely provides important bacteriostatic (cleansing) effects (Ephraim Bekele and Tarik Kassaye, 1987). It is not known to what extent the smoke of wood chips from different tree species affects bacteria, or if species are selected merely on the basis of the flavors they impart to the milk. Both factors are probably important. Informants reported that A. nilotica chips are the most commonly used material for smoking gorfa. When a *gorfa* is smoked with *A. nilotica* chips milk reportedly takes a bit longer to sour and has a superior taste (D. L. Coppock, ILCA, personal observation). This suggests that the volatile compounds present in these chips are effective in killing bacteria.

The production of long-term fermented milk with a shelf life of up to 60 days has stimulated particular research interest in its microbiological and chemical processes (Tarik Kassaye, 1990). However, it is important to note that household studies of milk processing and allocation indicate that in terms of annual volume it is virtually insignificant.

On the Borana Plateau cattle provide most of the milk for processing, followed distantly by small ruminants. The inability of camel's milk to yield an apparently suitable butter (even after vigorous churning) may be an important species difference that could affect the choice, given limited management resources, of whether a cattle-owning household should also acquire camels (see Section 7.3.3.3: *Dairy processing and marketing*). Even though the evidence regarding the suitability of camel's milk for processing is equivocal, Dahl and Hjort (1976: p 185) stated that camel's milk sours quickly. They also mentioned that some camel-keeping groups process camel's milk by heating it and preparing the curds into storable cheeses. The Gabra have demonstrated to ILCA staff how they make a waxy butter from camel's milk using a process that involved heating and extended agitation (D. L. Coppock, ILCA, personal observation). But Dahl and Hjort (1976) did also cite a variety of other conflicting references regarding the suitability of camel's milk for processing. Other perspectives on the subject are provided in Rao et al (1970) and Galvin and Waweru (1987).

Results from milk processing studies that evaluated the efficiency of butter making are presented in Section 7.3.3.3: *Dairy processing and marketing* including a discussion of the feasibility of implementing dairy technology interventions. As is discussed below, the presumed steady decline in the ratios of livestock to people on the plateau may preclude much optimism regarding the implementation of milk processing interventions, since it is anticipated that surpluses will become smaller. The practice of milk sharing within encampments may further reduce available surpluses even though the actual degree of milk sharing may be exaggerated (Coppock et al, in press).

4.4.10 Dairy marketing

Detailed discussions of Borana dairy marketing may be found in Holden (1988) and Holden et al (1991) while the main points are summarised here:

Market access is a critical factor in the participation of pastoral women in dairy marketing. Households closer to market are able to sell more frequently and this was a reflection of the opportunity cost of women's travel time to market, which influences net returns (Askari and Cummings, 1976). Effects of distance to market varied with household wealth, and wealth has been found elsewhere to be a critical factor in pastoral dairy marketing (Kerven, 1987b; Grandin, 1988). Very low levels of milk supply in poor households during dry seasons precluded their ability to increase marketable output in response to a given reduction in distance. In contrast, during the wet season poor households had a higher milk supply and a greater marketing response over distance. The pattern was somewhat similar for other wealth classes, but they had greater flexibility in supply and could be more responsive over distance regardless of season.

Compared to poor ones wealthy households sold greater absolute quantities of dairy products, but on average retained four times more milk for household and calf consumption than poor households. The poor had only about 25% as much milk per person as the wealthy. It also appeared that, when milk supply per household increased, either because of effects of wealth or season, people first increased their consumption of dairy products in preference to maximising dairy sales. This seems in contrast to highland smallholders with cross-bred cattle who may first use milk for sale (Wagenaar-Brouwer, nd).

Consumption was a priority with wealthy households as sales of surpluses are used primarily for nonessential purchases (Nestel, 1985: Kerven, 1987b: Waters-Bayer, 1988). By contrast, the poor appeared compelled to buy grain because their levels of milk offtake were below subsistence requirements. Again, one litre of milk (3.3 MJ GE) sold bought 3.5 kg of grain (52.5 MJ GE) in the dry season, providing nearly a 14-fold increase in energy. This illustrates that having surplus milk is not a prerequisite for dairy marketing to be important. Indeed, the reverse is more true for a pastoral society.

Despite their lower absolute volume of dairy sales, income from dairy sales provided 37% of the annual income of poor households when close to market; for the wealthy this was 22%. The poor, with few animals to sell without endangering their herd capital (Swift et al, 1984; Behnke, 1987), had no viable alternatives to selling milk in order to get money. As long as the lives of nursing calves are not endangered, dairy marketing would generally contribute to the food security of poor households. That is from the direct effect of providing cash income and the indirect effect of delaying sales of animals for some other crisis in the future. Also that compared to animal sales, dairy sales permit purchasing of quantities of grain that are more convenient to handle by the household. For example, Nestel (1985) noted that the Maasai who purchased large volumes of grain from an animal sale often lost a significant amount to neighbours and relatives who came to request hand-outs.

4.4.10.1 Dairy marketing and welfare of humans and calves

Field data supported some, but not all, elements of the hypothesis that poorer households closer to market would be relatively more affected by trade in dairy products. Improved access to market only appeared to reduce the proportion of milk allocated to calves in poorer households. As there was no clear effect of proximity to market on intake of dairy products by women or young children, the increase in milk offtake by poor households closer to town is probably best attributed to increased daily sales.

The nutritional consequences of trading dairy product for grain by poorer families can be illustrated by assuming: (1) such households to have 3.5 AAME and 3.8 lactating cows (evenly distributed among the three productivity classes); (2) a nutrient content of milk of 3.3% crude protein (CP) and 3.7 MJ GE/kg (Roy, 1980; Nicholson, 1983a); (3) maize grain having 15 MJ GE and 7.4% CP per kg on a dry-matter basis (Cossins and Upton, 1987: p 213; ILCA Nutrition Unit, unpublished data); and (4) the nutritional guidelines for a 55-kg average adult male (Cossins and Upton, 1987) as recommended in FAO (1973) and NAS (1974).

If this family resides far from town and sells no milk, the daily milk offtake rate of 48% (1.8 litre) found among the modal poor family could provide about 39% and 18% of the daily total requirements for CP (154 g) and GE (37 MJ), respectively. This implies that the family must either reduce demand for food and/or receive more food from their social network, gathering bush foods or relief grain. If the family increases milk offtake to 63% (2.3 l), then about 49% and 23% of its daily requirements for CP and GE, respectively, are provided, but this is still short of meeting needs. However, if the increment of 15 percentage points of increased offtake (0.5 litre) is sold at a ratio of 3.5:1 that means for 1.75 kg of maize about 125% and 87% of the CP and GE requirements, respectively, will be met (Holden, 1988). This shows that proximity to market and favourable terms of trade are especially important for poor families. A chronic pressure to trade even more milk could compromise the nutritional status of people for vitamins or amino acids foregone in milk and not found in grain (Nestel, 1985: pp 158–163; Shrimpton, 1985); and nutritional balance of grain and milk is desirable (Nestel, 1985: p 158).

It was not confirmed by the researchers that poorer families closer to town would have more grain in their diets. Informants, however, reported that it is "common knowledge" that poor people close to town sell milk daily and live on purchased grain, often to the detriment of their children (D. L. Coppock, ILCA, personal observation). A significant effect of wealth on intake of dairy products by women and children was observed, unlike patterns observed for Maasailand where all wealth classes had similar intakes (Grandin, 1988). This discrepancy may have been due to the extreme poverty of many of the Boran spreading the differences among all wealth classes. It could also be because of the lingering effect of the 1983–84 drought on herd-level milk production (Holden et al, 1991).

The overall calf mortality rate of 18% and milk offtake of 41% recorded by Holden et al were consistent with other findings for an average rainfall year in the study area (see below). Despite the more restricted milk intake of calves in poor households overall, this did not appear to affect the mortality rate at the time. Households were able to minimise acute effects on their calves (Wagenaar et al, 1986).

Paradoxically, calf morbidity rates were reportedly high in both wealthy and poor households, despite their differences in milk offtake. One hypothesis is that morbidity of calves in poor households was due more to nutritional stress from milk restriction, while that for calves in wealthier households was probably due more to health management problems that arose from more calves being concentrated in a small area and hence getting less individual management attention (Mulugeta Assefa, 1990: p 26).

The increase of 15 percentage points in milk offtake for cows of poorer households closer to market may be equivalent to 150 ml/calf/day in the dry season. This is 28% of the calculated intake for calves of poor families at the time and represented a substantial decrement that could reduce vigour and increase the loss of calves to nutrition-related diseases. Informants reported that this is a common pattern among the poorer families nearer to market that must sell milk to survive (Coppock et al, 1992).

4.4.10.2 Dairy marketing in a wider perspective

Considering the conceptual model of economic stress responses in pastoral societies addressed thus far, some of the literature on pastoralism suggests that dairy marketing is symptomatic of increasing poverty (Dahl and Hjort, 1976: p 181; Toulmin, 1983; Waters-Bayer, 1988). This is illuminated further by the contention that the Borana used to have taboos against selling dairy products but have probably been forced to do so more recently (Dahl and Hjort, 1976: p 181).

If pastoral poverty is defined as a decline in per capita milk production and livestock holdings, then it is anticipated that the long-term trend would be for most of the Boran to become poorer. This would result from a steady increase in the human population, low rates of emigration and economic diversification and limits on the livestock that can be carried by the system (see Section 7.2: *A theory of local system dynamics*). Effects of drought (such as killing a high percentage of cattle and largely sparing people; see Chapter 6: *Effects of drought and traditional tactics of drought mitigation*) would be in addition to these pressures. This means that drought could periodically exacerbate the poverty among the Boran. If it is assumed that the primary reason for selling dairy products is to buy grain because the milk supply is insufficient for survival in terms of energy, this suggests that an increasing number of families would be regularly involved in dairy marketing over the long term (at least from the pool of encampments within reach of a marketing town), and that a big upsurge in dairy marketing activity could be expected during the early stages of a drought and during the post-drought recovery period when there is sufficient milk to sell, but not enough to sustain households. The degree of dairy marketing therefore is likely to be variable from year to year.

Lack of a standardised time series for the Boran precludes a test of this hypothesis and existing data often lumps dairy sales with those of other commodities. For example, AGROTEC/CRG/ SEDES Associates (1974f: p 71) noted that about 22% of the annual household income of EB 86 in 1972 was derived from the sale of "animal products" other than live animals and presumably some of this was milk and butter. Negussie Tilahun (1984) reported that an average of 5% of the annual income of EB 830 in 1983 was from the sale of "animal products" that included butter and milk and that dairy income was important for the purchase of dry goods (another indicator that these families were wealthier than average; see Section 4.4.1: *Genreal aspects of household economy*). Donaldson (1986: pp 50–51) found that 30% of the household budget of EB 384 during five months at the height of the drought in 1983–84 was from sales of dairy products, hides, handicrafts and other mis- cellaneous items. Holden and Coppock (1992), whose peri-urban sampling approach probably provided the most accurate range of data, figured that 20% of the average annual income of EB 440 was derived from dairy products. Holden (1988: p 42) found that about 30 of 105 households reported that the income from the sale of dairy products was more important to them than consuming the milk itself. However, the fact that the study reported in Holden (1988) and Holden and Coppock (1992) was carried out in 1987, only three years after the end of the 1983–84 drought, may imply that a period of particularly high levels of dairy marketing was witnessed in view of the drought-recovery scenario proposed above.

Like livestock, formal dairy markets were perhaps small and less well organised prior to the 1980s. Urban populations were smaller and the number of milk or butter traders was limited. In contrast for 1987, S. J. Holden (ILCA, personal communication) noted the complexity of trading interactions in the towns of Mega and Yabelo (with populations of 3000 and 7000, respectively); many pastoralists had private arrangements to supply dairy products directly to urban families and restaurants in addition to regular market-day activities. Informants reported, that milk was sold prior to 1980, but that the Boran used this income more commonly to purchase items like coffee and sugar, not grain (D. L. Coppock, ILCA, unpublished data). At least in the small town of Dubluk, butter traders reported in 1987 that competition to buy from producers was far less in the early 1980s than in the late 1980s.

In sum, these studied observations provide useful focal points for system monitoring and tests of hypotheses. They also point to important dynamic constraints in the consideration of dairy processing or marketing interventions. This perspective, as well as a comprehensive theory of pastoral development and change that takes into account long-term trends and short-term cycles, is presented in Chapter 7: *Development-intervention concepts*.

Chapter 5

Livestock husbandry and production

Summary

This chapter highlights work from experimental trials and producer surveys concerning livestock management and productivity in the Borana system. Most of these studies were conducted in average rainfall years under conditions of moderate to high stocking rates of cattle. The primary focus is on cattle which are the most important livestock species to the Boran overall. Ancillary livestock include small ruminants, camels, equines and poultry.

General aspects of cattle husbandry here including maintaining a female-dominated herd structure, dividing up animals into satellite herds to conserve local resources, uncontrolled breeding, milking management of cows, intensive hand-rearing of nursing calves and aportioning tasks according to gender and age are similar to those observed elsewhere in semi-arid Africa. One unusual feature of Boran, however, is the high degree of water restriction of cattle during dry seasons such that animals may be watered once every three to four days. This practice is permitted probably, in part, by the relatively cool ambient temperatures which help cattle conserve body water otherwise used for thermo-regulation. Restricted watering is a long-held practice of the Boran that has positive attributes in terms of saving human labour, extending grazing radii from water points and increasing water-use efficiency.

Results from trials conducted under conditions indicate that while cattle watered once every three days during dry seasons may lose weight faster than those on daily watering, because restricted watering reduces forage intake, cattle on restricted watering can compensate for it by regaining weight faster during subsequent rainy periods. One significant short-term cost of restricted watering is a reduction in milk production of around 13%. The ability of cattle on restricted watering to regain weight or minimise fall in milk production, is probably constrained to a higher degree under the high stocking rates characteristic of pastoral management compared to those observed under experimental conditions.

A general synthesis of key aspects of productivity and management for mature cattle indicates that: (1) the ratio of females to males in the regional cattle herd is on the order of 71:29; (2) cows have their first calf at 4 to 4.5 years of age and may produce 6 to 6.5 calves over a reproductive life of 8 to 8.5 years; (3) the average calving interval is 14 to 15 months; (4) milk yield/cow ranges from 680 to 1000 kg for lactations which vary from 7 to 13 months in duration, respectively; (5) the median milk yield/cow is about 850 kg over 320 days (or 2.6 kg/head/day); (6) annual calving rates average around 70%; (7) mature weights for Boran bulls and cows are on the order of 400 and 225 kg, respectively; and (8) mortality rates for animals older than 2 years of age are less than 5% per annum in average rainfall to dry years. These productivity figures appear reasonably good for cattle under traditional pastoral management, and are even comparable to the lower range of productivity values for animals reared under ing and research station conditions in sub-Saharan Africa. This provides some evidence to support contentions that indigenous Boran cattle are relatively productive compared to other African breeds and that the central Borana Plateau is a particularly good environment for cattle production.

Season has a dramatic effect on cattle breeding and milk production. Nearly 70% of calf births occur during the long rains and another 17% during the short rains. Daily milk production per cow roughly doubles in rainy seasons compared to dry seasons, and during dry seasons fewer cows are lactating. Lactation curves are unusual in that they may have a bimodal, rather than unimodal, shape. This probably shows acute seasonal constraints in cow nutrition during some years.

Cattle productivity may also vary with regards to the wealth class of pastoral households. Compared to cows held by wealthier households with a higher ratio of milk cows per person, those held by the poor reportedly have lower calving rates, lower milk production, lower absolute milk offtake for human consumption, lower milk intake for calves and higher rates of calf mortality. These patterns may be largely attributable to a higher milking intensity practised in poorer households.

Productivity may also be influenced by grade of cow. The Boran recognise three classes of milk cows (high, intermediate and low producers) and these vary substantially in terms of daily yields with high producers yielding over 50% more milk than low producers. Household surveys suggest that despite their greater milk production, compared to lower producers high producers may have a longer calving interval. Costs of higher milk yield may thus be related to the extent to which higher-producing cows must mine body reserves in support of lactation, which may then compromise reproduction. Different productivity classes of cows may

also vary in terms of their vulnerability to resource restriction during dry years and drought. Informants reported that high producers are among the first to perish during difficult circumstances. Another important factor that affects milk production are ticks. A survey of 560 milk cows indicated that 13% of teats were closed as a result of tick-induced damage. This implies that an average eight-cow household may need one extra cow simply to offset this loss in milk production capacity.

Compared to other aspects of cattle productivity, calf growth rates appear to be low. Birth weights average 18 kg and are affected by season of parturition. Field studies that quantified growth from birth to 210 days of age indicate that average daily gains for nursing calves are variable but on the order of 136 g/head/ day, typically less than 1% of live weight. Growth is probably substantially influenced by competition with humans for milk as milk offtake for people averages 30 to 40% of total yields in general. At 250 days of age a calf which consumes 195 kg of the milk yield (35% of production) may weigh around 60 kg which is only 45% of the live weight of 132 kg projected if the calf were to have all the milk.

Calf mortality rates appear high and similar to that in other pastoral systems in Africa. Producer surveys suggest mortality rates and causes vary according to interactions between the wealth of pastoral households and the type of rainfall year. Averaged over all years, wealthy, intermediate and poor households reported calf mortality rates of 24%, 16% and 30%, respectively. It has been postulated that the high mortality rates for calves of the wealthy are primarily caused by disease-related factors that result from a reduced management input per calf. The higher mortality rates for calves held by the poor are probably more related to nutritional stress arising from competition with people for milk. Across all households in a modal rainfall year, calf mortality may average 22 to 25%, with roughly half of the deaths primarily due to poor nutrition and the other half caused by health complications such as calf scours, black leg, pasteurolosis and foot-and-mouth disease. For a dry year mortality rates are similar but two-thirds of losses being directly attributable to nutrition. In a drought year 70 to 90% of the calf crop may be lost, all primarily due to poor nutrition.

Calf management is typically performed by married women and the pattern of management changes depending on the season of birth of the calf. Calves born during the dry seasons or short rains usually receive more intensive care reflecting the greater scarcity of resources and higher competition with people for milk. Management by women includes gathering cut-and-carry forage and hauling water for relatively immobile calves which are kept in or near the family hut.

More limited observations on ancillary livestock suggest that productivity and management practices in Borana for goats, sheep and camels are similar to those found elsewhere in semi-arid Africa. Exceptions may include the fact that sheep are apparently rarely milked in average rainfall years and breeding among small ruminants being uncontrolled. Camels serve various purposes depending on ethnic group; the minority Gabra rely on camels mostly for milk while the Boran use them more for hauling goods and occasionally for pulling ploughs. In contrast to cattle, disease appears to be a more pervasive constraint for the production of small ruminants and camels. This may be a consequence of the relatively moist conditions in which these species are commonly held, in upper semi-arid and subhumid locations. Equines are often observed on the Borana Plateau but occur at low population densities. Donkeys are used to haul goods while mules and horses are ridden by men. Little is known concerning the importance of chickens to Borana households even though they can be frequently seen in encampments. It is thought that chickens may be an increasingly important market item for Borana households in peri-urban locations.

5.1 Introduction

Pastoralists are largely dependent on livestock for their wellbeing. Therefore, studies of livestock production and management in terms of milk, reproduction, weight gains, health and mortality are critical in understanding constraints and opportunities for improvements. The objective of this chapter is to review such studies for the Borana system that were conducted during the 1980s. The primary emphasis is on cattle, because cattle are the dominant species herded by the Boran in the southern rangelands. Other species covered to a lesser degree include small ruminants, camels and equines.

5.2 Methods

5.2.1 Cattle production

Relationships among milk production, milk offtake and calf growth were investigated at encampments in six *madda* by Nicholson (1983a) during 1981–82. Lactation curves and total milk production were quantified for 23 cows by measuring offtake and estimating milk consumption of calves from their growth, composition of milk, and assumptions concerning conversion of milk to live-weight gain (Nicholson, 1983a: pp 28–29). An equation was developed to predict calf growth based on milk intake. The equation includes the formula of Tyrrell and Reid (1965) and includes the empirical requirement of 13.6 MJ ME for a kilogram of growth for pre-ruminant calves (Roy, 1980). This equation is presented in Figure 1, Annex E. Birth dates, birth weights and growth of 133 calves were recorded at encampments in eight locations. Growth was recorded weekly by weighing calves with hanging scales from birth until 210 days of age. Data were analysed with a four-way ANOVA to detect main effects and interactions of sex, location and month and season of birth from least-squares means (Nicholson, 1983a).

Effects of household wealth, cow milking class and type of rainfall year (normal, dry or drought) were variously considered on aspects of cattle holdings and cattle production including rates and causes of calf mortality, age at first calving, calving interval, duration of lactation and milk production by Mulugeta Assefa (1990). These data were also used for economic modeling (see Section 7.3.3.4: *The calf: prospects for growth acceleration*) and were generated from interviews of 90 households in 1988 from 30 randomly selected encampments in Did Hara and Dubluk *madda* (15 each; see Figure 2.10). Wealth strata were as described in Section 4.2.4: *Dairy processing and marketing.* Household members provided details on lifetime production history for 482 cows. One, two or three-way ANOVAs were performed on 16 response variables (Mulugeta Assefa, 1990: pp 11–12).

5.2.2 Water restriction and cattle productivity

One unusual feature of the Borana pastoral system is the role of water restriction on livestock production. Labour constraints and restricted access to water and grazing, in conjunction with the relatively cool climate, have promoted a system whereby cattle may be watered once every three to four days at the height of the dry season (Alberro, 1986; D. L. Coppock, ILCA, personal observation). In a series of trials under conditions in the Ethiopian Rift Valley, Nicholson (1987a; b) studied effects of drinking frequency, extensive walking and night enclosure on various production aspects of Boran and Friesian x Boran cattle. For the drinking frequency experiment, 75 cows with new-born male calves were assigned one of one, two, or three-day watering intervals for 28 months (July 1983 to September 1985) interrupted by *ad libitum* watering during wet seasons for all groups. Watering frequency was thus restricted only during dry seasons (September to March) to mimic pastoral practices. Other than watering frequency, animals were treated similarly. They grazed in 90-ha paddocks and received standard health prophylaxis. Suckling was unrestricted and calves were weaned between 210 to 240 days of age.

Response variables included: (1) monthly live weights for cows, nursing calves and weaned animals; (2) a monthly condition score for mature cows; and (3) water consumption for cows by weighing animals before and after drinking. Ancillary studies included: (1) effects of treatment on milk intake of calves, measured during three 10-day periods using live weights before and after suckling as well as a tritiated water method (Coward et al, 1982); and (2) effects of treatments on dry-matter intake and digestibility for steers and cows. Intake for the steers was indirectly measured using a natural marker of indigestible acid detergent fibre (Van Soest, 1982) which was determined from forage and faeces and combined with whole faecal collections for 10 days. For cows, intake was determined under stall-feeding conditions where this marker method could be validated. Statistical analyses employed a least-squares ANOVA for feed intake experiments. Dynamics of live weight and condition scores were displayed as time-series graphs. More details are available in Nicholson (1987a; b).

5.2.3 Other production and management studies

Growth characteristics of over 2600 immature male cattle purchased during 1979–82 for the Sarite cooperative (see Section 1.4.5.5: *development*) were analysed by Nicholson (1983b). Although the concept in the southern rangelands is being phased out, the work is useful in terms of documenting variability in growth attributable to season, differing regional origin of animals and castration practices. For Group 1, monthly weights were analysed over seven months from November 1980 to June 1981. For Group 2, entry and exit weights were analysed over an average of five months from March to August 1982. Imbalances in data sets led to different analyses for both groups. Average daily gain (ADG) was analysed for Group 1 using a three-way ANOVA with least-squares means to detect effects of origin, and castration. A two-way analysis (origin x herding group) was conducted for Group 2.

Some preliminary data were collected on production performance of about 100 goats and sheep and a few camels managed at Gabra encampments near Beke Pond during average rainfall years by Belete Dessalegn (1985) and reviewed in Cossins and Upton (1987). Some aspects of these studies will be reported here.

Descriptions of management practices were conducted for cattle (Belete Dessalegn, 1983; Donaldson, 1986; Cossins and Upton, 1987; Kabaija and Little, 1987; Holden, 1988; Mulugeta Assefa, 1990; Menwyelet Atsedu, 1990), small ruminants (Belete Dessalegn, 1985; Cossins and Upton, 1987) and camels (Belete Dessalegn, 1985; Donaldson, 1986). Surveys documenting presence of camels and equines in Borana encampments were conducted by Coppock and Mulugeta Mamo (1985).

5.2.4 Livestock health

Except for Mulugeta Assefa (1990: pp 34–37), who recorded information on health problems related to calf mortality during interviews on cow history, animal health was never a significant focus of research. The Southern Rangelands Development Unit (SORDU) collated data on cause of mortality for animals which received veterinary attention during 1976–1987, and these are reported here. Donaldson (1986: pp 38–40) noted causes of cattle mortality during drought including incidence of disease. Coppock (1990b) conducted a dry-season survey of the incidence of probable tick-induced damage to cow udders. This survey involved examination of 560 randomly selected cows from 63 herds at water points in the Dubluk, Medecho, Melbana and Beke Pond regions during September, 1989. Response of 24 Gabra herd owners to another questionnaire on camel production problems in the Beke Pond area (D. L. Coppock, ILCA, unpublished data) indicated disease was the most common production problem. Respondents were asked to list diseases in order of perceived importance and ranked data were analysed using Friedman's nonparametric test (Steel and Torrie, 1980). The heavy reliance on interview information, without professional necropsy or physical examinations, is a significant limitation on these results. The pastoralists demonstrated an ability, however, in naming diseases and associated symptoms consistent with those provided by local veterinary staff (Abakanou Kereyou, TLDP Animal Health Coordinator, personal communication).

Preliminary identification of some tick species common to the southern rangelands was conducted at the International Centre for Insect Physiology and Ecology (ICIPE) in Nairobi. This is reported by Nicholson (1985).

5.3 Results

5.3.1 General aspects of cattle management

The Boran manage cattle in a traditional pastoral fashion. Nursing calves are kept separate from their dams except when calves are used to stimulate let-down of milk when they share milk production with people at usually two (or rarely three) milkings per day. Bulls are commonly run with cows all year and breeding is thus uncontrolled. Periodicity of breeding, however, is strongly influenced by seasonal fluctuations in nutrition (see Section 2.4.1.5: *Native vegetation*). As will be shown, seasonal breeding results in seasonal patterns of calving and milk production. Based on preliminary data collected at Did Hara *madda* in 1983, Belete Dessalegn (1983) noted that adult cattle were corralled an average of 11 hours per 24-hour day and spent 50% and 22% of the remainder of the time grazing and traveling, respectively. Cows were milked in the early morning and evening. Cattle were recorded to walk up to 27 km for a round trip on a grazing day and up to 46 km on a watering day during a dry season. Grazing time on the watering day was compensated by a shorter time in the corral (Belete Dessalegn, 1983). Local crude salt from Chewbet (near Mega) with composition of 41% NaCl and minor quantities of macro and trace minerals is frequently provided to cattle in corrals (Kabaija and Little, 1987). Cattle spend 98% of their feeding time on grasses and other herbaceous plants and 2% on browse (see Section 3.3.5.1: *Livestock food habits*).

Where water and grazing resources permit, the Boran lead a semi-settled existence (Cossins and Upton, 1987). The household may remain sedentary throughout a given year or succession of years and family residences in a given *madda* may last for generations. Cattle are herded either as less mobile *warra* groups or far-ranging *forra* groups, depending on conditions of the resource base, availability of labour and according to the sex and age class of animals and whether or not cows are in milk. As described by Donaldson (1986: pp 9–10, 31–36), the primary purpose of the *warra-forra* system is to distribute animals away from the home area during times of restricted availability of forage (and sometimes water). Strong and less-productive animals are sent with the *forra* herds that are usually managed by older boys and young men (Cossins and Upton, 1987: p 210). At the extreme, *warra* herds are comprised of milking cows and some weak or sick yearlings that return to the encampment each night. These are kept within closer grazing orbits whose radii vary depending on whether the day is used for grazing or grazing and watering (Figure 2.12a, b). In contrast, the *forra* herd is composed of dry cows and males of diverse ages and ranges widely (sometimes across the Kenya border if the local resource base is depleted). The composition and size of *warra* and *forra* herds is dynamic across seasons and type of average rainfall, dry or drought years. Years of high rainfall may be characterised by *warra* herds of larger size and a more heterogeneous composition while the inverse holds for *forra* herds. Examples of the dynamic nature of assigning animals to *warra* or *forra* herds in response to drought are given in Section 6.3.1.1: *Livestock dispersal and herd composition.*

Both *warra* and *forra* herds may be watered once every three to four days during dry periods. This is considered a management adaptation to minimise labour required to raise water from the deep wells (see Section 2.4.1.7: *Water resources*) and maximise size of grazing orbits (Nicholson, 1987a).

Calf management was initially described by Donaldson (1986: pp 34–36). During the first 7 to 12 months of life the calf diet consists of milk from restricted suckling and a combination of grazed and cut-and-carry forage. Nursing calves may be tethered near the hearth in the main room of the family hut or in special pens near corrals. Pens are constructed from wood and are often topped by a mud roof. The amount of milk a calf receives varies with season, milking class of the dam (high, average or low) and human demand for milk. In general, milk intake for calves will be the highest during wet seasons for those born to high-producing dams owned by wealthier families that put less demand on the milk supply because the ratio of milk cows to people is high (see Section 5.3.3: *Cattle production and pastoral wealth*).

The married women are mainly responsible for day-to-day management of nursing calves. This includes construction, maintenance and cleaning of calf pens, forage collection, removal of external parasites, transport of water for calf consumption during dry seasons and the allocation of milk to calves and people (see Section 5.3.3: *Cattle production and pastoral wealth*). The household heads (usually male) receive the income from the sale of cattle and they can oversee day-to-day management of calves, especially in the case of a new and inexperienced wife (Holden, 1988: p 40). Women control income from sales of dairy products (see Section 4.3.5.3: *Effects of distance to market, wealth and season on dairy marketing*).

The household investment in calf rearing varies depending on the health and vigour of the calf, work-force available and the season when the calf is born. If a calf is sickly there will typically be a higher investment in hand-rearing for as long as necessary. The innovation of the Borana *kalo* (fodder bank), described in Section 7.3.1.2: *Grazing management*, is in part a strategy to facilitate access to grazing by sick or injured immatures that cannot travel far. The calf-management pattern is thus highly variable but generally has these features:

1) During the first one or two months calves are continuously tethered inside the family hut or in pens except the when they suckle in the morning and evening or allowed to bask in the sunshine and wander around the encampment. All of their food at this time is milk under restricted access. Calves are typically allowed to suckle two teats while the women milk the other two. Calves are always used to stimulate milk let-down (Donaldson, 1986: p 34). If a calf dies the skin may be stuffed and used to stimulate milk let-down (Donaldson, 1986). Milk intake by calves is regulated to ensure that they don't get too much milk and become ill (D. L. Coppock, ILCA, personal observation; Roy, 1980);
2) Calves born during the long rains (April to early June and a time of high forage quality, abundance and diversity), in the third month of life they may be allowed to graze around the encampment and/or receive cut-and-carry forage in addition to restricted access to milk. Donaldson (1986: p 35) estimated the average (±SE) daily quantity of cut-and-carry forage to be 0.22±0.07 kg/calf on an as-fed basis (N=10). This feeding pattern continues until weaning at 7 to 12 months of age. Forage from grazing gradually makes up a larger proportion of the diet until weaning. Grazing may be initially delayed during the wet season if local outbreaks of ticks or other parasites are considered too risky for calf health.
3) If calves are born during the short rains (October and November) or in either dry season, the reliance on cut-and-carry forage may be much greater. These calves may not graze until the following long rains. Women may spend many hours per week collecting forages for calf feeding, an investment of time and energy that can substantially increase during dry seasons (see Section 4.3.3: *The labour of married women*). The greater emphasis on hand-feeding young calves during stressful periods is probably because by the time dry seasons are well underway, forages in proximity to encampments become heavily grazed. Another reason for hand-feeding at the height of the warm dry season may be to minimise exposure of young calves to excessive heat and possible dehydration while grazing (D. L. Coppock, ILCA, personal observation).
4) Depending on health and general condition, a calf as young as four months of age can join a calf herd (supervised by children) that roams within a kilometer of the encampment. By the time the calf is one year old and able to travel greater distances, it may join the *forra* herd (Donaldson, 1986: p 34).

Given limited resources, investment in calf rearing by the Boran is relatively intensive. Efforts to keep animals under confinement during most of their first year is important in helping calves thermoregulate in what can often be a cold and windy environment during rainy periods. This minimises risks of predation. Manure is regularly removed from calf pens and women attend to health problems such as removal of ticks using kerosene application and traditional remedies to heal wounds and internal ailments (see Section 3.3.5.2: *Household use of plants and pastoral perceptions of range trend*).

Another major activity is bringing water to young immobile calves during dry periods. During wet seasons local ponds fill up and calves can either walk short distances to water or it can be brought to them by women or older children using traditional containers or plastic jerry cans. During dry seasons, however, milk yields drop, forage dries out and it becomes necessary for women to haul water from distant wells. In an analysis of management for seven calves, Donaldson (1986: pp 34–35) estimated that on average (±SE), calves received their first hand-carried water at 59±17 days of age, were watered once every 5.5±0.6 days and consumed 278±78 ml of water/day. Menwyelet Atsedu (1990) found that 86% of 67 respondents stated that calves were watered every other day in dry periods. The range of distances from encampments to wells (7 to 16 km) is probably dictated to a large extent by how far women and calves can walk in dry seasons to get to water supplies and cut-and-carry forage (Cossins and Upton, 1987; Hodgson, 1990).

5.3.2 Calf growth and milk offtake

Average live weights of nursing calves reared under pastoral management during 1981–82 are shown in Table 5.1, and suggest that prior to weaning at 210 days of age, animals gained only 28.6 kg for an overall average daily gain (ADG) of 136 g/head/day. At 90 days of age only 15 of 106 calves were growing at or above a rate of 1% of live weight per day (Nicholson, 1983a: p 17). Births (*N*=133) were seasonally distributed. Most (65%) occurred during March to May (before and during the long rains) followed by another 17% during the short rains in October and November (Nicholson, 1983a: p 16). Significant main effects and interactions among location, birth month, and birth season on calf weight up to 210 days were evident (Nicholson 1983a: pp 9, 16–19). Effects of location were speculated to be related to differences in local pastoral management and/or ecology that influenced animal health, milk production, watering frequency and/or forage intake. Effects of time of birth were attributable to seasonal effects on the nutrition of dams during their last few weeks of pregnancy and during lactation. Calves born during the long rains thus tended to have higher birth weights than those born during dry seasons when dams were under more stressful nutritional conditions. Likewise, compared to those born in the middle of the long rains, calves born during the short rains had access to a milk yield that would be substantially modified by harsh nutritional conditions as a result of the following warm dry season from December through March. Growth curves for calves from the different regions are provided in Nicholson (1983a: pp 10–15) and are quite variable.

In relative and absolute terms, milk offtake for human consumption varied according to season, stage of lactation, location, cow, and the time of day that milking was done (Nicholson, 1983a: p 20). Evening offtake averaged 18% greater than morning offtake, probably as a result of the longer interval between morning and evening milking than the reverse (i.e. 14 vs 10 hours, respectively). Mean monthly offtake/cow (±SE) varied from 39±15.9 (Melbana *madda*; *N*=60) to 25±16.8 kg (Hobok *madda*; *N*=76). Total offtake for 51 lactations (x±SE) averaged 313±15.2 kg. Total offtake appeared to increase as duration of lactation increased; this is illustrated in Table 5.2. Influence of season and year on total and mean offtake is shown in Figure 5.1. Maximum deviations occurred between the long rains and the end of the dry periods. For example, the mean offtake/cow during the month of May in 1981 (52 kg) was over twice that of September 1981

Table 5.1. *Average calf live weights and average daily gain (ADG) at five ages prior to weaning in the southern rangelands during 1982.*[1]

Category	Age (days)				
	1	30	90	150	210
Live weight (kg)	18	25.2	35.3	44	46.6
ADG (g)		240	192	240	136

1 *N* = 133, 133, 106, 91 and 37 for animals at 1, 30, 90, 150 and 210 days of age, respectively.

Source: Nicholson (1983a).

Table 5.2. *Milk offtake and lactation features for 51 Boran cows under traditional management in the southern rangelands during 19 months in 1981–82.*

Offtake range (kg)	No. lactations within range	Mean lactation length (months)
100–149	2	7
150–199	6	7
200–249	3	8.7
250–299	17	8.5
300–349	10	8.3
350–399	4	8.8
400–449	2	9
450–499	3	14.7
500–549	2	14
550–600	2	13.5

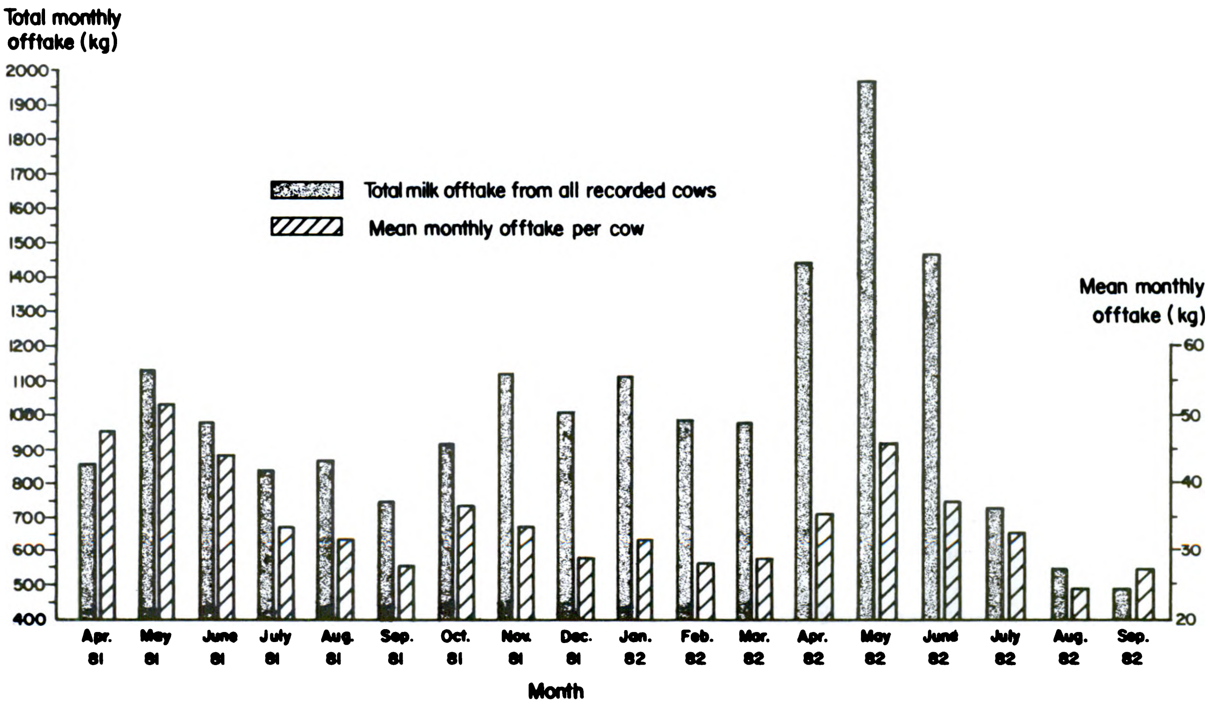
Source: Nicholson (1983a).

(27 kg), at the end of the cool dry season. Similarly, values for May 1982 (46 kg) were 64% higher than those in February 1982, at the end of the warm dry season.

The peak cumulative milk offtake in May 1982 (nearly 2000 kg) reflected a higher number of cows in milk (43 out of 51) compared to May 1981 (22 out of 51). The low cumulative yields in dry seasons reflected more of a reduction in output/cow rather than a large decline in numbers lactating (usually around 30). Nicholson (1983a: pp 25–26) also noted that offtake followed a bimodal distribution in reflection of the strong nutritional effects on lactation in different seasons (Figure 5.2 a, b). If a cow gave birth in the long rains, offtake would have a pronounced early peak soon after calving and a smaller secondary peak during the short rains in October and November. However, if a cow calved in the short rains, the first peak would be smaller, followed by a larger peak during the subsequent long rains. This seasonal effect obscured effects of stage of lactation on milk yield.

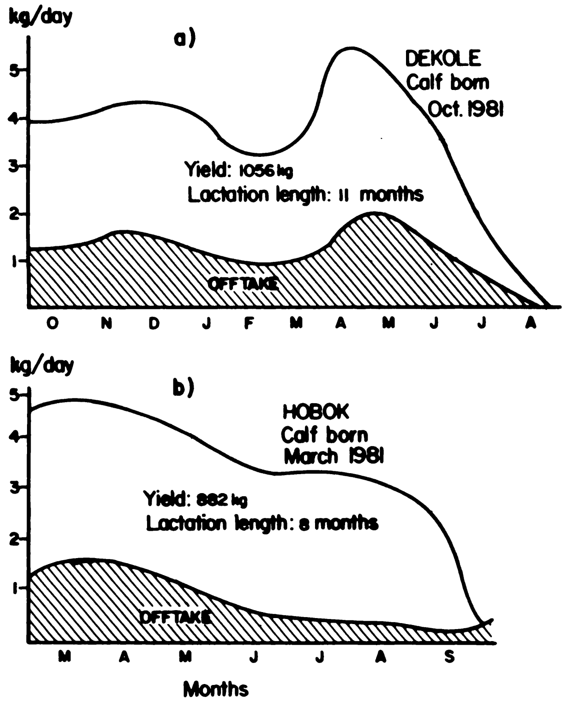
Median and mean lactation lengths of 23 cows were 250 and 320 days, respectively (Nicholson, 1983a: p 33). The highest total milk yield was 1952 kg over 13 months (5 kg/day) while the lowest was 554 kg over 7 months (2.6 kg/day). The mean yield (±SE) was 922±66.7 kg over 10.6 months (2.9 kg/head/day). However, Nicholson (1983a: p 38) considered the median value of 843 kg to be the best estimate because it was not unduly biased by a few excessively large lactations. Table 5.3 gives the distribution of milk yields and duration of lactation for the 23 cows. For lactations longer than

Figure 5.1. *Influence of season and year on total and average milk offtake for a sample of 51 Boran cows during 1981–82 in the southern rangelands.*



Source: Nicholson (1983a).

Figure 5.2 (a, b). *Examples of bimodal lactation curves for two Boran cows under pastoral management in the southern rangelands during 1981–82.*



Source: Nicholson (1983a).

Table 5.3. *Estimated milk yields and duration of lactation for 23 Borana cows under traditional management in the southern rangelands during 1981–82.*[a]

Milk yield (kg)	Average duration of lactation (months)	Frequency
501–600	7	3
601–700	7.3	2
701–800	6.5	3
801–900	7.8	5
901–1000	8.2	4
1001–1100	8.4	1
1101–1200	10	3
1201–1500	10	1
1501–2000	13	1

[a] Where milk yields were estimated from offtake for human consumption plus milk intake required for observed growth of calves. See also Figure E1.

Source: Nicholson (1983a).

seven months or shorter than 11 months, season of birth strongly affected milk yield; lactations that started in March or April were 31% higher than those started in October or November (Nicholson, 1983a: p 33). Ratios of milk used for human offtake versus calf intake across location and month of lactation are presented in Nicholson (1983a: pp 36–37). Overall, the offtake rate (±SE) was 39±0.24% for lactations that began in the long rains and 29±0.12% for those which began in the short rains.

There were 24 calves with complete records for milk intake and growth (Nicholson, 1983a). A comparison of the actual weights of calves at an average of 250 days of age with their estimated weights based on consumption of milk otherwise "lost" to humans is presented in Table 5.4. The actual weight ($\bar{x}$±SE) averaged 61±2.6 kg while the projected weights based on an additional milk intake of 312 kg were 131±6.6 kg, an increase of 115%. This reflected an increase in milk intake from 195 kg (35% of yield) to 607 kg (100% of yield). Conversion of the additional milk to live weight incorporated estimates of milk composition (Nicholson, 1983a: p 33). Total solids comprised 14.54% and fat 5.4%. The remaining composition was nonfat solids (9.14%), protein (3.3%), lactose (4.9%) and ash (0.8%). Conversion of offtake into predicted calf growth suggested that calf growth was considerably retarded by a restricted nutrient intake and it was hypothesised that such nutritional stress could result in delayed pubertal development with negative consequences for lifetime productivity of females (Nicholson, 1983a: p 26).

5.3.3 Cattle production and pastoral wealth

The 30 encampments studied by Mulugeta Assefa (1990) included a total of 633 households of which 113 (18%) were classified as wealthy, 200 (31%) as middle class and 320 (51%) as poor (see Section 4.3.1: *General household structure and economy in average rainfall years*). Results from statistical analyses of effects of household wealth on family size, cattle holdings and production parameters are given in Table 5.5. Sampled households of different wealth strata varied in the number of family members and absolute and per capita holdings of cattle. Wealthy households had 7 and 2.6 times the number of cattle that poor or middle-class households held in absolute terms. The ratio of total cattle per person varied from 14.2:1 (wealthy), 7.3:1 (middle class) to 2.3:1 (poor) and the ratio of milk cows to person tripled from poor to middle class and doubled from middle class to the wealthy (Table 5.5). The percentage of female cattle for all herds was estimated at 74% (Mulugeta Assefa, 1990: p 22).

Although no significant differences (P>0.05) were observed among cattle of the various wealth classes in terms of reported age at first calving, calving interval, or daily milk offtake per cow for human consumption, all other aspects did vary. In

Table 5.4. *Actual calf live weights at weaning under traditional pastoral management and predicted live weights given hypothetical access to total milk production in the southern rangelands.*[1]

Age (months)	Live weights (kg)		Age (months)	Live weights (kg)	
	Actual	Predicted		Actual	Predicted
7	53	113	6	41	91
8	54	124	7	74	131
8	54	137	7	53	102
13	72	155	8	56	129
14	97	239	8	42	98
10	65	128	7	58	99
8	68	159	11	65	141
9	49	103	8	57	124
11	60	137	10	66	112
8	61	135	11	65	153
6	44	100	10	72	176
12	72	125	7	68	142

1 Predicted calf weights were based on an equation converting milk offtake to live weight (see Figure E1).

Source: Nicholson (1983a).

Table 5.5. *Household wealth effects on family size, per capita cattle holdings and herd size, composition and various production aspects of cattle in the southern rangelands during 1985–89.*[1]

Variable	Units	Wealth class[2]		
		Wealthy	Middle class	Poor
Family size	no	6.4*x*	4.8*y*	5.6*z*
Cattle herd	no	91*x*	35*y*	13*z*
Mature male cattle	no	24*x*	9*y*	3*z*
Female cattle (<4 years old)	no	27*x*	12*y*	5*z*
Mature cows	no	39*x*	14*y*	5*z*
Cows: person	ratio	6*x*	2.9*y*	0.8*z*
Age at first calving	years	4.5*x*	4.5*x*	4.4*x*
Calving rate	%	71*x*	70*x*	56*x*
Calving interval	days	455*x*	454*x*	462*x*
Lactation period	mo	7.5*x*	8.2*x*	8.4*y*
Daily total milk yield	ml	1983*x*	1899*x*	1570*y*
Daily milk offtake	ml	864*x*	836*x*	832*x*
Daily milk intake by calves	ml	1119*x*	1063*x*	737*y*
Daily milking frequency/cow	no	1.4*x*	1.7*y*	1.8*z*
Average teats milked/cow/day	no	1.4*x*	1.6*y*	1.8*z*
Calf mortality[3]				
All years	%	23.9*x*	16.5*y*	30.4*z*
Average rainfall year	%	19.4*x*	18.4*x*	25.1*x*
Dry year	%	21.4*x*	11*y*	25.7*x*
Drought year	%	69.2*x*	50*y*	89*x*

1 Where tabulated data are based on interviews of 90 households regarding production history of 482 cows and 1540 calves. Entries in the same row accompanied by a different letter (*x, y, z*) were significantly different ($P \leq 0.05$).

2 Where wealth classes are based on ratios of cattle to people per household.

3 Where an average rainfall year has 600 mm or more of rainfall, a dry year has 450 mm or less and a drought year is a second consecutive dry year.

Source: Mulugeta Assefa (1990).

general, poorer households had fewer cows and these reportedly had lower calving rates, longer lactation periods, lower daily milk production and lower milk intake for calves. Poorer families also milked their cows more frequently and intensively. Poorer families had the highest rates of calf mortality averaged across all types of rainfall years but rates were similar to those of wealthy families when average rainfall, dry and drought years were considered separately. Middle-class families had the lowest rates of calf mortality in dry and drought years (Table 5.5).

Productivity parameters of cattle were also affected by the productivity class (high, medium or low) to which they were assigned by the Boran (Table 5.6). These categories seemed to be determined by milking characteristics such as length of lactation, daily milk output as measured by daily milk offtake. Animals in the high producer class were consequently milked more frequently and more intensively, with more milk still remaining for calves compared to low producing cows. Paradoxically, however, compared to low-producing cows, the high producers were reported to have their first calf slightly later and a slightly longer calving interval over their lifetime (Table 5.6). Overall, the 482 cows had an average of 3.2 calves at the time of the survey. With an average age at first calving of 4.46 years and an average calving interval of 15 months, the average age of cows surveyed was about nine years. The Boran reported that a cow may continue to calve until it is 17 years old (Mulugeta Assefa, TLDP/ILCA postgraduate researcher, personal communication).

Using interviews and empirical methods, Nicholson and Cossins (1984) and Cossins and Upton (1987: p 207) reported results similar to those of Mulugeta Assefa (1990) for average age at first calving (four years), annual calving rate (75%), calving interval (15 months) and mortality rate of nursing calves (25%).

Results similar to those from Nicholson (1983a) were also obtained by Mulugeta Assefa (1990) regarding seasonal effects on calving and milk production (Table 5.7). Out of the 1549 calves in the cow history analysis, 69% were reportedly born in the long rains, 17% in the short rains and the remaining 14% during the dry periods. Reported milk production, offtake per cow, and milk intake per calf all roughly doubled in wet compared to dry periods, while offtake rate averaged 46% in each season. The average total milk production per cow over a 7.9-month lactation was estimated as 436 kg, with 201 kg (46%) for people and the rest for the calf (Mulugeta Assefa, 1990: p 20).

5.3.4 Water restriction and cattle productivity

5.3.4.1 Effects on calves

Varying watering frequencies had no effect on calving percentage as the means for all four treatments over the two calving seasons in 1984 and 1985 ranged from 74 to 78.5% (Nicholson, 1987a: p 121). Average birth weight of calves overall was 26.4 kg (*N*=398). Birth weights of calves whose dams were in the daily watering treatment were only about 10% higher on average than those from other treatments in 1984–85 (25.8 kg vs an average of 23.4 kg, respectively), a negligible difference (Nicholson, 1987a: p 121). More resolution into treatment effects was provided by 210-day calf weights at weaning (Table 5.8). Compared to daily

Table 5.6. *Influence of cow-productivity class (high, medium or low) on various aspects of production in the southern rangelands during 1985–89.*[1]

Variable	Units	Cow-productivity class		
		High	Medium	Low
Age at first calving	years	4.54*x*	4.47*xy*	4.38*y*
Calving interval	days	478*x*	449*y*	445*y*
Lactation period	months	8.7*x*	8.2*x*	7.1*y*
Daily milk yield	ml	2309*x*	1684*y*	1460*z*
Daily milk offtake	ml	1239*x*	789*y*	505*z*
Daily milk intake by calves	ml	1070*x*	895*y*	955*y*
Daily milking frequency	no	2*x*	1.8*y*	0.9*z*
Average teats milked/cow/day	no	2*x*	1.8*y*	1.5*z*

1 Where tabulated data are based on interviews of 90 households regarding production history of 482 cows and 1549 calves. Cow productivity classes were defined by the respondents. Entries in the same row accompanied by a different letter (*x, y, z*) were significantly different (P≤ 0.05).

Source: Mulugeta Assefa (1990).

Table 5.7. *Reported calf birth frequency, milk production and allocation and milking intensity of cows during four seasons in the southern rangelands during 1985–89.*[1]

Category	Season[2]			
	Warm dry	Long rains	Cool dry	Short rains
Number of births	161*w*	1078*x*	43*y*	267*z*
Daily milk production per cow (ml)	1023*w*	2619*x*	1342*y*	2286*z*
Daily milk offtake (ml)	467*w*	1216*x*	625*y*	1069*z*
Daily milk intake by calves (ml)	556*w*	1403*x*	717*y*	1226*z*
Daily milking frequency per cow	1.4*w*	1.6*x*	1.5*y*	1.6*x*
Average number of teats milked/cow/day	1.4*w*	1.6*x*	1.5*y*	1.6*x*

1 Based on a sample of 482 cows and 1549 calves. Entries in the same row accompanied by a different letter (*w, x, y, z*) were significantly different ($P \leq 0.05$).

2 Where the warm dry season occurs from December to March, the long rains occur from April to June, the cool dry season from July to September and the short rains from October to November.

Source: Mulugeta Assefa (1990).

watering, trends indicated that when watering was limited to once every three days, 210-day weights decreased on the order of 12% across all three years. The animals watered *ad libitum* could not be followed after the first year, so only live weights of the remaining treatments up to two years of age are available (Table 5.9). Despite an apparent spread of 21 kg (11% of the overall mean) at one year of age, weights of animals from all treatments had converged by two years of age with a spread of 6 kg (2% of the overall mean).

5.3.4.2 Effects on cows

Seasonal weights of lactating cows changed markedly and ranged from around 400 kg during and soon after wet seasons to about 320 kg at the end of the long dry season. As a per cent of live weight prior to the dry season, the variation in weight loss was from about 20% for groups watered daily or every other day to 27% for those watered once every three days (Nicholson, 1987a: p 123). Weight dynamics were confounded by pregnancies. Time-series graphs indicated no clear differences among

Table 5.8. *Live weights of calves (±SD) at 210 days of age whose dams were subjected to various levels of water restriction at Abernosa ranch in the Ethiopian Rift Valley during 1983–84.*[1]

Water-access treatment	Calves born in		
	1983	1984	1983–84
Ad libitum	147.3 ± 19.61	143.9 ± 18.83	146.2 ± 17.44
Once daily	142.1 ± 20.81	139.8 ± 14.3	139.6 ± 18.69
On alternate days	136.5 ± 18.78	133.8 ± 16.48	130.8 ± 17.91
Every third day	132 ± 18.67	125.6± 16.86	125.5 ± 18.03

1 Where $N = 98$, 101 and 199 for calves born in 1983, 1984 and both years, respectively.

Source: Nicholson (1987a).

Table 5.9. *Live weights of weaned immature cattle (± SD) at various ages whose dams had been subjected to different levels of water restriction at Abernosa ranch in the Ethiopian Rift Valley during 1983–84.*[1]

Water-access treatment	Age (months)			
	12	15	18	24
Once daily	209.9 ± 24.64	218.7 ± 23.32	230 ± 27.8	312.8 ± 19.65
Alternate day	188 ± 6.99	210.2 ± 15.99	216.3 ± 14.76	308.4 ± 14.37
Every third day	191.4 ± 13.99	215.5 ± 23.5	215.5 ± 27.1	306.1 ± 17.7

1 Where $N = 74$ calves born in 1983 with an average of 25 per group.

Source: Nicholson (1987a).

treatments. During the wet season all groups regained weight that they had lost in the previous dry season. Non-lactating cows also showed seasonal changes in live weight but these fluctuations were not as dramatic as those of the lactating ones. Time-series graphs suggested that when these cows were watered daily, they were only 20 kg heavier than those watered once every three days (415 vs 395 kg, respectively). The group watered every second day had weights that fell in between the two groups. Differences in live weight were most apparent during the height of the dry season when cows watered daily weighed about 405 kg vs an average of 375 kg for the others (Nicholson, 1987a: p 124). Condition scores for both lactating and non-lactating cows suggested that animals watered daily were usually in a higher plane of condition throughout the trial than animals in other groups (Nicholson, 1987a: p 125).

5.3.4.3 Intake of water, feed and milk

Relative water consumption per unit live weight of cows in the dry season is shown in Table 5.10. Maximum observed intake was 90 litres/head for a lactating cow with a dehydrated weight of 301 kg. Maximum water intake as a percentage of dehydrated weight was 34.4%. Cows under restricted watering were more efficient in their water use. Water consumption by lactating cows watered once every three days was up to 34% lower compared to those watered daily. For non-lactating cows the same contrast varied by 22%.

Faecal output and estimated feed intake are presented in Table 5.11. These data were interpreted to suggest that subjecting cattle to restricted watering depressed dry-matter intake by 13 to 20% for steers.

Results for milk intake by calves in the third month of lactation shown in Table 5.12 suggested that milk intake was depressed by about 12 to 14% in animals whose dams were watered once every three days compared to the others.

5.3.5 Weight gain patterns for bulls and steers on a ranch

Of the 1535 animals in Group 1 (see section 5.2.3 above), only 1179 (77%) were analysed because these had complete data on sex (entire or castrate), purchase origin and herder group (Nicholson, 1983b: p 4). Over seven months (212 days), from November 1980 during the short rains right through the long dry season to June 1981 (the end of the

Table 5.10. *Average water consumption (±SD) of lactating (LC) or dry cows (DC) subjected to various levels of water restriction at Abernosa ranch in the Ethiopian Rift Valley during the dry season (September to March) in 1983.*[1]

Water-access treatment	Cow class	Water consumption			Per cent of dehydrated weight
		Per drinking event		Per day	
		(litre/head)	(ml/kg)	(ml/kg)	
Once daily	LC	28.7 ± 10.1	79.4 ± 17.6	79.4 ± 17.6	7.9
	DC	23.3 ± 7.8	57.3 ± 11.3	57.3 ± 11.3	5.7
Alternate days	LC	54.6 ± 12.6	151.0 ± 42	75.5 ± 9.0	15.1
	DC	42.0 ± 9.7	108.2 ± 28.3	54.1 ± 14.7	10.8
Every third day	LC	65.3 ± 14.2	156.7 ± 50	52.2 ± 14.7	15.7
	DC	49.4 ± 10.9	133.5 ± 32.3	44.5 ± 12.5	13.4

1 Where $N = 26$ per treatment.

Source: Nicholson (1987a).

Table 5.11. *Faecal output and estimated feed intake for steers subjected to various levels of water restriction at Abernosa ranch in the Ethiopian Rift Valley in 1983.*[1]

	Observed faecal output ($g/kg^{0.75}$/day)	Calculated feed intake ($g/kg^{0.75}$/day)	Mean live weight (kg)
Once daily	35.9	52.9	248
Alternate days	30.6	42.3	238
Every third day	31.6	46.1	231
	(SE = 1.27)	(SE = 2.44)	(SE = 2.4)

1 Where $N = 54$. For methods see the text.

Source: Nicholson (1987a).

Table 5.12. *Milk intake of calves (kg/head/day; ±SD) whose dams were subjected to various levels of water restriction at Abernosa ranch in the Ethiopian Rift Valley during 1983.*

Water-access treatment	Analytical method[1]	
	Weighing	Water turnover
Once daily	4.93 ± 0.34	5.10 ± 0.52
Alternate days	4.82 ± 0.32	4.78 ± 0.37
Every third day	4.19 ± 0.40	4.36 ± 0.40

1 See text for experimental details.

Source: Nicholson (1987a).

long rains), all animals on average gained about 40 kg from an initial weight of 167 kg (Table 1, Annex E). Weight gains of bulls and steers were similar, but there were significant effects (P<0.001) due to origin and herder group. Nicholson (1983b: p 9) noted some minor data problems of where animal was purchased and herd groups as well as some initial differences in weight, but pointed out differences in weight gain that could have been influenced by location of purchase. Animals from Mega and Marmaro regions had similar initial weights (Table 1, Annex E) and were evenly distributed among herd groups. However, the animals from Mega gained only 140 g/day versus 237 g/day for those from Marmaro. Nicholson (1983b: p 9) hypothesised that this difference was related to interactions between genotype and environment. Animals from Mega (located in a mountain range at 1900 m in the upper semi-arid and subhumid zones) were supposed to have been crosses of local Borans and highland zebus that were less adapted to the arid conditions of Sarite. In contrast, animals from Maramaro were presumed to have been reared under conditions similar to those at Sarite. Other superior performers (in terms of ADG) came from Orbati and Hobok which are also hot and dry areas. The second worst performers after those from Mega came from Dubluk located at 1500 m and only 40 km from high-altitude Mega.

Of the 1104 animals purchased for Group 2 between January 1982 (the warm dry season) and March 1982 (beginning of the long rains), only 734 (65%) had complete records on weight, purchase origin, herd group and purchase and sale price. Whether or not an animal had been castrated was not recorded (Nicholson, 1983b: p 15). Although weights were recorded several times, the final analysis of ADG used only the second weight after entry into the (22 March) and the final sale weight in the cool dry season two months after the long rains had ended (around 15 August 1982). This was intended to standardise the time frame of the analysis since animals had variable weight dynamics as a result of their time of arrival during the previous dry season (Nicholson, 1983b: p 15). Weight gains significantly varied (P<0.001) according to origin over the 143-day period as calculated by least-squares regression.

In contrast to the previous analysis, a clear pattern of ADG that varied according to climate (place of origin) was not evident. This was likely due in part to the less stressful production conditions during this seasonal sequence as well as a low number and small sample sizes of animals from high-altitude sites. In addition, there was some confounding of animal origin and date of entry into the (Nicholson, 1983b: p 23). The live weight at which the best price was received was predicted from differentiation of a least-squares quadratic equation fit (P<0.001) to the final sale data (Nicholson, 1983b: pp 27, 37). The most profitable sale weight was about 410 kg with EB 1.26/kg received. This was only 9% higher, however, than the EB 1.15/kg received for an average-sized animal of 282 kg. Differentiation of another least-squares quadratic equation significantly fitted to purchase data (P<0.001) suggested that the most profitable purchase weight was 211 kg (Nicholson, 1983b: pp 38–39).

5.3.6 Cattle health and sources of mortality

From cow-history questionnaires, Mulugeta Assefa (1990) noted general sources of calf mortality according to: (1) purely disease-related factors; and (2) nutrition-related factors that included deaths caused by interactions of disease with a low plane of nutrition. Calculated across all pastoral wealth classes, disease alone may have been responsible for about half of the annual calf mortality of 22% in an average rainfall year (Table 5.5). As annual rainfall declines, the importance of purely disease-related mortality may also decline. In an isolated dry year, disease may account for only one-third of the 21% annual calf mortality. Disease alone may account for only a negligible number of calf deaths in a multiple-year drought. Health problems reported by the Boran as most important overall were calf scours, black leg, pasteurolosis and foot-and-mouth disease (Mulugeta Assefa, 1990).

Tables 2 to 4, Annex E, enumerate causes of death for mature cattle and calves during average rainfall dry, and drought years on the Borana Plateau from 1976–1987. Results suggest that deaths of adult cattle from pasteurolosis, black leg and anthrax occur in all types of rainfall years while tick-related diseases may increase in years of average or above average precipitation. Strongylosis also appeared to be more common in dry years. For calves, calf scours, foot-and-mouth and black leg were commonly reported in all years. Deaths due to poor nutrition were far more prevalent in calves than adult cattle.

After they reach two years of age, cattle have relatively low rates of mortality during years of average rainfall or during isolated dry years. Cossins and Upton (1987: p 207) gave annual mortality rates of 5% and 2% for cattle aged two to three and three to four years, respectively.

Complications from tick bites on sensitive tissues like cow udders have important implications for milk production (Coppock, 1990b). The inspection of 560 randomly selected cows from 63 herds in four *madda* revealed that 291 out of 2240 teats (13%) were badly damaged by complications from tick bites, some being completely sealed off.

5.3.7 Ancillary livestock

5.3.7.1 Sheep and goats

Cattle are undoubtedly the most important livestock species in the Borana system, but other species play useful secondary roles. The next most important animals that produce food and generate income are small ruminants, which comprise about 7.4% of the TLUs on the Borana Plateau overall (Cossins and Upton, 1987: p 208). An average Borana household may have seven small ruminants of which 70% are goats (Cossins and Upton, 1987: p 213), that add to about 6% of an average families' TLUs and livestock capital value based on 14.6 cattle/family (Cossins and Upton, 1987: p 215) and average prices reported in Negussie Tilahun (nd: p 71). The dominant breed of sheep is the fat-rumped, black-headed Somali while the goats consist of both the Somali and small East African breeds. The Somali goat is distinguished from the small East African one by its white coat and larger body size (Pratt and Gwynne, 1977: p 163).

Sheep and goats are very important to the household economy in terms of providing a source of convenient amounts of cash (about EB 50/head) on a more frequent basis. This can partially substitute for sales of cattle (Coppock, 1992b; see Section 4.4.4: *Traditional marketing rationale*). Like the case of cattle, however, the main decision maker and beneficiary of a sale of a goat or sheep is probably the male head of household (C. Fütterknecht, CARE-Ethiopia, personal communication). Small quantities of milk from goats provide a useful supplement for children during average rainfall years and for all family members during drought (Cossins and Upton, 1987: p 208). It may also be expected that small ruminants are relatively more important for poorer families with few cattle (Coppock, 1992b). Despite the ability of small ruminants to proliferate better than larger stock, they are probably more susceptible to disease, especially in the wetter parts of the Borana Plateau, thus making their production a more risky enterprise (Cossins and Upton, 1987: p 208).

Day-to-day management of small ruminants is usually performed by women and children. Children act as herders (Cossins and Upton, 1987: p 208) while women build and clean corrals of adult animals and construct elevated wooden pens in the family hut for kids and lambs. Sheep and goats may be watered once every five days during the dry season (Donaldson, 1986: p 8; Cossins and Upton, 1987: p 208). Belete Dessalegn (1985: pp 41–55) noted that goats were corralled about 14 hours per day and spent an average of eight hours per day feeding throughout the year (with 15% more feeding time in wet seasons). They were observed to travel on average 5.7 and 13 km/day during the long rains and warm dry seasons, respectively (Belete Dessalegn, 1985).

Preliminary production data for small ruminants are presented in Belete Dessalegn (1985: pp 25–38) who monitored animals at a Gabra encampment in the Beke Pond area from May 1984 to May 1985, a drought year in the southern rangelands (see Chapter 6: *Effects of drought and traditional tactics of drought mitigation*). A sample of 59 does and 60 ewes produced 1.4 and 0.9 young each, with twinning in 7% and 4% of goat and sheep parturitions, respectively. Animals were born throughout the year, especially goats. Age at first parturition was about 17.5 months for both species. Average birth weights were 2.4 kg for both kids (N=93) and lambs (N=56). Both species were weaned at about five months of age. Average daily weight gains of nursing young ranged from 82 g/day (sheep) to 76 g/day (goats). Parturition interval ($\bar{x}\pm$SD) averaged 219±27 days for goats and 248±36 days for sheep. Milk offtake averaged 46 kg for goat lactations over an average of 147±31 days (N=5). Sheep were not milked. Milk offtake for humans followed stimulation of milk let-down by the young. Offtake appeared to be the highest during rainy periods (Belete Dessalegn, 1985: p 38). The average daily offtake throughout all lactations and seasons was 0.32 kg/head. This decreased to 0.26 kg/head/day at the height of the long dry season in 1985.

Mortality of nursing young was 32% (*N*=83) for goats and 45% for sheep (*N*=54). Post-weaning mortality was 10% (*N*=57) for goats and 12% for sheep (*N*=30). Total losses added to 39% (*N*=83) for goats and 46% (*N*=54) for sheep. Belete Dessalegn (1985: pp 36–37) enumerated sources of mortality for these 57 animals plus 62 others in the same encampment. Disease apparently killed 80% (N=119) of animals of both sexes of all age classes, with minor losses from accidents or predators. Contagious caprine pleuropneumonia (CCPP) was diagnosed as the cause of at least 12 of 95 deaths from disease. Internal parasites were also thought to be a major factor limiting production, aggravated perhaps by the unsanitary conditions under which small stock were reared (Belete Dessalegn, 1985: p 40).

5.3.7.2 Camels

Dromedary camels constitute a very small fraction of livestock on the Borana Plateau (Cossins and Upton, 1987: 208–209), although they serve very useful functions for several pastoral groups. On the central plateau the Gabra minority rely on camel milk as the mainstay of their diets. The Gabra also use camels to transport their portable huts when they need to move. The locations of Gabra and Gari settlements largely account for the pockets of camels on the central plateau. Camels become more abundant as one travels eastwards past Negele where Somali pastoralists become dominant. It has been speculated that camels have become more abundant on the Borana Plateau as a result of bush encroachment during the last 200 years (ERP, 1984: p 29).

Even though camel management has not been studied in detail, nursing camels are usually corralled separately from the adults and herded near encampments by children. Belete Dessalegn (1985: pp 10–17) noted that camels were corralled about 12 h/day. Distance traveled by adult camels varied from about 7 km/day in rainy periods to 26 km/day in the warm dry season. Travel in the dry season comprised almost 30% of diurnal activity. Daily feeding time ranged from about 7.5 h (long rains) to 5.2 h (warm dry season). Camels are watered once every 7 to 15 days in dry seasons (Donaldson, 1986: p 8). Feeding wise they were observed to be exclusively browsers with diets dominated by *Acacia brevispica*, *Rhus natalensis*, *Cadaba farinosa* and *Balanites* spp (Woodward, 1988; see Section 3.3.5.1: *Livestock food habits*).

Interviewees of Gabra herd owners from the Beke Pond region ranked various diseases and ailments as the most important constraints in camel production affecting both immatures and matures, although the rank order differed (Tables 5.13 and 5.14). Trypanosomiasis, otherwise rare on the plateau, is reportedly picked up by camels when they travel east along the Dawa river to browse in gallery forests during the dry season (Sileshi

Table 5.13 *Perceived production problems for mature camels as ranked by 24 Gabra herd owners in the Beke Pond region in the southern rangelands during 1987.*[1]

Number	Mean rank[2]	Disease/symptoms[3]
1	2.88*w*	Trypanosomiasis
2	3.06*wx*	Thick nasal discharges
3	4.0*wx*	Swelling of lymph nodes
4	5.0*wx*	Chronic respiratory ailments
5	5.54*xy*	Abscesses
6	7.56*yz*	Pox
7	7.67*yz*	Boils
8	8.13*z*	Nervousness
9	8.13*z*	Lameness
10	8.6*z*	Diarrhoea/emaciation
11	8.6*z*	Rabies
12	8.65*z*	Infected ear wounds

1 Derived from household interviews. Problems were listed and ranked from most common (1) to least common (12). Only health problems were mentioned.

2 Entries accompanied by the same letter (*w, x, y, z*) were not ranked differently (P>0.05) according to Friedman's test (Steel and Torrie, 1980).

3 Translations of terminology in Oromigna and Somaligna were provided by Abakano Kereyu (TLDP Animal Health Coordinator, personal communication).

Source: Coppock (1988).

Table 5.14. *Perceived production problems for immature camels as ranked by 24 Gabra herd owners in the Beke Pond region in the southern rangelands during 1987.*[1]

Number	Mean rank[2]	Disease/symptoms[3]
1	2.33*v*	Oedema
2	2.52*v*	Diarrhoea
3	4.31*vw*	Thick nasal discharges
4	5.19*wx*	Swelling of lymph nodes
5	5.23*wx*	Pox
6	5.52*wxy*	Boils
7	6.94*xyz*	Muzzle dryness/head swelling
8	7.29*xyz*	Pox-like disease
9	7.83*z*	Bloat
10	7.83*z*	Sarcoptic mange

1 Derived from household interviews. Problems were listed and ranked from most common (1) to least common (10). Only health problems were mentioned.

2 Entries accompanied by the same letter (*v, w, x, y, z*) were not ranked differently (P>0.05) according to Friedman's test (Steel and Torrie, 1980).

3 Translations of terminology in Oromigna and Somaligna were provided by Dr Abakano Kereyu (TLDP Animal Health Coordinator, personal communication).

Source: Coppock (1988).

Zewdie, SORDU veterinarian, personal communication).

Most Borana encampments in the central region have at least one camel. A survey of 60 encampments in four *madda* indicated that 56 had at least one camel, with an overall average of three/encampment (Coppock and Mulugeta Mamo, 1985). The Boran use camels mainly as work animals (Cossins and Upton, 1987: p 209), in commercial operations for hauling salt mined from volcanic craters to markets or for just domestic needs such as: (1) carrying grain and other commodities from market; (2) carrying large quantities of drinking water from wells for both people and calves in dry seasons; and (3) ploughing fields. Camels are not ridden by the Boran or Gabra. The most important uses or values of camels were ranked by 24 Gabra herd owners (Table 5.15). Camels on the central plateau may represent two races, the smaller slender *geleb* and the large *quorti* (D. L. Coppock, ILCA, personal observation). Mature specimens of the *quorti* may weigh over 500 kg and are heavily built.

In an analysis limited to three camels during 18 months of the 1983–84 drought, Belete Dessalegn (1985: p 3) reported a mean offtake (±SD) of 1045±58 litre/lactation that lasted an average (±SD) of 430±35 days. Camels were milked three times/day (morning, afternoon and evening) when forage conditions were favourable, but this changed to twice/day (early morning and late evening) when they had to travel longer distances to feed. This translated into about 3.6, 3 and 1.7 litres of daily offtake during the first month, second to sixth

Table 5.15. *Priority attributes of camels as ranked by 24 Gabra households in the Beke Pond region in the southern rangelands in 1987.*[1]

Number	Mean rank[2]	Attribute
1	1.14*x*	Milk production
2	2.29*xy*	Transport of goods
3	3.67*yz*	Market ability
4	4.24*z*	Drought resistance
5	4.55*z*	Rental for transport
6	5.12*z*	Meat

1 Derived from household interviews. Attributes were listed and ranked from most important (1) to least important (6).

2 Entries accompanied by the same letter *(x, y, z)* were not ranked differently (P>0.05) according to Friedman's test (Steel and Torrie, 1980).

Source: Coppock (1988).

months and seventh to fourteenth months of lactation, respectively (Belete Dessalegn, 1985: p 4). Laboratory analysis revealed an average composition of camel's milk as 14.1% total solids, 4.6% fat, 3.6% protein, 4.6% lactose and 0.8% ash (Belete Dessalegn, 1985: p 3). Camel milk is apparently unsuitable for making marketable butter (see Section 7.3.3.3: *Dairy processing and marketing*).

5.3.7.3 Other livestock

Equines are also found in small numbers on the plateau (see Section 4.3.1: *General household structure and economy in average rainfall years*). A survey of 60 encampments (Coppock and Mulugeta Mamo, 1985) indicated that 45 had donkeys (with an average of four each), 34 had mules (two each) and only 13 had horses (seven each; these results were skewed by four encampments at Medecho *madda* that had 10, 12, 15 and 35 horses).

Donkeys are used as pack animals and may haul water, firewood, cut-and-carry forage for calves and salt. Mules are routinely ridden by men, using locally made saddles and bridles. Mules may also be used as pack animals. Horses are primarily reared as a prestige animal (Cossins and Upton, 1987: p 209) and are ridden by wealthy men to important meetings and ceremonies. Equines are not ridden by women. Horses and donkeys are watered once every two or three days in dry seasons, respectively (Donaldson, 1986: p 8).

Chickens are common at Borana encampments and the women build elevated hen houses out of local materials. Women manage chickens and sell them to town dwellers (C. Fütterknecht, CARE-Ethiopia, personal communication). Chickens thus could be an important (and often overlooked) source of women's income. It is unclear whether the pastoralists ever eat mature birds or the eggs, as this has never been recorded in household surveys (Negussie Tilahun, 1984; Donaldson, 1986; Holden, 1988). Chickens are probably most valuable as marketable commodity.

5.4 Discussion

5.4.1 Cattle management

Typical patterns of cattle management, including separation of adults and immatures, nightly corralling of adults, milking cows with the calf at foot, allocation of milking quarters to human or calf consumption, intensive hand-rearing of calves, water restriction of adult cattle and calves in dry seasons, splitting cattle into home-based and satellite herds and differentiation of management roles according to sex and age among household members have been commonly observed to various degrees in similar systems throughout sub-Saharan Africa (Dahl and Hjort, 1976; McCabe, 1983; Wagenaar et al, 1986; de Leeuw and Wilson, 1987; Massey, 1987; Coppock et al, 1988; Grandin et al, 1991). Alberro (1986: p 37) commented that the Boran sustain an ecological balance in their system in part by not desiring to accumulate large numbers of cattle and by slaughtering unwanted calves in the dry season. This was speculated to be a management adaptation to a restricted resource base. It is notable that there is no support for such speculation based on observations reported here. Like other pastoralists, Borana herd owners seek to accumulate cattle for various social and economic reasons (see Section 4.5.4: *Traditional marketing rationale*).

The standard practice of watering cattle once every three to four days in dry periods in response to local constraints of forage, water and labour is somewhat unusual, but such practices are permitted by the relatively cool temperatures (Section 2.4.1.4: *Climate, primary production and carrying capacity*) which facilitate maintenance of cattle water budgets by reducing evaporative losses for thermo-regulation (King, 1983). In interviews with Borana elders, the hypothesis that restricted watering of cattle is a relatively recent innovation due to population pressure was rejected (D. L. Coppock, ILCA, unpublished data). According to the elders, the practice has apparently lasted for many generations. This suggests that labour and/or water limitations have been historically important in the region.

5.4.2 Cattle production

The proportion of females to males in Borana cattle herds found by Mulugeta Assefa (1990: p 19) of 74:26 is in agreement with previous surveys by AGROTEC/CRG/SEDES Associates (1974h) who found a ratio of 69:31. This is also similar to results for other pastoral and agropastoral groups throughout sub-Saharan Africa with an average of 65% females: (de Leeuw and Wilson, 1987). The high proportion of females is thought to help stabilise milk production by offsetting the longer calving intervals characteristic of these systems (Jahnke, 1982 cited by Mulugeta Assefa, 1990: p 20).

The average age at first calving of four years found by Nicholson and Cossins (1984) and 4.5 years by Mulugeta Assefa (1990: p 21) also agree with earlier surveys done on the Borana Plateau by AGROTEC/CRG/SEDES Associates (1974h) and Faulkner (cited in Donaldson, 1986). These figures are higher than the mean of 3.6 years for *Bos indicus* found in a number of traditional systems reviewed by Mukasa-Mugerwa (1989: p 59). Age at first calving is highly influenced by the nutritional environment (Mukasa-Mugerwa, 1989: p 59). Mulugeta Assefa (1990) also found cows among the low-producer class that reportedly had their first calf two months earlier than the high-yielding ones, which may underlie some fundamental differences among cow classes (see below). Nicholson and Cossins (1984) noted that age of first calving of improved Borana cattle on Kenya commercial ranches was only 2.4 years. This may be a particularly exceptional situation, as Pratt and Gywnne (1977: p 149) gave a range of 3 to 4.3 years for Borans managed on ranches and research stations in East Africa. Trail and Gregory (1981), in a study of 10 years of data from the Kenya Rift Valley, found 3.3 years to first calving for Borans. It may thus be concluded that age at first calving of Borana cattle on the plateau is at the upper end of the range for animals reared on traditional settings. The ability of some Borans to calve markedly earlier under improved management is presumably related to the secure forage base and upgrading of the genotype.

Estimates of weights for mature Boran cattle vary markedly. Nicholson (1983b) found an average size for male cattle at Sarite of 282 kg, less than the mean of 318 kg for mature males reported by Alberro (1986: p 33). The animals studied by Nicholson were probably younger than those considered by Alberro. Nicholson and Cossins (1984: p 19) reported that it takes five years to produce a maximum-sized male of 350 to 450 kg and this is in contrast to Church et al (1957) who estimated the time to be six to seven years. Alberro (1986) also noted a maximum size of about 500 kg for males and an average mature weight of 225 kg for females on the plateau. Genetic upgrading of animals under conditions reportedly produces mature males and females that weigh from 550 to 850 and 400 to 550 kg, respectively (Alberro, 1986: p 33).

Annual calving rates of 67% (Mulugeta Assefa, 1990: p 21) and 75% (Nicholson and Cossins, 1984: p 2) in average rainfall years exceed earlier estimates of 50 to 60 % by AGROTEC/CRG/SEDES Associates (1974h). Considering uncontrolled breeding and the variable environment, a rate of 67 to 75% is at the upper end of the scale for either traditional production systems (34 to 69%) or for research and commercial conditions (53 to 82%) in Africa (Mukasa-Mugerwa, 1989: p 64). Uncontrolled breeding is the norm in African traditional systems (Wagenaar et al, 1986; de Leeuw and Wilson, 1987; Mukasa-Mugerwa, 1989: p 59; Wilson, 1989) with the hope of having calving distributed through all seasons to provide milk year round. Higher calving rates are correlated with higher rainfall (Cossins and Upton, 1988a: p 122; Mukasa-Mugerwa, 1989: p 66) which underscores the fundamental role of the nutritional environment in regulating conception. Disease, genetics and management may also play key roles otherwise (Mukasa-Mugerwa, 1989: p 63). De Leeuw et al (1991) noted for Kenya's Maasailand (which, like the southern Ethiopian rangelands, is also under a bimodal rainfall regime) that with two seasons of average or above-average rainfall per year, the calving percentage would come to 75%. One average or above-average rainy season per year would yield an annual rate of 58% while two below-average rainy seasons in a year would yield 43% . This perspective is very relevant for the Borana Plateau, but it must also be qualified by stocking rate and competition for forage (see Section 7.2: *A theory of local system dynamics*).

Mulugeta Assefa (1990) found markedly lower calving rates for cows held by poor households (56%) versus those of middle-class or wealthy households (70–71%). This could be related to the higher milking intensity he observed within poor households. The poor reportedly milked each cow more often, using more quarters and one month longer than wealthy families. Similar patterns of milking pressure were found among the Maasai (de Leeuw and Wilson, 1987: Grandin, 1988). More intensive milking has been noted to increase the period or lactation anoestrus in zebu cattle, the hormonal mechanism is reviewed by Mukasa-Mugerwa (1989: p 72). Evidence from other pastoral systems suggests milking effects on lactation anoestrus are minor. De Leeuw et al (1991) found that when milking is prolonged by one month the calving interval increased only by three days, as cows milked for four or five months calved 20 or 21 months later, respectively. For Mali, de Leeuw and Wilson (1987) estimated that every additional month of milking increased calving intervals by 10 days.

The generally higher level of milk deprivation of calves of poor families (see below) may also have a long-term effect on calving rates. Despite the ability of calves to compensate for the effects of early milk deprivation and reach maturity at a similar time across all wealth classes (see Section 7.3.3.4: *The calf: Prospects for growth acceleration*), they may be impaired in terms of subsequent breeding success. Mulugeta Assefa (1990: p 23) cited Clutton-Brock et al (1987) who noted that the lifetime breeding success of different cohorts of red deer (*Cervus elaphus*) were strongly related to the differences in nutritional conditions of the years of their birth.

Calving intervals overall were estimated at 14 to 15 months (Nicholson and Cossins, 1984: p 3; Mulugeta Assefa, 1990: p 23) which agrees with

AGROTEC/CRG/SEDES Associates (1974h). This estimate is lower than the 20–26 months reviewed by de Leeuw and Wilson (1987) and is at the lower end of the 12 to 26 month range for zebus proposed by Mukasa-Mugerwa (1989). Calving intervals on the Borana Plateau are strongly influenced by the environment, as over 90% of conceptions and births occur either in the long or short rains or shortly thereafter (Nicholson, 1983a; Mulugeta Assefa, 1990: p 24; Sovani, 1990). This effect of the environment has also been observed on ranches (Trail and Gregory, 1981). The different calving rates found among wealth classes by Mulugeta Assefa (1990) also imply that calving intervals may vary at most from about 14 months for animals owned by the wealthy to around 20 months for those owned by the poor.

Assuming a succession of average rainfall years, Nicholson and Cossins (1984) reported that having reached four years of age a heifer will likely produce 6 to 6.5 calves in a reproductive lifetime of 8 to 8.5 years. Culling commonly starts around 12 years of age. A few animals in their survey were between 15 to 20 years old and reportedly still calving. Anecdotal observations of Alberro (1986: p 34) agreed with this assessment. This is a marked increase in performance over zebus in the Ethiopian highlands that reportedly yield only three to four calves over a reproductive life of 7.6 years (Mukasa-Mugerwa et al, 1989). Data from Trail and Gregory (1981) suggest that improved Borans under conditions produced seven calves over a productive life of 7.7 years, only moderately higher than that observed on the Borana Plateau. Data from Trail and Gregory (1981) also indicated that the cows were culled around 11 years of age, which on average is only several years younger than that observed by Nicholson and Cossins (1984).

The results of Nicholson (1983a) for average calf birth weight (18 kg) and a low ADG for nursing calves (136 g/day) are similar to estimates for pastoral systems elsewhere (Wagenaar et al, 1986; de Leeuw et al, 1991; R. T. Wilson, ILCA, unpublished data). The estimates of median milk yield (843 kg) and lactation length (320 days) by Nicholson (1983a) were higher than those of Belete Dessalegn (1982; 488 kg over 249 days) or that of Mulugeta Assefa (1990; 436 kg over 237 days). These substantial differences reflect differences in research methods and the effects of the different sites and years, Nicholson (1983a) probably provides the most accurate baseline set of data. Nicholson and Cossins (1984) stated that milk production ranged from 680 to 1000 kg/lactation.

It is noteworthy that milk output of Borana cattle under highly seasonal range conditions appears: (1) similar to that of native cattle of the Ethiopian highlands under conditions; and (2) higher compared to native cattle of the Ethiopian highlands under smallholder conditions. Kiwuwa et al (1983: p 13) reported yields for Arsis and zebus as averaging 869 kg over a 287-day lactation. Mukasa-Mugerwa et al (1989) noted that zebus under traditional management yielded about 524 litres over a 239-day lactation, roughly 62% of that for Borans reported by Nicholson (1983a).

In sum, these contrasts give some credence to claims that the indigenous Boran is, even at minimum a moderately good and efficient milk producer (Pratt and Gwynne, 1977: p 147; Alberro, 1986). Pratt and Gwynne (1977: p 149) indicated that Borana cows under management in East Africa may yield up to 2641 kg/lactation, over three times the mean value for pastoral management found by Nicholson (1983a). Such production levels are presumably related to genetic effects as well as a secure forage base resulting from moderate stocking rates.

Mulugeta Assefa (1990) noted that there are three classes of milking cows in the Borana system that vary significantly with respect to several production aspects. Although the lowest producers were milked less intensively over the shortest length of time, compared to the highest producing cows, they had a slightly lower age at first calving and a shorter calving interval that could lead to a slightly higher lifetime productivity. The shorter calving interval could be due to a reduced period of lactation anoestrus; the high producing animals sacrifice more of their body stores to support milk production and the next conception is thus delayed (Mulugeta Assefa, 1990: p 24). This difference among cow classes is most likely to be genetic but it is doubtful that the Boran have a breeding regime that promotes one class of cow over another given that animals of various owners are herded together and breeding is uncontrolled. It is more likely that selection is fortuitous. If the high producing cows are more susceptible to death during droughts (Cossins and Upton, 1985; ILCA, 1986: p 25), a selective breeding regimen would be fruitless over the long term, anyway.

In their study of different cattle breeds in a seasonal environment, Vercoe and Frisch (1983) argued that *Bos taurus* breeds and their crosses were more productive under favourable conditions than *Bos indicus* because the former have a higher basal metabolic rate. However, *Bos indicus* was postulated to be more likely to survive unfavourable enviromental conditions. This illustrates the important trade-off between productivity and survival and may apply to the different classes of milk cows in Borana.

The finding of Nicholson (1983a) that the shape of the lactation curve of Boran cows in the rangelands as being typically bimodal fluctuating markedly with season, is in sharp contrast to the classical lactation curve (Wood, 1967). This underscores the great influence of the nutritional environment under traditional production conditions. But with shifts in animal density, the bimodal lactation curve may vary in its occurrence from year to year (see Section 7.2: *A theory of local system dynamics*).

Nicholson (1983a) found that milk offtake for human use ranged from 30 to 40% of production and that the average daily offtake was about 0.92 litre/cow. Work done by Holden et al (1991) and Mulugeta Assefa (1990) indicated similar average rates of offtake overall, but again considerably more resolution was provided by differentiating households into wealth classes. The findings of Nicholson (1983a) are remarkably similar to those for Maasailand (40% offtake with 0.94 litre/cow/day; de Leeuw et al, 1991), a transhumant system in Mali (20 to 35% offtake with 0.7 kg/cow/day; Wagenaar et al, 1986) and other pastoral and agropastoral systems reviewed by de Leeuw and Wilson (1987; up to 1.1 kg/cow/day). Even smallholders may take 45% of the yield of local zebus (producing 2.2 litres/cow/day) in the Ethiopian highlands (Mukasa-Mugerwa et al, 1989).

The low growth rates of nursing calves on the Borana Plateau were hypothesised to be related to milk deprivation due to high offtake (Nicholson, 1983a; Nicholson and Cossins, 1984; Cossins and Upton, 1988b). The same relation has been proposed by Pratt and Gwynne (1977: p 36), Wagenaar et al (1986), Wilson (1987), Preston (1989) and de Leeuw et al (1991; see Section 7.3.3.4: *The calf: Prospects for growth acceleration*). It was also found in the Borana Plateau that this competitive relation will vary markedly according to proximity to market, wealth strata and cow productivity class (Holden et al, 1991; see Section 4.3.5.3: *Effects of distance to market, wealth and season on pastoral dairy marketing*). It is thus a hypothesis that requires caution in generalising. Wagenaar et al (1986: p 50) noted that higher absolute offtakes of milk from Fulani cows were positively correlated with better calf performance, rather than the reverse. This has relevance to the work done by Mulugeta Assefa (1990) and Holden et al (1991) in which it was commonly stated by producers that they tried to avoid milking low-yielding cows so that their calves could have all the milk, milking only the high-yielding cows and sharing the milk with their calves. Even in this situation, calves of the high-yielding cows are likely to have more milk than calves of low-yielding ones. Thus, the relation between milk offtake and calf performance is underpinned by cow productivity, which probably explains the result of Wagenaar et al (1986).

It has been further speculated that milk restriction for Borana calves could have a carry-over effect in causing permanent stunting, delaying time to puberty and therefore reducing lifetime productivity of females (Nicholson, 1983a; Nicholson and Cossins, 1984; Cossins and Upton, 1988b). This has also been postulated by Preston (1989). However, these claims have been tested and rejected to be invalid in the southern rangelands. Animal weight tends to become harmonised during the post-weaning period as a result of compensatory growth and seasonal effects (see Section 7.3.3.4: *The calf: Prospects for growth acceleration*).

In sum, considering the vagaries of the southern rangelands environment, there is no indication that the fundamental productivity of Borana cows is unusually poor. In fact, productivity appears to be similar to the lower end of the range for animals kept under African and research station conditions and even superior to that of indigenous breeds in the Ethiopian highlands. Major differences in productivity likely arise from genetic improvements, but institutionalising breeding to this end is very risky under existing conditions of drought vulnerability where survival capability, and not merely high productivity, is the ultimate measure of success. Although calves grow slowly, this may mean little in a system where high turnover of the inventory is not a production value, production costs are low, and increasing growth rates via more forage feeding and provision of extra water is expensive and very difficult (Section 7.3.3.4: *The calf: Prospects for growth acceleration*).

5.4.3 Cattle mortality and health

Excluding drought impacts, mortality rates for adult cattle were reported to be low after two years of age, with an annual rate of about 5% due mostly to disease and accidents (Cossins and Upton, 1988b). This low rate is in agreement with values for cows reported by de Leeuw and Wilson (1987) who concluded that adult cattle mortality is a minor determinant of overall herd productivity in pastoral systems. This relatively stable state of affairs on the Borana Plateau has been so probably more during the past 20 years or so, because of veterinary campaigns. Nicholson and Cossins (1984: p 5) cited Church et al (1957) as reporting large losses of stock on the plateau as a result of unchecked rinderpest outbreaks in the 1950s. Pratt and Gwynne (1977: p 38) contended that rinderpest control was still ineffective in southern Ethiopia in the early to mid-1970s; but this has changed since then (SORDU, 1988). Long-term destabilising effects of disease control on livestock populations have been mentioned by Pratt and Gwynne (1977: p 38) and Lamprey (1983; cited in Ellis and Swift, 1988). Wood (1989) noted the role of veterinary activities in the growth of cattle herds in western Zambia during the 1980s.

Nicholson and Cossins (1984: p 5) reported that mortality rates of calves, in contrast to those of mature cattle, varied markedly across seasons and years. Their estimates were 10% for average rainfall years and 23% in dry years. The sequence should also include the 90% losses in a drought (Donaldson, 1986; see Section 6.3.1.1: *Livestock dispersal and herd composition*). Mulugeta Assefa (1990) calculated calf death rates of 21, 19 and 69% for average rainfall, dry and drought years, respectively. He also found that lowest mortality rates were rigisterd for animals held by middle-class households, which again justifies the segregation of data by wealth classes. Data from AGROTEC/CRG/SEDES Associates (1974h) and Church et al (1957) suggested that up to two years of age calf mortality was about 40%, presumably in average rainfall years. However, these claims were discounted by Nicholson and Cossins (1984: p 5) as inaccurate.

The overall average calf mortality rate of 18 to 25% for Borana calves up to one year of age during nondrought years is comparable to the 15 to 21% rates found for some agropastoral systems in the review by de Leeuw and Wilson (1987), and that is markedly lower than that for transhumant systems with rates of 27 to 36% including peri- and post-natal losses (Wagenaar et al, 1986; de Leeuw and Wilson, 1987). De Leeuw et al (1991) noted that Maasai calves have particularly low rates of mortality (12% for calves up to seven months of age) and they attributed this to intensive hand rearing and the high cultural value placed on calves. Calf survival was mentioned as the top production priority of the Maasai, exceeding even milk supply for the family. The Boran also rear calves intensively but they have probably poorer access to veterinary inputs compared to Kenya's Maasai (Evangelou, 1984: pp 76–84; see Section 7.3.3.5: *Calf mortality mitigation*).

De Leeuw and Wilson (1987) concluded that high calf mortality is the most important factor causing the low output of traditionally managed herds. Likewise, Dahl and Hjort (1976) cited Williamson and Payne (1965) as recommending that calf mortality rates over 15% should attract serious attention for interventions. In contrast, Cossins and Upton (1988b: p 267) speculated that only very modest overall production gains would result from substantial reductions in calf mortality in the Borana system. This view was derived from modeling that employed a "steady state" approach which allowed no net herd growth and contrasted intervention options that shifted the proportion of various age and sex classes of cattle. An increase in the proportion of calves tended to increase overall herd mortality and decrease output by slightly reducing the proportion of milking cows. This approach was later critiqued by Upton (1989) concluding that the benefits of calf mortality mitigation were underestimated by Cossins and Upton (1988b). This is discussed further in Section 7.3.3.5: *Calf mortality mitigation*.

Nicholson and Cossins (1984: p 7) list seven major causes of mortality for calves and suspected pasteurellosis as the most important, followed by five other diseases and finally starvation. A more recent review of calf diseases is found in Mulugeta Assefa (1990: pp 31–34). Mulugeta Assefa (1990) more clearly segregated reports of calf deaths according to disease and starvation and noted that losses because of diseases were more common in average rainfall and dry years but that during drought nearly all deaths were due to starvation. Nutrition-related losses were most likely the result of competition for milk in poor households while losses from disease of calves belonging to wealthy households were most likely because of lower labour investment (Mulugeta Assefa, 1990).

The limited capability of the regional veterinary unit at SORDU to provide "farm-gate" services to immobile calves means that this large cohort, comprising 24.6% of the regional cattle herd according to Cossins and Upton (1987), remains particularly vulnerable to disease. Mulugeta Assefa (1990: p 33) cited SORDU's (1988) summary of animal health statistics from 1976–87 as estimating that although 25% of calf deaths on the plateau were caused by disease, only 2.6 and 6.1% of the calf population had been vaccinated or otherwise treated, respectively. The logistical difficulties in implementing disease control programmes for calves dictate that at least appropriate feeding management tactics must be devised to reduce calf mortality (see Section 7.3.3.5: *Calf mortality mitigation*).

The pre-eminent importance of milk production to the welfare of the Boran indicates that health problems specific to cows should receive more attention. Besides spreading several dangerous diseases on the Borana Plateau (but not East Coast Fever), ticks may cause swellings and lesions of soft tissues of cattle (Hill, 1982). The results of the survey on cow udders and teats damaged by ticks (Coppock, 1990b) have important implications for milk yields. A 13% damage rate for teats implies that a household with an average of eight cows may require one more cow simply to maintain current level of milk production. Assuming these data are representative of the entire study area, and if cows make up 45% of the total cattle population of 250 000 head (Cossins and Upton, 1987: p 206; Assefa Eshete et al, 1987), it suggests that the number of cows would need to be increased by 14 600. At current high stocking levels these additional cows would have to compete with or displace other cattle that are also valuable for economic security (Coppock, 1992b). Because a cow only loses one or two teats from tick damage (D. L. Coppock, ILCA, personal observation), it is impaired but remains productive; so that ticks are a burden on the system in terms of milk production efficiency. It is unclear, however, whether or not the undamaged portions of the udder increase production of milk to compensate for damaged portions. This should be a topic for future research.

One solution for tick control is implementation of appropriate chemical prophylaxis and range management practices such as prescribed burning (see Section 7.3.3.1: *Mature cattle* and Section 7.3.1.4: *Site reclamation*). Concern has been raised, however, if an unsustainable introduction of acaricides would not reduce the natural resistance of Boran cattle to tick-borne diseases (G. Smith, former TLDP consultant, personal communication). The literature is conflicting on the degree to which Boran cattle are immune to tick-borne diseases. On the basis of anecdotal observations, Alberro (1986: p 32) noted that Boran cattle were infested with ticks and yet they seemed to have a high degree of tolerance to disease due to early exposure as calves. He also remarked that the Boran herd owners do not feel it necessary to remove ticks because they believe their cattle possess such immunity. This is an understandable response to overwhelming tick problems since they consistently express concern about tick control in ILCA surveys (D. L. Coppock, ILCA, personal observation). In contrast, Pratt and Gwynne (1977: p 145) mentioned that Boran cattle are more susceptible to tick-borne diseases than the East African Zebu, but this remark may be biased because of the occurrence in Kenya of East Coast Fever which is deadly (Stobbs, 1966). Hill (1982) cited AGROTEC/CRG/SEDES Associates (1974h) as listing 21 different types of ticks on the Borana Plateau and that the local stock are resistant to tick-borne piroplasmosis, anaplasmosis, theileriosis and rickettsiosis except when nutritionally stressed. Despite these conflicting comments, still use of acaricides could be useful for adult animals that have been exposed to tick-borne diseases as juveniles while the topic requires further investigation (see Section 7.3.3.1: *Mature cattle*).

5.4.4 Cattle productivity and watering frequency

One of the most important findings of the work of Nicholson (1987a) was that cattle possess the ability to compensate in the wet seasons for moderate amounts of live weight lost in dry periods as a result of water restriction. Water restriction acted primarily to overheat animals and thus depress their dry-matter intake, a fact which had been noted previously (King, 1983). The fundamental problem of water shortage in dry periods tends to discount the effectiveness of forage interventions specifically targeted to improve the nutrition of adult cattle in dry seasons. In contrast, because of their smaller size, improvements of forage and water resources for calves in dry seasons appear more feasible (Section 7.3.3.5: *Calf mortality mitigation*).

This ability to compensate for the ill effects of water restriction is significant for beef production and the recovery of cows to allow conception. However, the results obtained by Nicholson were probably positively influenced by conditions at Abernossa compared to the pastoral situation because of the high availability of forage at the and because the animals were apparently not corralled at night, which would allow them to forage when temperatures were cooler. Dry season standing crops may vary 10-fold between Abernossa and pastoral systems (D. L. Coppock, ILCA, personal observation), animals on the Borana Plateau are confined, for example nightly for about 11 hours (Belete Dessalegn, 1983). This suggests that compared to the pastoral situation, the animals may have lost weight more slowly in dry periods and while being able to recover more quickly in wet seasons. The biggest difference in animal response between the two systems may occur in dry periods. Assuming that forage quality is similar, cattle could probably have more opportunity to consume a higher quantity of forage during the first one or two days after watering compared to those grazing communal rangeland. Conversely, differences in animal response in the two systems may be less in rainy seasons, and this would depend more on differences in the quality and productivity of forage. Despite these points, however, it is clear that watering cattle once every three days is common during dry seasons on the Borana Plateau. Further study would be needed to assess the degree to which weight compensation by cattle is impaired under pastoral, as opposed to ranch, conditions.

Cattle watering once every four days was observed at some well groups on the Borana Plateau during the long dry seasons of 1988 and 1989, and this was reportedly due to a low volume of ground water in particular areas (D. L. Coppock, ILCA, personal observation). This variation with year may be related to the possibility that certain watersheds receive lighter precipitation during the long rains. In any case it supports comments by Alberro (1986: pp 34–35) that Borana cattle can be watered once every four days and are thus particularly tolerant to water deprivation, although as previously mentioned the relatively cool climate probably contribute to this through slower rates of dehydration (King, 1983). The Boran recognise that cattle need to be adapted to thr regime of watering every three days. They thus refrain from daily watering of calves in dry seasons even when sufficient water is available (D. L. Coppock, ILCA, personal observation). The role of water restriction in calf growth and the effects of small-scale water development for use by calves and households is reviewed in Sections 7.3.3.4: *The calf: Prospects for growth acceleration* and 7.3.3.5: *Calf mortality mitigation*.

Nicholson (1987a) concluded that overall effects of water restriction were negligible and recommended restricted watering practices particularly for ers. Significant benefits such as water use efficiency (30%), extension of grazing area (ninefold), forage conservation and savings of labour and/or fuel were noted from restricted watering. In one striking example, Nicholson (1987a) noted a potential annual savings of 1.9 million tonnes of water as a result of increased water-use efficiency by 800 000 cattle throughout the southern rangelands if they were all to go on a once every three days watering regime. Such advantages of water restriction probably outweigh most disadvantages to the Boran and are instrumental in helping a high density of both people and animals survive despite their being restricted to areas around the deep wells for a habitat (see Section 2.4.1.7: *Water resources*). In addition, implicit recognition that cattle can compensate for certain seasonal stresses such as water restriction is probably one reason why the Boran are apparently uninterested in supplementing the diet of cattle during dry seasons as long as the situation is not life threatening (see Section 4.4.4: *Traditional marketing rationale*).

Cossins and Upton (1988b: p 259) echoed the benefits of watering every three days and stated there were no apparent costs associated with the practice. While this may be true in terms of live weight loss and physical condition, the conclusion needs to be qualified with respect to milk yield, which is the key production parameter and of acute importance to the Boran in dry periods. Nicholson (1987a) noted that the reduced calf growth among the group watered every three days was indicative of a drop in milk production. The water turnover and weighing trials indicated that this reduction was about 13%. This is a considerable depravation for the calves, but the Boran obviously have the perspective that the interacting constraints of labour, water and forage outweigh this.

In a related eight-month experiment with four treatments not reported here, Nicholson (1987b) examined the interactive effects of corralling nightly and trekking to water once every three days on live weight and physical condition dynamics and activity budgets of growing and breeding cattle at Abernossa. The main effect of walking and corralling combined was to reduce grazing time by 40% when compared to control animals. Walking and corralling also depressed dry-matter intake but only 12% (compared to the controls), indicating that the restricted animals fed at faster rates when given the opportunity (Nicholson, 1987b). The overall effects of corralling and walking a total of 3040 km on animal response variables were interpreted to be small and overshadowed by the generally poor base level of nutrition, as reported earlier by Payne (1965).

Using calculations of maximum live-weight differences between walked and sedentary groups (20 kg) and the assumption that this live weight should contain 480 MJ GE (MAFF, 1984), Nicholson (1987b) calculated that the cost of walking was 0.6 KJ/kg/km, roughly one-third of the value reported by King (1983). Nicholson (1987b) speculated that this apparent energy saving may have been caused by walking adaptation, physical fitness and/or other energy-conserving mechanisms, but he also acknowledged that the true energy value of the lost live weight was unknown and involved complicated interpretation. The role of energy-sparing mechanisms in *Bos indicus* under stress has been dealt with by others (Ledger and Sayers, 1977; Western and Finch, 1986) but detailed and properly designed metabolic trials appear to be lacking. Nicholson (1987b) also commented that there was no evidence that walking caused dramatic declines in milk yield. This had been postulated by Sandford (1983a) as a likely energy trade-off with implications for improving the distribution of water points in a way that minimised travel. It is important to distinguish, however, whether the possible cause of such a trade-off is indeed energy allocation or merely foraging time and if productivity lost is because of walking. The latter is a simpler explanation as it is a more pervasive seasonal constraint for cattle in pastoral systems (Coppock et al, 1988). Once again the direct transferability of results to a pastoral system may be questioned here because of the superior foraging conditions on ranches. Further details on this point are available in Nicholson (1987b).

5.4.5 Cattle growth and implications for breed persistence

The question of poor adaptability of cattle from higher elevations when taken to the lowlands was raised in the analysis of Sarite cattle by Nicholson (1983b) and this may be relevant to whether or not highland genotypes could have a sustained influence on diluting the Boran breed in the rangelands. Borana herd owners have been noted to obtain highland cattle in their attempts to re-stock after droughts (Negussie Tilahun, 1984 cited by Mulugeta Assefa, 1990: p 19), and highland zebus are regarded as inferior compared to the Boran (Alberro and Solomon Haile Mariam, 1982a, b). The ability of highland stock to eventually dilute the Boran is a component of the debates regarding genetic conservation of superior indigenous breeds in relation to livestock development in Ethiopia (Alberro, 1986; G. Smith, former TLDP consultant, personal communication).

Based on preliminary growth data, Nicholson (1983b) hypothesised that cattle procured from higher elevations on the plateau were poorer performers in the warmer and drier lowlands. He also speculated that these animals were probably genetically related more to highland stock than to the Boran. If the growth data are considered indicative, it may be further speculated that long-term climate patterns (including droughts that induce high levels of stress and cattle mortality; see Section 6.3.1.1: *Livestock dispersal and herd composition*) may serve to keep highland genotypes out of much of the lower elevations of the southern rangelands on a sustainable basis. Research to test this hypothesis should precede any large investment in an attempt to conserve the Borana genotype from alleged dilution by highland breeds.

To sum up, when the vagaries of the southern rangelands are considered, performance of Borana cattle appears quite satisfactory. Results for production parameters, however, are only indicative and must not be regarded as static. As often noted, the environment is the supreme regulator of production here and this interacts with a dynamic population density that competes with cattle for resources. Wagenaar et al (1986: p 50) noted that only a detailed time series of data, systematically collected over many consecutive years, could provide the most useful insights into production dynamics and system function. All that was presented in this chapter has been a group of discrete studies, often difficult to compare with each other and impossible to compare with work conducted 20 to 35 years earlier.

Although hard evidence is lacking, it appears that the current population densities of both humans and cattle on the Borana Plateau may be the highest on record (see Section 7.2: *A theory of local system dynamics*). This may set the stage for more regular density-dependent influences on cattle productivity. This depends on climatic patterns and whether such key inputs as veterinary campaigns and manpower can be maintained. If it is assumed that veterinary and labour inputs improve or remain constant, a long period of average rainfall will allow the cattle population to reach and maintain a density where it impacts the environment and consumes forage reserves otherwise saved for droughts.

Under these conditions it can be expected that milk production, weaning weights, cow condition and calving rates will fall and calving intervals will increase. Heavy wet-season grazing could even impair the ability of cattle to regain weight lost during the dry season as a result of restricted watering. Some herd owners reported that lower milk yields and a reduced condition of cattle are already occurring as a result of heavy grazing in 1990, less than six years after the 1983–84 drought (D. L. Coppock, ILCA, unpublished data). On the other hand, if there is regular drought, this will kill animals, de-couple interactions to more of a density-independent situation, help preserve the environment and create years of high productivity per cow in drought-recovery years as a result of low competition for forage. These scenarios of variable environmental check on production parameters are supported by the observation that Borana cows managed under conditions at Abernossa have reproduction cycles occurring throughout the year (S. Sovani, ILCA, personal communication). This presumably is related to the low stocking rates and high standing crops of forage on the ranch as well as the stock being upgraded genotypes.

5.4.6 Small ruminants

General observations of small-stock management indicate that patterns of milking, herding, corralling and intensive rearing of kids and lambs practised by the Gabra and Borana are similar to many reported for elsewhere in sub-Saharan Africa (Wilson, 1988). Two notable differences may be the lower likelihood of Boran or Gabra milking sheep compared to goats (Cossins and Upton, 1988b: p 265) and the apparent lack of any breeding control. De Leeuw et al (1991) noted that the Maasai use breeding aprons in an attempt to control the seasonality of conceptions in small ruminants. In his review, Wilson (1989) commented that uncontrolled breeding systems typical of indigenous management are usually more productive than those on research stations where restricted breeding occurs.

Small ruminants comprise about 5% of the livestock biomass held by the average, eight-cow Borana family (Cossins and Upton, 1987: p 213). This is considerably less than the 15 to 25% range reported for small ruminants in other pastoral settings (Wilson, 1988). The mean age at first parturition for sheep and goats at Beke Pond (17.4 months) is near the average (17 months) for both species reviewed by Wilson (1989), but the mean birth interval of 7.7 months appears lower than that given by Wilson (10 months). Litter sizes on the Borana Plateau of (1 for sheep and 1.1 for goats) also appear to be slightly lower than those in Wilson's (1989) review of 1.38 (goats) and 1.16 (sheep).

The greatest constraint to small ruminant production in the Beke Pond area is apparently disease, which is in agreement with the assessment of Wilson (1988: p 324) for sub-Saharan Africa in general. Contagious caprine pleuropneumonia (CCPP) is reportedly the most pervasive disease of small ruminants on the Borana Plateau (Sileshi Zewdie, SORDU veterinarian, personal communication). In the past there has been no vaccine for CCPP manufactured in Ethiopia but it is anticipated that production will commence in the early 1990s (Sileshi Zewdie, SORDU veterinarian, personal communication). The lack of veterinary service for small ruminants in the SORDU project area today means they will continue to be high-risk species to produce, although the management costs are much less compared to cattle in terms of herding, milking and watering. To compensate for the lack of veterinary drugs some pastoralists reportedly use human antibiotics from clinics to treat illnesses of small ruminants. That special health programmes for small ruminants are hard to sustain is apparent from remarks by Hill (1982: p 5) who noted that mobile clinics for small ruminants and camels were routinely sponsored by the Ethiopian Government prior to 1980.

Perhaps the most important information collected to date on small ruminants on the Borana Plateau is from aerial surveys which indicated that numbers of sheep and goats were less affected by the 1983–84 drought compared to cattle in general (see Sections 6.3.1.1: *Livestock dispersal and herd composition* and 6.3.1.3: *Small ruminant productivity*). Small ruminants probably contribute to household income diversification and stability. They may also offer a higher rate of economic return compared to cattle (Cossins and Upton, 1988b). Browsing goats in particular use vegetation in a fashion that is complementary to grazing cattle (Belete Dessalegn, 1985; Coppock et al, 1986a; Woodward, 1988; see Section 3.3.5.1: *Livestock food habits*). Wilson (1988) noted a keen awareness regarding the value of small ruminants in rural African systems, and this is applicable here.

5.4.7 Camels and donkeys

Wilson (1984: pp 17–18) noted that the upper limit of the camel's habitat range is around 550 mm of annual rainfall, and that Islam is an important factor in its distribution. Observations on the Borana Plateau confirmed these points as camels are most abundant in the 650-mm rainfall zone and appear to become very rare some 75 km north of Yabelo where annual rainfall approaches 750 mm. Disease in these more mesic locations may be an important limiting factor (see below). In addition, the camel's presence further north is also restricted by there being other ethnic groups. The pockets of Muslim Gabra to the north, south and south-west of the study area have been instrumental in introducing camels to the Boran.

Many of the Gabra moved to various pockets on the Borana Plateau from the Kenya border during the conflict with Somalia in the late 1970s. The concentration of Gabra in the upper semi-arid zone near Yabelo is most likely due to their free access to the large communal ponds constructed in the 1960s (see Section 1.4.5.2: *Water development strategy)*. The Gabra are not allowed to have easy access to the traditional deep wells to the south that are the property of the Boran and therefore under their control. Ethnic conflicts in 1991 led to reported evacuation of Gabra from Borana-held territory (D.L. Coppock, Utah State University, unpublished correspondence). Wilson (1984: p 44) stated that Gabra camels of northern Kenya are typically small and compact in form. While this somewhat fits the description of the *geleb*, it does not describe the massive *quorti*. The *quorti* more resembles the Somali milk camel (Wilson, 1984: p 42). It is thus apparent that some diversification of camel holdings may have occurred among the Gabra.

Limited observations regarding camels indicate that their most common use by Borana and Gabra pastoralists is to transport grain, water, salt and other goods. They also have a critical role in milk production for the minority Gabra. The Borana, however, have insufficient numbers of camels to provide a meaningful supply of milk to their diets. A few Borana innovators have been observed using male camels to pull ploughs for cultivation.

Although limited in scope, data of Belete Dessalegn (1985) verifies the high milk yields and long lactation period of camels compared to cattle (1045 litres over 430 days), which is at the low end of the scale for camel milk production according to the review by Mukasa-Mugerwa (1981: p 61). Camels in East Africa may produce up to 2100 litres over an 18-month lactation (Dahl and Hjort (1976) cited by Mukasa-Mugerwa (1981: p 61)). Data from Coppock (1988) also illustrates that camels reportedly produced over 10 times more milk than cattle during the height of the 1983–84 drought (1 vs 0.095 litre/head/day; see Section 6.3.2.1: *Livestock*). Similar perspectives on the role of camels in improving stability of pastoral production systems have been reported by Coughenour et al (1985), Coppock et al (1986c) and McCabe (1987). The higher milk yields of camels are not only significant in terms of household milk consumption but also provided the Gabra with the chance to sell milk when prices were high so that they could buy grain (Coppock, 1988; see below).

Disease is reportedly the most important constraint of camel production in the Beke Pond region. Sileshi Zewdie (former SORDU veterinarian, personal communication) considered trypanosomiasis as the biggest threat to camels and he felt that infections are incurred by browsing along riverine location and during long-distance commercial treks out of the study area. Tick-borne diseases and skin infections are also prominent (Coppock, 1988). Today SORDU is unable to provide veterinary care for camels.

The Boran are very interested in acquiring camels but they often mention problems of cost and market access as major constraints in their attempts to procure them (see Section 7.3.3.2: *Camels, donkeys and small ruminants*). Other constraints may include low rates of reproduction (Wilson, 1984: p 136), the additional labour inputs required for their management and some peculiar aspects of biology such as inducible ovulation that requires management training (Wilson, 1984: p 84). Despite these obstacles, camels can play a more useful role on the Borana Plateau (Section 7.3.3.2: *Camels, donkeys and small ruminants*).

The very small population of donkeys and mules indicated from surveys is unexplained. This should receive more research attention in the future. It is possible that water shortage may be a factor in limiting the donkey population. Research in Kenya's arid zone, however, has demonstrated that donkeys perform adequately on a restricted-watering regime as well as on very poor quality forage (Coppock et al, 1986a, b; 1988). Another constraint on donkeys could be forage competition from numerically superior cattle (see Section 3.4.3: *Use of native plants*). If equines are restricted to graze in the vicinity of encampments, this may make them even more vulnerable to forage competition and hence to death during drought. The high loss of 60% of the equines during the 1983–84 drought attests to this situation (see Section 6.3.1.1: *Livestock dispersal and herd composition*). Donkeys could play a greater role in alleviating labour burdens on women (see Section 4.3.3: *The labour of married women*).

This chapter has reviewed some baseline features of livestock management and production in an attempt to provide a general perspective on the system. As will be shown in Chapter 7, however, the proper orientation is to view livestock production and management as potentially highly dynamic from year to year. Livestock production and management vary in terms of short-term cycles and long-term trends as defined by interactions of the cattle population with the environment. Integrated research and development perspectives are presented in Chapter 8: *Synthesis and conclusions*.

Chapter 6

Effects of drought and traditional tactics for drought mitigation

Summary

This chapter reviews the impacts of the 1983–84 drought on the Borana production system and outlines key tactics that households used in response to drought. A secondary objective is to highlight the effects of another drought in 1990–91 and interpret cattle population dynamics observed from 1982 to 1991 within an ecological framework of density-independent or density-dependent regulation of population size. Most of the empirical findings in this chapter are consistent with those in the literature on drought responses of pastoral populations in East Africa.

The 1983–84 drought was driven by rainfall deficits during four consecutive wet seasons over two years. Most research was conducted by monitoring five encampments in the central zone (i.e. lower semi-arid) where drought impacts were most severe. In terms of livestock management, an early response to the first failure of the long rains in April 1983 was to shift the ratio of resident herds to satellite herds from 71:29 to 34:66, respectively, within seven months. Many of the satellite herds (consisting of hardy immatures, dry cows and males) moved from central zones to drought-reserve areas at the periphery of the central plateau during the first year. These reserves were characterised either by an improved forage base plus reliable deep wells (as in the Web region) or by flushes of forage production stimulated by more frequent rainfall at higher elevations (as to the north of Did Hara).

Once these reserves were depleted, satellite herds began to endure higher rates of loss and moved off the central plateau during the second year to secure grazing in the southern Ethiopian highlands and northern Kenya. The net result was a reduction in cattle density in the study area on the order of 50% by 1985. Patterns for other livestock species are less well documented. Sheep and goat flocks may have travelled extensively in some situations during the drought, but overall they appeared to maintain their population densities in most locales compared to cattle during the drought. The small camel population appeared to increase during the drought by 45% and this was probably due to migration from adjacent regions.

The main effect of the drought on the production system was deminished cow nutrition due to reduced forage production. Compared to a dry season in an average rainfall year, the acute effects of the 1983–84 drought reduced daily milk offtake to an average household by 92% (i.e. from five litres/family per day to 416 ml/family per day). Eighty per cent of this decline was caused by a drop in calving rate from 75 to 9%, with the remainder contributed by a drop in daily offtake per lactating cow from 500 to 260 ml. However, a minor part of this milk deficit was made up by small ruminants at Borana encampments, as 60% of 200 female goats and 50% of 113 female sheep were lactating during the height of the drought.

Considered overall, human diets, normally dominated by cow's milk (55%) and cereals (32%) on a gross energy basis sufficient for maintenance and growth in average rainfall years, shifted to a situation during the drought in which cereals dominated (52%) compared to milk (14%) and meat and blood combined (2%), with an average per capita caloric deficit of 27%. Reported duration of acute hunger was 32 months from August 1983 to April 1986. People compensated for reduced food production by: (1) giving priority to young children to receive milk; (2) shifting diet composition for other age groups to include more cereals, meat and blood to accomodate the needs of children; (3) reducing the size and frequency of meals for adults and older youths; and (4) sending the elderly or other volunteers to famine relief camps as a last resort. Roughly 27% of surveyed households in 60 encampments changed location during the drought, but there was no evidence of mass migration. The general impression was that most people attempted to stay in one place and wait out the drought. Maize, sorghum, enset *(Ensete ventricosum)* and sugar were sources of food energy in the surveyed regions. Gathered bush foods (bulbs, fruits, gum and roots) assumed greater importance during the drought but still represented opportunistic sources of nutrients rather than staples. Hunting was not important. Cattle hides were reportedly boiled and eaten in some instances. Famine relief did not occur until late 1985 and thus was largely unimportant during the two years of low rainfall (i.e. 1983–84). Human diets began to improve rapidly with the onset of average rainfall in April 1985. Although morbidity in the human population was widespread during the drought, surveys indicated that the incidence of drought-induced mortality was low (i.e. <5%). About

18% of the population had moved to famine relief camps by 1985. In a survey of 48 families in the upper semi-arid zone, most families reported one birth during the drought, suggesting that the human population grew, although it did so more slowly than normal.

Besides dramatic declines in milk production, the other major effect of the drought was to reduce pastoral terms of trade by 90%. Pre-drought prices of EB 1.00 per kilogram of live weight for cattle declined to EB 0.30 by 1984. This was mirrored by an increase in maize prices from EB 0.40 per kilogram to EB 1.00 over the same time. Other important consumer goods and livestock species increased or decreased in price accordingly. Cereals were thus commonly available in markets, but their high cost relative to livestock cost reduced effective demand. Low livestock prices resulted from high supply and low demand, particularly in the second drought year. The strategy of families during the first year may have been to sell the same number of animals as in average rainfall years, but to use more of the income to purchase food grains (i.e. 66% versus 30% of income used to buy food). In contrast to the first year, animal offtake rates probably increased markedly in the second drought year in response to a much greater need for food. Although cattle were often reported to have been sold to buy grain near the end of the drought, livestock were not always mentioned as the most important sources of income. A peri-urban sample of 48 pastoral households in the upper semi-arid zone revealed that milk, household utensils, firewood and other bush commodities were more important than livestock as frequent sources of income. Credit was not available from merchants for food purchases. Temporary employment as labourers was secured by members of 27% of 43 peri-urban households in the upper semi-arid zone.

Loss of assets due to drought was high. Monitored cattle herds experienced a net loss on the order of 60% (N = 4143), with 42% lost to mortality, 14% to sale and 4% to slaughter. Losses occurred differentially depending on age and sex class. Researches hypothesise that cattle mortality occurs in distinct waves over time, with the most productive cows perishing earlier on. Cattle losses ranged from 40 to 90% of immatures, 45% of mature cows and 22% of mature males. Immatures were vulnerable owing to lack of milk and low mobility. Milking cows were vulnerable because of their higher nutritional requirements and the tendency to keep them nearer to overused encampment areas. Mature males were less vulnerable because of their general hardiness and high mobility. They were commonly sold to purchase grain. Small ruminants (N = 788) experienced a 16% mortality rate, with 15% sold and 7% slaughtered. Net reduction in this population throughout the drought was minimal, however, because births tended to balance losses. A survey of 96 Borana and Gabra households in the upper semi-arid zone indicated that the effects of ethnic group and household wealth were important factors in mitigating asset losses. Poor households tended to have lower producing cows than wealthier households. Poor Borana and Gabra households lost 52% of their cattle compared with 28% for wealthy households due to higher rates of mortality, sales and slaughter. Poor Gabra lost over 60% of their camels compared to an average of 40% for other Gabra wealth classes. There was thus no evidence that camels were any less susceptible to drought than cattle in terms of mortality in this instance. Key advantages in having camels, however, may lie more in terms of persistence of milk production for home consumption, and sale and use of male camels for transporting grain. Interviews in the upper semi-arid zone suggested that on average at the height of the drought, cows yielded a milk offtake of 140 ml/head per day over a lactation period of six months, while camels yielded 770 ml/head per day over nine months. The overall pattern of livestock use during drought suggests that animals were not held for quick disposal or sale during times of stress. Instead, they appear to be assets that are held as long as possible in anticipation of improving conditions. Families are apparently willing to undergo great hardship before they are forced to sell animals. This behaviour has significant implications for exacerbating the effects of drought on the population.

Owing to favourable rainfall from 1985 onwards, the mature-cow component of the regional herd had probably recovered in terms of numbers and productivity by 1989 (or even earlier); thus the impact of the 1983–84 drought was six years overall. Opportunistic cultivation of cereals by pastoralists during 1985–89 was an important means to ameliorate hunger, as were emergency feeding programs during 1985–87. However, deficient rainfall in 1990–91 again resulted in large losses of livestock, hardship for pastoralists and re-initiation of famine-relief activities. The cattle production system seems remarkably resilient, but density-dependent factors increasingly have negative effects on livestock populations and human welfare. In terms of cattle performance, the Borana system thus appears to be an equilibrial production system in which increased stocking rates raise the risk of negative impacts on animal mortality rates and productivity. A hypothesis is forwarded that the apparent increased frequency and severity of drought on the Borana Plateau is ultimately a consequence of the high and unsustainable density of people, and not a changing rainfall pattern. Traditional drought reserves are probably being increasingly compromised during normal rainfall years as a result of overflow human settlement and unregulated grazing. Opportunities for widespread dispersal of stock during drought are also becoming more limited as a result of general population increases in southern Ethiopia and northern Kenya. The human condition on the Borana Plateau has recently been disrupted further by weapons proliferation, ethnic clashes and marketing interruptions culminating from the demise of the previous government in 1990. Ethnic clashes, in part, are probably attributable to competition for increasingly scarce grazing and water resources.

6.1 Introduction

The mitigation of the effects of drought on pastoral populations in sub-Saharan Africa has received much attention in the literature (Wade, 1974; Charney et al, 1975; Hogg, 1980; Campbell, 1984; Sinclair and Fryxell, 1985; Moris, 1988). With few exceptions (e.g. McCabe and Ellis, 1987), the commonly held view is that traditional pastoral societies are increasingly unable to cope with drought, as indicated by large losses of herd capital, widening poverty and frequent famine. Traditional pastoral systems are thus thought by many to be in the process of gradual destruction through the combined effects of internal and external forces as exacerbated by drought. The primary objective of this chapter is to review information collected during and after the 1983–84 drought on the Borana Plateau in terms of livestock and human response and to compare the findings with those from other pastoral systems. A secondary objective is to highlight more cursory observations of the effects of the 1990–91 drought to determine whether cattle population dynamics in the Borana system during 1981–91 resemble equilibrial or non-equilibrial patterns (Ellis and Swift, 1988; Behnke and Scoones, 1991). An integrated perspective will be introduced in Section 7.2: *A theory of local system dynamics* in which the general effects of subsequent droughts on the Borana system can be predicted.

Before the 1980s, the last drought on the Borana Plateau occurred in the mid-1970s (Donaldson, 1986: p 28). In contrast to an isolated dry year, a drought is defined here as two or more consecutive years when rainfall [or length of growing period (LGP)] is less than 75% of the long-term average (see Section 2.4.1.4: *Climate, primary production and carrying capacity*).

The 1983–84 drought began with the long rains (April to June) in 1983 when precipitation was roughly 50% of the long-term average. This was followed by three consecutive rainy seasons with deficient rainfall: (1) the short rains in October and November 1983; (2) the long rains in 1984; and (3) the short rains in 1984. These wet seasons commonly had enough rainfall to green-up the rangelands for a short period of time, but new forage was quickly consumed (Donaldson, 1986: p 38).

In terms of rainfall, the drought ended during the long rains of 1985. The total period for which rainfall was below average was thus two years. Forage production was high and crops of maize were produced during the long rains of 1985 as an opportunistic means of recovery for the Boran (Cossins and Upton, 1988b: p 272). However, response lags in the food chain dictated that milk production would not significantly resume until April 1986 and that recovery of near pre-drought levels of milk offtake by people was probably delayed until 1988 (see Section 7.2: *A theory of local system dynamics*). Duration of acute drought impact on the production system was thus on the order of five years.

6.2 Methods

6.2.1 Effects of drought in the lower semi-arid zone

Negussie Tilahun (1984) provided a baseline description of Borana households for average rainfall years during 1981–82 (see Section 4.3.1: *General household structure and economy in average rainfall years*). This work was followed by another survey of 20 households conducted for 21 months from March 1984 to November 1985 coincident with the 1983–84 drought (Donaldson, 1986: p 28).

The families in the drought survey of 1984–85 were distributed among five encampments in three *madda* (Did Hara, Medecho and Melbana). During November 1984 to November 1985 data were collected weekly for 15 families; observations of family structure and food intake were recorded, and sources and amounts of cash income and expenditure elicited using questionnaires. For the diet study, one enumerator in each encampment recorded total food consumption for members of four families for 24 h/week (Donaldson, 1986: p 52). Amounts of each food consumed were estimated by calibrating appropriate household containers. Gross energy (GE) intake was quantified by multiplying dry-matter intake of each food item by its calorific value from nutritional tables (Donaldson, 1986: p 53). Daily requirements for GE were based on 10.6 MJ GE for an African Adult Male Equivalent (AAME), where a male >16 years of age=1 AAME; a female >16=0.8 AAME; and all youths ≤16=0.6 AAME (FAO, 1973, cited in Cossins and Upton, 1987:

p 120). Cossins and Upton (1988a) and Coppock and Mulugeta Mamo (1985) reported on human mortality during the drought based on samples of five and 60 encampments, respectively.

An important aspect of resource management is the use of resident (*warra*) and satellite (*forra*) cattle herds (Helland, 1980b). The former are dominated by milk cows, calves and yearlings, whereas the latter consist of dry cows, bulls, steers and others that do not produce milk but that are hardy and able to travel (see Section 5.3.1: *General aspects of cattle management*). The *warra/forra* system serves to reduce grazing pressure near wells and encampments by sending away animals that are not contributing to immediate subsistence needs (Helland, 1980b). One objective of the drought study was to examine the dynamics of *warra/forra* allocation. The age and sex structure and size of *warra* and *forra* herds were recorded at five encampments for eight months between November 1984 and June 1985 and research noted, why cattle were shifted from one herd to another and tallied all births, deaths, slaughters, sales and purchases. Age and sex structure and size of *warra* and *forra* herds were obtained for November 1983 (in the first dry year) using recall from the same herd owners (Donaldson, 1986: p 29). Description of drought dynamics of cattle dispersal and composition of cattle herds were based either on an average of 621 head (*forra*; four sample dates) and 509 head (*warra*; eight sample dates). Pre-drought data were based on several thousand head enumerated in a water-point survey during 1982 (Donaldson, 1986: p 29).

Detailed data on cattle allocation dynamics were supplemented with information from five aerial surveys conducted during March 1983, March and September 1984 and March and June 1985 (Milligan, 1983; Cossins and Upton, 1985: pp 138–142; Assefa Eshete et al, 1987). A follow-up, post-drought survey was conducted during July 1986 (Assefa Eshete et al, 1987). General aspects of the systematic reconnaissance flight (SRF) methodology were reviewed in Section 4.2.6: *Grain cultivation*. Results were combined from 1983–85 for surveys that had subtle differences in methodology. The main difference in methods between Milligan (1983) and subsequent surveys was that Milligan (1983) collated data according to *madda* and particular range units, whereas Assefa Eshete et al (1987) collated data in 1984–85 according to six regions distinguished by spatial and ecological criteria. Regions included Did Hara (2400 km^2) and Sarite (3125 km^2) to the north, Web (3200 km^2) and Gayu (3050 km^2) to the east, Medecho (1700 km^2) in the central region and Dilo (2000 km^2) to the west. These are depicted by Assefa Eshete et al (1987: map 1). Data collection of Milligan (1983) was expanded by Assefa Eshete et al (1987: p 4) to include visual estimates of per cent canopy cover for grasses, woody plants, crop cultivation, potentially arable landscapes and hardpan soil surfaces. This chapter will emphasise the effects of drought on population densities of cattle, small ruminants, camels, equines and people as derived from these surveys.

Milk cows are the critical group of animals to pastoralists, and as will be shown, they may be particularly vulnerable to drought (Donaldson, 1986). The subsequent recovery of the cow population after drought in several different regions was analysed by Cossins and Upton (1988a: p 124) using a standard-herd growth model (Upton, 1986b), with parameters for production features characteristic of average rainfall years in 1981–82 (Cossins and Upton, 1987: p 207). Actual recovery of the regional livestock population was assessed by Solomon Desta (nd) in a comprehensive census of animals using over 3000 water points throughout the SORDU sub-project area during five weeks in February and March 1987.

Milk offtake from cattle during the height of the drought was measured one day per week for five months from November 1984 to March 1985 for each lactating cow in the *warra* herds at the five *olla* (Donaldson, 1986: p 44). Offtake included milk from morning and evening milkings. Milk intake of calves was not measured. Heart-girth measurements were taken monthly on *warra* cattle of all age and sex classes during the same period and converted to live weight by the equation:

$$LW = e^{-8.88}(HG + 1)^{2.87}$$

where LW is live weight (kilograms) and HG is heart girth (centimetres) [from Nicholson (1983) cited in Donaldson, 1986: p 43]. Estimates of calving percentage from November 1984 to November 1985 were based on records for 176 cows of prime reproductive age at the five encampments (Donaldson, 1986: p 42).

Fewer studies were conducted on other livestock species. Milk offtake was monitored for 129 sheep and 197 goats one day per week from November 1984 to March 1985 at the five encampments (Donaldson, 1986: pp 53–55). A population of 788 goats and sheep were monitored at the five encampments for incidence of mortality, sales and slaughter from November 1983 through March 1985 (Donaldson, 1986: pp 127–128). Complete daily records of milk offtake were compiled for lactations for three camels over 14 months during 1983–84 (Belete Dessalegn, 1985). The camel data are reported in Section 5.3.7.2: *Camels*.

6.2.2 Effects of drought in the upper semi-arid zone

The effects of drought on the household economy of 96 sympatric Borana and Gabra families (48 each) in the Beke Pond area were evaluated using questionnaires in two separate surveys conducted in 1987 and 1989 (Coppock, 1988; Webb et al, 1992). The main objectives were to contrast how cattle owners fared in comparison to camel owners, and how families poor in livestock fared compared to those wealthy in livestock. Families were stratified into wealthy, intermediate and poor categories according to family size and reported livestock holdings before the drought (i.e. AAME/TLU ratio; where 1 TLU = 250 kg live weight (Jahnke, 1982); see Section 4.3.5.3: *Effects of distance to market, wealth and season on dairy marketing*). Livestock losses to mortality, sale and slaughter, and gains from births and trade were recorded for each family to quantify loss of pre-drought assets due to drought and post-drought recovery and were aggregated for each wealth strata. Comparative persistence of milk production in cattle, camels and small ruminants at the height of the drought was estimated from verbal recall estimates of the median number of reported lactating stock per household, lengths of lactation and daily milk yields calibrated using traditional containers. Human births, deaths and incidences of migration were recorded, as was reliance on famine relief, traditional social networks, other sources of food, employment, non-livestock assets and trade. Changes in reported livestock holdings and family size during drought were analysed using a factorial ANOVA blocked by ethnic group and stratified by wealth. Changes in livestock holdings were analysed on a percentage basis using SAS (1987).

6.2.3 Assessment of effects of the 1990–91 drought

The 1990–91 drought was again driven by several consecutive rainy seasons with deficient rainfall and had detrimental effects on the production system. Extensive field research by ILCA, however, had been terminated by 1990. Observations on the effects of this drought have therefore, been contributed as personal communications from SORDU and CARE-Ethiopia staff. Interviews of 30 Borana leaders in late 1989 (D. L. Coppock, ILCA; unpublished data; Coppock, 1992b) revealed important insights regarding the nature of cattle population regulation in the system, and these are reported here. Interview methods are described in Section 4.2.3: *Livestock marketing*.

6.3 Results

6.3.1 Drought effects in the lower semi-arid zone

6.3.1.1 Livestock dispersal and herd composition

Cattle herd dynamics at encampments

The following results are primarily based on monitoring that began with pre-drought cattle holdings of 4143 head in March 1982. The drought from April 1983 to March 1985 was characterised by cattle death and offtake from the pre-drought inventory as well as the birth of 650 calves that experienced very high rates of mortality. Results were compiled mainly from Donaldson's (1986) study. An earlier synthesis is reported in Cossins and Upton (1988a).

The initial effects of the drought were felt within a short time after the failure of the long rains in April 1983. An early response was to move a portion of *warra* animals to join *forra* herds (Donaldson, 1986: pp 33–34). Records on the dispersal of 289 head from *warra* to *forra* indicated that 91% of the animals were moved in response to a depleted base of local forage. While the net trend was for *warra* animals to move to *forra*, it is notable that cattle were occasionally moved back from *forra* to *warra* throughout the drought. From 817 records, cattle were returned to *warra* herds if local access to forage improved temporarily (57% of records), labour shortages occurred on *forra* (18% of records) or when animals had become weakened and required hands-on care by the householder (15% of records).

The drought was characterised by a relatively rapid shift of *warra* animals to *forra* early on. The pre-drought allocation of 71% of all cattle to *warra* and 29% to *forra* in 1982 (N=4143) had shifted to 34% (*warra*) and 66% (*forra*) by November 1983, only seven months into the drought. Subsequent shifts were minor; the peak allocation to *forra* was 69% by November 1984. Within three months after average rainfall returned in April 1985, the *warra:forra* allocation had shifted back to 45:55. Data collection was terminated at this time.

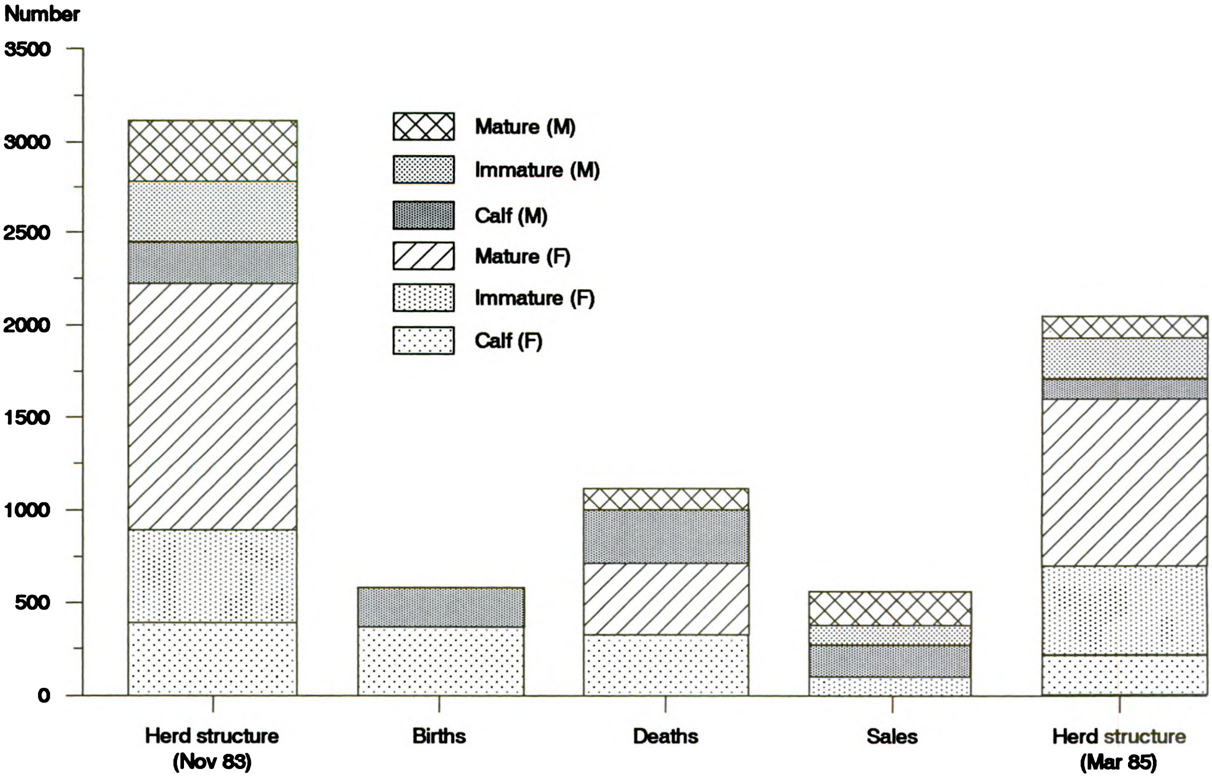
As a result of shifts in cattle allocation between *warra* and *forra*, parturition and differential rates of sex and age-specific mortality and offtake and the sex and age composition of *warra* and *forra* herds also changed in a dynamic fashion (Donaldson, 1986: pp 29–31). The pre-drought structure of *warra* herds (N=2941) was 51% mature cows, 8% mature males, 6% immature males (1–4 years old) 10% immature females (1–4 years old) and 25% calves of both sexes (<1 year old). Nineteen months into the drought (i.e. by November 1984) this had changed to 52% cows, 3% mature males, 15% immature males, 28% immature females and 2% calves (*N*=323). The composition of *warra* herds became similar to that for pre-drought holdings by June 1985, although the numbers of animals had decreased significantly (see below). For *forra* herds the pre-drought composition (*N*=1201) was 38% cows, 15% mature males, 26% immature females, 9% immature males and 12% calves. This shifted to 34% cows, 8% mature males, 38% immature females, 17% immature males and 3% calves by November 1984 (*N*=913). Overall dynamics for *warra* and *forra* herds are shown in Figure 6.1.

Estimates of cattle mortality were based on records of individual animals at the five *olla* commencing in November 1983. Although this study neglected the first seven months of the drought, animal losses should be expected to be lower during this time compared to those occurring during the ensuing 17 months. Thus, based on a total herd size of 3493 cattle in November 1983 plus 650 calves born between November 1983 and March 1985 a total of 1738 animals subsequently died giving an overall drought-induced mortality rate of 42%. Mortality rates for various age and sex classes were as follows: (1) calves, 443 of 777 or 57%; (2) immature females 196 of 728 or 27%; (3) immature males, 225 of 511 or 44%; (4) mature cows, 791 of 1759 or 45%; and (5) mature males 83 of 368, 22%. Mature cows constituted 45% of the 1738 cattle deaths followed by calves (25%), immature males (13%), immature females (11%) and mature males (6%).

Donaldson (1986: pp 77–78) derived cattle mortality rates for 10 age and sex classes in a drought year based on observed herd structure changes in 1984. For females categorised as mature (i.e. four years old), 3–4, 2–3, 1–2 and <1 year old, he calculated annual mortality rates of 20, 10, 5, 10 and 90%, respectively. For males in the same age classes he calculated annual mortality rates of 7, 5, 5, 10 and 90%.

The death of 78 cattle in the *warra* and *forra* herds was witnessed, and the leading cause of death for adult cattle was speculated to be starvation (67%); mortality rates were probably higher for lactating cattle under severe nutritional stress (Donaldson, 1986: pp 39–40). The leading causes of calf mortality were speculated to be starvation and the interaction of poor nutrition with diarrhoeal diseases (Donaldson, 1986: p 40).

Figure 6.1. *Herd structure in early drought (1983), at the end of drought (1985) and sources of change for cattle held by five Borana encampments in the central zone of the Borana Plateau.*



Source: Cossins and Upton (1988a).

Based on data of Donaldson (1986), Cossins and Upton (1985: pp 141–143) noted that cattle mortality appeared to occur in "waves" and a depiction of this is shown in ILCA (1986: p 25). The most vulnerable adults were postulated to have died during December March 1984 less than a year after the drought commenced and this was followed by smaller peaks in July October 1984 and December–March 1985. This pattern is also reflected in calf mortality data (ILCA, 1986: p 25). Cossins and Upton (1985: pp 142, 144) hypothesised that the most productive animals died in the first couple of waves and the net result was a smaller population of hardy, but less productive, cows by June 1985. Some support for this hypothesis comes from Mulugeta Assefa (1990: pp 1–26) who recorded three classes of milking cows recognised by the Boran. In cow-history questionnaires he found that the highest producers were commonly regarded as being most susceptible to drought (see Section 5.4.2: *Cattle production*). The best explanation for this hypothesis is that higher-producing animals are more susceptibile because their higher nutritional requirements are more quicky compromised.

Cattle were also sold to purchase grain and occasionaly slaughtered. Roughly 584 of 4143 animals, or 14%, were reportedly sold. These were mainly older stock. Another 158 mature males were unaccounted for, and these were presumably sold or slaughtered. Based on herd structure analysis by Donaldson (1986: pp 77–78), offtake rates for females in a drought year were estimated to be 5% for those 2–4 years old, with no offtake for other age classes. For males, he estimated that 35% of mature males were taken off, followed by 20% and 10% of those 3–4 and 2–3 years old, respectively. The total reduction of inventory not attributable to mortality was on the order of 18%.

In sum, total herd inventory was reduced by around 60% from the combined effects of mortality, sale and slaughter. Importantly, such dramatic losses of animals may not be representative for the study area as a whole, as these study *olla* were primarily located in the central zone, which was among the worst-hit regions (Donaldson, 1986: p 30).

Regional dynamics of livestock populations

Aerial survey results combined for all regions of the 15 475-km² study area from 1983 to 1985 are shown in Tables 6.1 and 6.2 and demonstrate large species differences in the maintenance of population density on the plateau during drought. These data suggest that cattle density declined by 54% from March 1983 to the end of the drought in March 1985 and

Table 6.1. *Cattle population dynamics in a 15 475-km² study area in the southern rangelands, 1983–85.*[1]

Region	Sample date									
	March 1983		March 1984		Sept 1984		March 1985		June 1985	
	Number	(%)[2]	Number	(%)[2]	Number	(%)[2]	Number	(%)[2]	Number	(%)[2]
Northern										
Did Hara	64 775		47 083		79 292		23 408		42 117	
Sarite	38 925		31 158		50 533		26 250		36 675	
Total	103 700	(41)	78 241	(34)	129 825	(49)	49 658	(42)	78 792	(35)
Eastern										
Web	31 492		49 759		52 333		9108		56 025	
Gayu	60 592		61 083		33 583		29 617		41 133	
Total	92 085	(36)	110 842	(48)	85 916	(33)	38 725	(33)	97 158	(43)
Central										
Medecho	28 292	(12)	18 192	(8)	28 358	(11)	10 933	(9)	23 892	(10)
Western										
Dilo	31 958	(12)	21 958	(9)	18 250	(7)	19 275	(16)	26 579	(12)
Total	256 034		229 233		262 349		118 591		226 421	
Per cent[3]	100		89		102		46		88	

1 Figures derived from Systematic Reconnaissance Flights (SRF). See text for methods.

2 Percentages in columns indicate the relative breakdown of the cattle population by region on any given sample date.

3 Percentages in this row used March 1983 as the baseline.

Source: Cossins and Upton (1985).

Table 6.2. *Population dynamics of small ruminants (sheep and goats) in a 15 475-km² study area in the southern rangelands, 1983–85.*[1]

Region	Sample date									
	March 1983		March 1984		Sept 1984		March 1985		June 1985	
	Number	(%)[2]	Number	(%)[2]	Number	(%)[2]	Number	(%)[2]	Number	(%)[2]
Northern										
Did Hara	9717		19 725		56 800		32 392		25 021	
Sarite	6225		4708		9667		4458		8275	
Total	15 942	(16)	24 433	(27)	66 467	(32)	36 850	(35)	33 296	(35)
Eastern										
Web	28 016		9367		37 017		3625		18 442	
Gayu	24 525		19 858		12 108		28 942		18 550	
Total	52 541	(54)	29 225	(33)	49 125	(24)	32 567	(31)	36 992	(38)
Central										
Medecho	10 192	(11)	12 500	(14)	28 958	(14)	15 175	(14)	17 053	(18)
Western										
Dilo	18 900	(19)	23 417	(26)	62 925	(30)	21 025	(20)	8696	(9)
Total	97 575		89 575		207 475		105 617		96 037	
Per cent[3]	100		92		212		108		98	

1 Figures derived from Systematic Reconnaissance Flights (SRF). See text for methods.

2 Percentages in columns indicate the relative breakdown of small ruminant populations by region on any given sample date.

3 Percentages in this row used March 1983 as the baseline.

Source: Cossins and Upton (1985).

subsequently recovered to 88% of the 1983 numbers by June 1985. In contrast, the small ruminant population appeared less affected in a negative fashion. Cossins and Upton (1985: p 139) noted that flocks may have immigrated to the plateau during the drought. Compared to 1983, camel numbers (from a base level of around 4000 head; dynamics are not tabulated) increased by 46% during the drought and returned to 94% of pre-drought numbers by June 1985. This was probably also owing to migration of camels into the study area (Cossins and Upton, 1985: p 139).

The lack of agreement between cattle losses observed at the household level of resolution versus net changes observed by aerial survey is unexplained. Cattle losses for households, however, were recorded for encampments in the hardest-hit regions. Migration of cattle from adjacent areas may also have influenced the aerial survey results.

Another comparison of livestock populations between 1982 and after one year of post-drought recovery in 1986 is provided in Table 6.3. These data are interpreted to indicate that the net change in population due to drought was on the order of minus 24% (cattle), plus 7% (small ruminants), minus 38% (camels) and minus 60% (equines).

In their analysis of regional data, Cossins and Upton (1985: pp 138–142) noted the redistribution of remaining cattle within the plateau during drought. *Forra* cattle were dispersed to the periphery of the plateau during the first year of drought; subsequent population declines in these regions during the second drought year likely indicated that many animals died and/or were moved out of the study area entirely. Donaldson (1986: p 32) reported that *forra* cattle ranged as far north as the southern Ethiopian highlands and as far south as Marsabit in Kenya. Cossins and Upton (1988a: p 127) noted that up to 75% of *forra* herds had moved off the central plateau during 1984. Numbers in Did Hara (to the north-east) increased from 65 000 head in March 1983 to 79 000 head by September 1984 and declined to 23 000 head by March 1985. Similar temporal patterns, respectively, were evident for Web to the east (31 000, 52 000 and 9000 head) and Sarite to the north-west (39 000, 51 000 and 26 000 head). The initial flow of animals in March 1983 was likely from the central

Table 6.3. *Contrast of livestock populations in a 15 475-km² study area in the southern rangelands during the pre-drought 1982 and post-drought 1986 periods.*[1]

Category	Sample date			
	June 1982[2]		July 1986[3]	
	Number	Per cent[4]	Number	Per cent[4]
Cattle	324 267	74.4	247 507	68.3
Sheep/goats	101 825	23.3	109 225	30.1
Camels	7558	1.7	4692	1.3
Equines	2450	0.6	999	0.3

1 Figures derived from Systematic Reconnaissance Flights (SRF). See text for methods.

2 Data from Milligan (1983).

3 Data from Assefa Eshete et al (1987).

4 Percentages calculated on per-head (not livestock-unit) basis.

Source: Assefa Eshete et al (1987).

zone (Medecho), the west (Dilo) and the south-east (Gayu) as these zones experienced linear declines in livestock populations as the drought progressed (Cossins and Upton, 1985: p 139). The attraction of these regional *forra* areas probably lay in the availability of forage and water, particularly in the case of Web which has many reliable wells. Scattered rain to the north in Did Hara during the middle of the drought in September 1984 attracted cattle herds (Cossins and Upton, 1988a: p 126).

6.3.1.2 Cattle productivity

Cow productivity is primarily a function of herd calving rate, the calving interval and individual milk production (Mukasa-Mugerwa, 1989). Seasonal weight dynamics and conditions can also be useful performance indices. All these production aspects were profoundly affected by the low level of nutrition caused by drought.

Donaldson (1986: p 41) noted from cow-history interviews that the calving interval for 61 cows in four encampments was at least 18 months during the drought, about 20% longer than the pre-drought value of 15 months. Calving percentage (the proportion of cows that produce a calf per year) declined dramatically however, from 75% before the drought to 9% (15 of 176 cows) during the drought (Donaldson, 1986: pp 22, 42).

The percentage of lactating cows averaged 20% (36 of 176) during the second year of the drought, considerably lower than the 75% in average rainfall years (Donaldson, 1986: pp 22, 42). Average daily milk offtake per cow during the height of the drought (based on four daily milk-yield measurements of 36 cows per month) dropped from about 500 ml/head/ per day from November 1984 through January 1985 to about 260 ml/head per day in March 1985 just before the drought ended (Donaldson, 1986: pp 43–44).

Compared to the total daily milk offtake for an average family in the dry season of an average rainfall year (i.e. about five litres/family per day), daily offtake during the worst time of the drought was reduced by about 92% (i.e. about 416 ml/family per day). This calculation assumes that an average, eight cow family in an average rainfall year has six lactating animals (Cossins and Upton, 1987: pp 207, 213) and that each cow has an offtake of about 830 ml/head per day in the warm dry season (Nicholson, 1983a: p 21). The low calving rate during the drought suggests that only 1.6 cows were lactating. The drop in offtake of 4584 ml/family per day is thus mostly due to the drop in calving rate (accounting for 80% of the decline in milk offtake), with the reduction in yield per cow accounting the remaining 20%. It is difficult to generalise too broadly, however, as regions varied in terms of drought impact on milk production. Other calculations of drought impact on milk production are provided in Donaldson (1986: p 47).

Donaldson (1986: pp 42–43) reported monthly live-weight dynamics, based on heart-girth measurements, of eight age and sex classes of cattle during the last five months of the drought through the end of the long rains in June 1985. Mature cattle (275 to 325 kg in December 1984) lost 11 to 14% of their live weight by April, but regained most of this by June. Young calves (averaging 27 kg from December to January) lost about 20% of their weight by April, but also regained it quickly after the rains. Paradoxically, immature animals 1–4 years of age appeared either to grow slowly or maintain their weight over the same period (Donaldson, 1986: p 43).

6.3.1.3 Small ruminant productivity

This is reviewed by Donaldson (1986: pp 53–54) and Cossins and Upton (1988a: pp 127–128). Based on an initial population of 788 goats and sheep (63% goats) at five encampments in

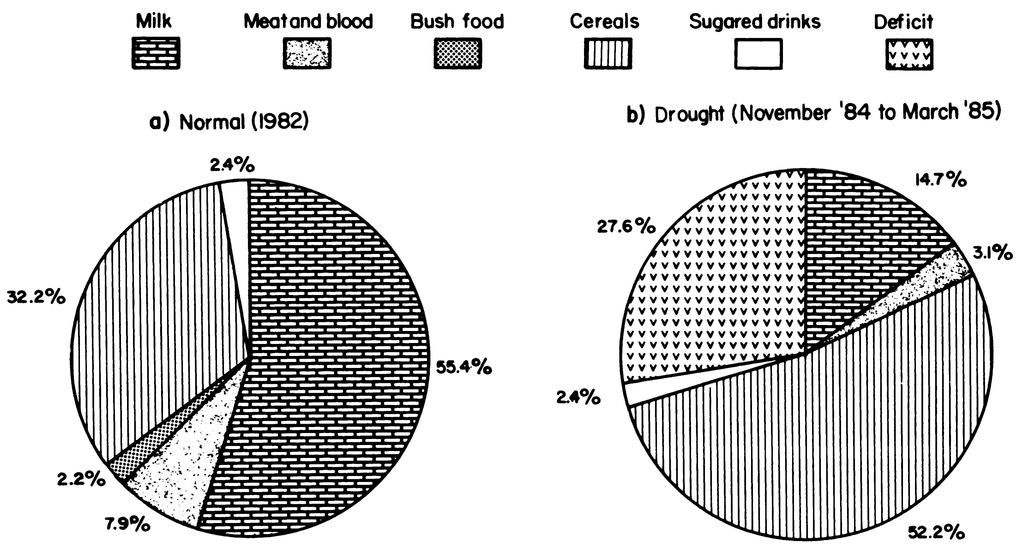
November 1983, small ruminant mortality during the next 18 months was relatively low with an average rate across both species of 16% (126 total). About 15% were sold and 7% were slaughtered. The net reduction in flock size by March 1985, however, was only 3%, suggesting that about 275 animals were born or otherwise acquired during the drought. Roughly 60% of the 200 mature female goats were lactating during the height of the drought (i.e. November 1984 to March 1985), versus about 50% of the 113 mature female sheep. Although sheep are not milked and goat's milk provides little more than a dietary supplement for children under average rainfall conditions (see Section 5.3.7.1: *Sheep and goats*), during the height of the drought the importance of these products increased (Cossins and Upton, 1988a). Mean milk offtake from goats ranged from 4.4 to 6.3 litres/head per month while for sheep it was 2 to 5.3 litres/head per month. The total daily yield of 28 litres/day from 177 small ruminants provided from 10 to 16% of total food needs on a gross energy basis in encampments in the central region, but only two to three per cent of that elsewhere (Cossins and Upton, 1988a: p 128).

Because of their small numbers, camels were not significant food producers in the five Borana encampments studied in the lower semi-arid zone. However, as will be described, camels were important milk producers for the Gabra in the upper semi-arid zone.

6.3.1.4 Human diet and mortality

A comparison of the aggregate human diet (on an energy basis) for an average household before (*N*=20) and at the height of the drought (*N*=20) is shown in Figure 6.2 a,b. These estimates are based on food intake values of individuals who lived in encampments and thus do not include *forra* herders, whose diet would have higher proportions of bush foods and cattle products such as blood (Cossins and Upton, 1988a: p 129). In contrast to the pre-drought diet dominated by milk, the drought diet was composed mostly of grain and was substantially below minimum daily energy requirements (Figure 6.2a,b). Thus, purchased grain only partially compensated for the drop in milk consumption (Cossins and Upton, 1988a: p 130). Consumption of meat and blood increased in absolute terms during the drought and occasionally these goods provided up to 40% of the daily energy intake for adults. Many animals died far from encampments and could not be retrieved, so wastage of meat was probably significant (Cossins and Upton, 1988a: pp 129–130). Consumption of blood is rarely reported in household surveys in average rainfall years (D. L. Coppock, ILCA, personal observation). During the height of the drought, however, Donaldson (1986: pp 47–48) reported that about 7% of *warra* and 28% of *forra* cattle were bled monthly and yielded around 2000 litres of blood in total for human diets. Both male and female cattle were bled.

Figure 6.2 (a,b). *Composited average diets on a gross energy basis for 20 Borana household in: (a) pre-drought 1982; and (b) during the height of the 1984–85 drought.*



Source: Cossins and Upton (1988a).

Donaldson (1986: pp 52–53, 85–86) and Cossins and Upton (1988a: p 130) noted that children under five years old received milk on a priority basis during the drought. In addition, it was speculated that adults restricted their food ration and altered their diet to permit these children to have what they needed. This is illustrated by Donaldson (1986: p 85) who found that the gross energy (GE) total daily intake for children under five years (=10.96 MJ GE; *N*=18 individuals each observed for 20 days) was 54% higher compared to that for four groups of older youths and adults (=7.14 MJ GE; *N*=18 individuals per group with each observed for 20 days). Children under five also appeared to receive the highest percentage of their dietary energy from milk (40%) and this steadily declined to 33, 13, 7 and 4%, respectively, for youths aged 6–10, 11–16, adult males and adult females. Consequently, across the same sequence the per cent grain consumed increased from 56% to 62, 82, 83 and 83%, respectively. Older family members had more diverse diets to help them compensate for a restricted intake of milk. Adults consumed more meat and blood (7% of GE intake for both sexes) and sugared tea (5% of GE intake for both sexes).

During the last six months of the drought, milk and grain constituted about 21 and 72%, respectively, of the average diet for the five sex and age classes and the mean daily-energy intake was 7.9 MJ GE. Energy intake increased and diet composition shifted rapidly after the drought ended. From April to June 1985 the average GE intake per person increased by 26% (to 9.99 MJ GE); milk made up 59% of the total, while grain declined to account for 25% of energy intake (*N*=1080 person observation days; Donaldson, 1986: p 85). During the cool dry season from July to September 1985 average energy intake (8.78 MJ GE) declined again by 13% compared to the wet season, milk dropped to account for 41% of energy intake and grain rose once again to account for 54% (*N*=1080 person observation days; Donaldson, 1986: p 86).

Cossins and Upton (1988a: p 130) reported that, on an annual basis, about 5% of the human population at the five encampments died during the 18 months of observation and that most of these persons were elderly. It is unclear, however, what proportion of these deaths was directly attributable to famine. Coppock and Mulugeta Mamo (1985) in a survey of 60 encampments in the same region reported that only one person apparently died in each encampment as a result of hunger. They also reported that local movement of families on the central plateau was significant; an average of four out of 15 households per *olla* (or 27%) left their encampment to search for grazing and food elsewhere. Human morbidity levels were assessed during the drought surveys. It is speculated, however, that incidence of morbidity was high.

6.3.1.5 Household economy

The general picture presented thus far indicates that the Boran experienced a dramatic shortfall of milk during the drought and a major response to this was to increase the purchase of grain through priority sale of male animals. The reported cash budgets for 15 families were recorded during the last five months of the drought and are summarised by Donaldson (1986: pp 50–51) and Cossins and Upton (1988a: pp 128–129).

From November 1984 to March 1985 the mean cash income from products sold for each household was EB 384, with 62% derived from cattle, 8% from other stock (probably small ruminants or poultry) and 30% from milk, butter, hides, handicrafts and other miscellaneous items. All this money was reportedly spent, with 43% used to purchase grain followed by sugar (10%), clothing (10%), other foods and beverages (13%), other items (7%); 17% was unaccounted for. Donaldson (1986: pp 13–14) noted that a household budget in an average rainfall year of EB 570 (for 12 months) was spent mostly on clothing (38%), followed by grain (17%), sugar (7%), other food and beverages (7%) and other goods (16%), savings accounted for 16%. It was noted that the expenditure on food at the height of the drought was 66%, considerably more than during the average rainfall year (30%). Donaldson (1986) speculated that absolute and relative food expenditures increased as milk production declined. Goods such as clothing were obviously given lower priority in a drought year. Trade-offs in budget priorities, expenditures and animal offtake occur among average, dry and drought years (Cossins and Upton, 1988a: p 125). Routine animal sales in an average rainfall year provide funds for clothing, food and miscellaneous items (see Section 4.3.1: *General household structure and economy in average rainfall years*). In an isolated dry year the same number of animals may be sold, but income is used primarily to buy food. This results in a temporary drop in living standards. During drought, however, the increase in animal deaths and in animal sales necessary for the purchase of the minimum amount of food have short and long-term effects on the household. Changing economic terms of trade between grain and livestock in different types of rainfall years also have a significant effect on pastoral welfare (Cossins and Upton, 1988a).

During a multi-year drought economic strategies vary each year. Cossins and Upton (1988a: p 129) noted that, during the first drought year (1983), the Boran were able to maintain their energy intake by selling the routine number of animals and spending most of their income on grain. However, during the second drought year of 1984, sales of all livestock had to be increased by 0.75 to 1.25 head per person, with about 70% of this consisting of cattle.

With a deficit in milk offtake of over 90%, the main survival option for the Boran is to trade animals and animal products in the market place for grain to secure adequate energy. Donaldson (1986: p 15) and Cossins and Upton (1987: p 213) noted that the price for cattle during pre-drought 1981–83 was around EB 1/kg live weight versus EB 0.40/kg for maize. Assuming 5.4 MJ GE/kg for livestock (Cossins and Upton, 1987: p 213) and 15 MJ GE/kg for maize (Holden, 1988), livestock cost EB 0.19/MJ GE whereas grain costs about EB 0.03/MJ GE. Selling 1 kg of live weight at 5.4 MJ GE thus yields money to purchase around 38 MJ GE of energy as grain. At 10.6 MJ GE/day required for one AAME, 1 kg of live weight would provide sustenance for about half a day, versus about 3.5 days for the monetary equivalent in grain. Thus, the availability of grain at favourable terms of trade enables a higher number of people to subsist than if they lived off of livestock alone (Donaldson, 1986: p 15; Cossins and Upton, 1988a: p 128). This simple relationship also explains why animals are not routinely slaughtered for food.

The decline in terms of trade between livestock and grain during the 1983–84 drought was documented by Donaldson (1986: pp 49–50) and Cossins and Upton (1988a: pp 128–129). After one year of drought the dramatic increase in number of cattle marketed and reduction in local demand forced cattle prices down from about EB 1/kg in November 1982 to EB 0.30/kg in March 1984. Over the same period grain prices rose from EB 0.40/kg to EB 1/kg (Donaldson, 1986: pp 49–50). Prices for other commodities such as sugar and coffee also increased (Cossins and Upton, 1988a: p 128). The terms of trade for grain:cattle calculated in Megajoules general energy (MJ GE) therefore fell from a pre-drought value of 7:1 to 0.8:1 at the height of the drought in mid-1984, a decline of nearly 90%. Terms of trade were more favourable between dairy products and grain, as pre-drought market prices for butter (EB 3.67/kg) and milk (EB 0.4/litre) increased by 300 and 250%, respectively, in 1984 (Cossins and Upton, 1988a: p 128). Few families, however, had reliable access to markets or sufficient milk to benefit from this option (Cossins and Upton, 1988a: p 128–129).

6.3.1.6 Post-drought recovery of cows

Cossins and Upton (1988a: p 124) used a herd growth model (Upton, 1986b) with parameters for cattle production levels during years of average rainfall (Cossins and Upton, 1987: p 207) to predict the length of time required for the mature cow class to regain their numbers after the 1983–84 drought. Drought mortality for cows in different regions was calculated from data of Donaldson (1986) and yielded rates of 25% (north) to 35% (east) and 50% (central). Assuming a series of average rainfall years post-drought, the model predicted that complete recovery in cow numbers would take from six years in the north to nine and 14 years in the east and central regions, respectively.

The modeling assessment by Cossins and Upton (1988a) was probably too conservative. Some results from Solomon Desta (nd) are shown in Table 1, Annex F, as they are the most comprehensive data on livestock populations ever collected in the southern rangelands. Results were interpreted by Solomon Desta (nd) to show that the cattle population was well on the way to full recovery from drought as early as 1987. This was confirmed by interviews of Borana leaders who contended in 1989 that the cattle population had already recovered from drought and was again vulnerable to future perturbation from a year of below-average rainfall (D. L. Coppock, ILCA, unpublished data; see Section 7.2: *A theory of local system dynamics*).

6.3.2 Drought effects in the upper semi-arid zone

6.3.2.1 Livestock

In a combined survey of 96 households by Coppock (1988) and Webb et al (1992), pastoral households in the Beke Pond region were divided into economic classes on the basis of reported TLU/AAME ratio before the 1983–84 drought. For camel-keeping Gabra the groups were defined as: (1) wealthy (i.e. having a ratio >5; *N*=13); (2) intermediate (2< ratio ≤5; *N*=20), and (3) poor (ratio ≤2; *N*=14). For cattle-keeping Boran, the groups were defined as: (1) wealthy (ratio >9; *N*=11); (2) intermediate (4< ratio ≤9; *N*=22); and (3) poor (ratio ≤4; *N*=14).

Reported livestock holdings across all wealth classes were distinct between ethnic groups before the drought. The average of 22.6 TLUs held by the Gabra (3.86 TLU/AAME) were composed of an even balance of cattle (50%) and camels (47%), with a few small ruminants (3%). In contrast, the average of 36.1 TLUs held by the Boran (6.56 TLU/AAME) were dominated by cattle (93%), with a few small ruminants (6%) and an occasional camel (1%). These figures suggest that the Boran in this sample were wealthier in animal holdings than the Gabra. Reportedly in possession of far more animals in the mid-1970s, these Gabra claimed to have been impoverished as a result of warfare and relocation from the Moyale area during the conflict between Ethiopia and Somalia in 1978–79 (Coppock, 1988: p 4; Hodgson, 1990). The following are notable points from the analysis.

Cattle: Based on a reported pre-drought population of 3144 head, 1066 (or 34%) were lost during the drought as a result of mortality, sale and slaughter when calculated across all 96 households. Out of these 1066 head, 759 (or 24% of the pre-drought number) died, 136 (or 4% of the pre-drought number) were sold and 171 (or 5% of the pre-drought number) were slaughtered. Wealth had a significant effect on cattle losses. Overall, the wealthy lost 28%, the middle class lost 35% and the poor lost 54% (P<0.001). Because the wealth classes differed in absolute numbers of cattle before the drought (i.e. from 53 head for wealthy Boran to four and 13 head for poor Gabra and Borana households, respectively), the absolute impacts were greater on the wealthy. Compared to the wealthy and middle class, the herds of the poor experienced greater losses from mortality (i.e. 30% versus an average of 23% for the others; P<0.001), slaughter (i.e. 9% versus an average of 5%; P=0.02), and sales (15% versus an average of 3%; P<0.001). The poor also lost more mature cows overall (i.e. 39% versus an average of 29%; P=0.002). Ethnic group was an important factor. The Boran lost relatively more cattle than the Gabra overall (i.e. 36% versus 28%; P=0.03), but the Boran held roughly 3.5 times more cattle per household before the drought (i.e. an average of 51 versus 15 head).

Small ruminants: Based on a reported pre-drought population of 530 head, 135 (or 25%) were lost during the drought as a result of mortality, sale and slaughter when calculated across all 96 households. Of these 135 head, 108 (or 20% of the pre-drought number) died, 21 (or 4% of the pre-drought number) were sold and only six (or 1% of the pre-drought number) were slaughtered. There were no apparent effects related to ethnic group or wealth class in the breakdown of these data. This was attributable to the consistently small number of small ruminants held per household and high variability in the data.

Camels: Based on a reported pre-drought population of 933 head, 436 (or 47%) were lost during the drought as a result of mortality, sales and slaughter when calculated across all 96 households. The vast majority (i.e. 90%) of camels were held by the Gabra. Of these 436 head, 391 (or 42% of the pre-drought number) died, 35 (or 4% of the pre-drought number) were sold and 10 (or 1% of the pre-drought number) were slaughtered. Wealth had a significant effect on camel losses. Overall, the wealthy lost 26%, the middle class lost 32% and the poor lost 44% (P<0.001). Because wealth classes differed in numbers of camels held before the drought (i.e. from 19 head for wealthy Gabra to 6 for poor Gabra, respectively), the absolute loss in assets was greater for the wealthy. Compared to the wealthy and middle classes, the herds of the poor experienced relatively higher losses from mortality (i.e. 64% versus an average of 40% for the others; P<0.001) and slaughter (i.e. 4% versus an average <1%; P=0.04). Sale data were equivocal among wealth classes.

These data provide evidence that drought has a differential impact on the herd assets of various wealth classes. In relative terms, the poor appeared to be hardest hit. There was no evidence, however, that herd assets of the camel-keeping Gabra were affected much differently from those of the cattle-keeping Boran. The advantages of having camels during a drought relate probably more to grain-transport capability, milk production for household consumption and sale in urban markets (see below). The apparent vulnerabilty of camels to drought, despite their seemingly abundant browse resources, may have been exacerbated by disease (Section 5.3.7.2: *Camels*).

6.3.2.2 Human welfare

The reported duration of hunger ($\bar{x}$±SE) was consistent among all wealth classes of both ethnic groups (32±0.5 months; N=48; Coppock, 1988: p 4). People reportedly started to experience hunger by August 1983 (five months after the first failure of the long rains in April and May), and the hunger ended by April 1986 (i.e. one year after the return of average precipitation). Movement of people into or out of the area was apparently minimal. A net gain of six people for 48 families was calculated based on reported migration during the drought (Coppock, 1988: p 7). There were no human deaths reported as resulting from hunger. Paradoxically, family size actually increased for both Boran and Gabra households largely from births. The average Borana family size of 7.42 before the drought increased to 8.46 after the drought, the net result of an average of 1.21 births, 0.25 deaths, 0.04 departures and 0.08 immigrants (N=24). A similar pattern was evident for the Gabra. The pre-drought average family size of 8.29 increased to 9.42 by the end of the drought, the net result of 1 birth, 0.04 death, 0.04 departure and 0.13 immigrant (N=24).

During the height of the drought, Borana families (N=8 per wealth class) reported median numbers of lactating cattle and milk yields as: (1) 18.6 cows each giving 177 ml of offtake for a total of 3.29 litres/household per day (wealthy); (2) 6.4 cows each giving 154 ml of offtake for a total of 0.99 litre/household per day (intermediate); and (3) three cows each giving 95 ml of offtake for a total of 285 ml/household per day (poor). Median reported lengths of lactations ranged from 7.1 months (wealthy) to 6.4 months (intermediate) and 3.9 months (poor). All families reported a negligible amount of daily milk offtake from small ruminants or from the very few camels (Coppock, 1988: pp 9–12).

During the same period, Gabra families (*N*=8 per wealth class) reported median numbers of lactating camels and milk yields as: (1) 4.3 camels each giving 1 litre of offtake for a total of 4.3 litres/household per day (wealthy); (2) 1.9 camels each giving 620 ml of offtake for a total of 1.2 litres/household per day (intermediate); and (3) 1.3 camels each giving 700 ml of offtake for a total of 880 ml/household per day (poor). Median reported length of lactations ranged from 10 months (poor) to 8.7 months (intermediate) and 7.4 months (wealthy). Gabra families also reported receiving total offtakes of: (1) 700 ml/household per day from four cows (wealthy); (2) 400 ml/household per day from two cows (intermediate); and (3) 116 ml/household per day from one cow (poor). The Gabra reported that they received a negligible amount of milk from small ruminants during the height of the drought (Coppock, 1988: pp 9–12).

Priority foods for adults or children (Coppock, 1988: pp 14–15) were similar between both ethnic groups and thus were composited for the final analyses shown in Tables 6.4 and 6.5. Particularly noteworthy was the high reliance on false banana (*enset* or *quocho* (*Ensete ventricosum*)) by adults and use of powdered milk for children. False banana was procured from trade with farmers in the adjacent southern highlands and was probably not readily available in other regions of the central plateau.

Table 6.4. *Common food items for adults during drought as ranked by 46 Borana and Gabra households in the Beke Pond region in the southern rangelands in 1987.*[1]

Number	Mean rank[2]	Item
1	1.66 *x*	Maize grain
2	2.68 *x*	Enset
3	4.54 *y*	Tea
4	5.55 *yz*	Sorghum grain
5	6.04 *z*	Tea + milk
6	6.08 *z*	Milk
7	6.12 *z*	Sugar
8	6.15 *z*	Wild "onion"[3]
9	6.16 *z*	Wheat grain

1 Derived from household interviews. Foods were listed and ranked from most common (1) to least common (9). Ranks by ethnic groups did not appreciably differ.

2 Entries accompanied by the same letter *(x, y, z)* were not ranked differently (P>0.05).

3 Bulbs of *Vigna vexillata*.

Source: Coppock (1988).

Table 6.5. *Common food items for young children during drought as ranked by 48 Borana and Gabra families in the Beke Pond region in the southern rangelands in 1987.*[1]

Number	Mean rank[2]	Item
1	2.05*x*	Porridge (grain + milk/water)
2	2.69*x*	Milk
3	3.51*xy*	Tea
4	4.89*y*	Tea + milk
5	4.89*y*	Enset
6	4.9*y*	Powdered milk
7	5.0*y*	Sugar

1 Derived from household interviews. Foods were listed and ranked from most common (1) to least common (7). Ranks by ethnic groups did not differ appreciably.

2 Entries accompanied by the same letter *(x, y)* were not ranked differently (P>0.05) according to Friedman's test (Steel and Torrie, 1980).

Source: Coppock (1988).

During the height of the drought in 1984, only two of 44 families reported receiving relief grain (Coppock, 1988: p 18). Famine relief did not reach the study area in large quantities until late 1985 (D. L. Coppock, ILCA, personal communication) so it can be inferred that much of the powdered milk referred to in Tables 6.4 and 6.5 was probably purchased in local shops. Famine relief was delayed, in part, because of the emergency famine situation in the highlands (RRC, 1985). The majority of sample households at Beke Pond had gained access to famine relief, Food-for-Work and donated agricultural inputs by 1986 (Webb et al, 1992). Pastoralists at Beke Pond, however, were probably better off than most in the study area because of their proximity to Yabelo town and the main tarmac road.

Except for the wild onion, bush foods did not appear to rank as important compared to foods produced in the home or purchased in the marketplace. Eight common foods from native vegetation are listed in Table 6.6. Hunting was not mentioned as a viable option. Animal hides were reportedly boiled and eaten on occasion (D. L. Coppock, ILCA, unpublished data). Consumption of blood by Gabra households but not by Borana households was reported by Webb et al (1992).

For both Borana and Gabra households, trends suggested that milk, mainly from camels (Gebra) or cattle (Boran), was the most important item for market (Table 6.7). Natural gum from trees, household utensils, firewood and charcoal rounded out priority items for sale. Opinion was unanimous that no credit was available from merchants during the drought for purchasing food. Interestingly, livestock did not appear in these ranking exercises, suggesting that livestock were not primarily held for sale to purchase food during drought (see Section 4.3.4.7: *Marketing attitudes).*

Only 4 of 23 Gabra households had a member who found employment during the drought, while 9 of 24 Borana households were able to do so

Table 6.6. *Wild plant material reportedly used as food during drought as ranked by 20 Borana and Gabra households in the Beke Pond region in the southern rangelands during 1987.*[1]

Number	Mean rank	Vernacular	Latin name	Edible portion
1	4.95*x*	*Singo*	*Vigna vexillata*	Bulbs
2	5.38*x*	*Buri*	*Mimusops kummel*	Fruit
3	6.63*xy*	*Medera*	*Cordia gharaf*	Fruit; gum
4	6.82*xy*	*Fulesa*	*Acacia drepanolobium*	Gum
5	7.1*xy*	*Ogomdi*	*Grewia*	Fruit
6	8.63*y*	*Chame*	*Vigna* sp	Roots
7	8.65*y*	*Kakalla*	*Ceropegia* sp	Roots
8	8.65*y*	*Gora gel*	*Capparis tomentosa*	Fruit

1 Bush foods ranked from highest (1) to lowest (14) in importance during drought. Mean rank values followed by the same letter (*x, y*) were not significantly different (P>0.05) according to Friedman's test. Vernacular is Borana Oromigna. See also Table B7.

Source: Coppock (1988).

Table 6.7. *Important items produced for sale during drought as reported by 24 Borana and 24 Gabra households in the Beke Pond region in the southern rangelands in 1987.*[1]

Boran			Gabra		
Number	Mean rank[2]	Item	Number	Mean rank[2]	Item
1	3.17*x*	Cow milk	1	3.18*x*	Camel milk
2	4.0*x*	Gums	2	6.37*xy*	Firewood
3	4.93*x*	Utensils	3	7.35*xy*	Utensils
			4	7.87*xy*	Gums
			5	8.18*y*	Charcoal

1 Derived from household interviews. Items were listed and ranked from most important (1) to least important (9). Gums are extracts from trees. Utensils included hand-carved pots, stools, milk churns and ornate walking sticks. That Gabra could transport firewood and charcoal to market may have reflected use of camels. Milk sales were important because these households lived within 30 km of the town of Yabelo.

2 Entries within the same column that are accompanied by the same letter (*x, y*) were not ranked significantly different (P>0.05) according to Friedman's test (Steel and Torrie, 1980).

Source: Coppock (1988).

(Coppock, 1988: p 17). All jobs were taken by men between the ages of 20 and 60. Jobs included pond digging, road maintenance, farm labour, urban construction and tree planting. Duration of employment averaged 29 days for the Boran and ranged widely from 12 days to 10 months for the Gabra (the 10-month job was working on construction in the town of Moyale). Wages varied from Food-for-Work (i.e. 2.75–4 kg grain per day) to EB 1.50–3.00 per day.

Webb et al (1992) reported that during the drought pastoralists at Beke Pond assisted each other to a higher degree than did to highland farmers. Sixty-one per cent of pastoral households (*N*=48), versus 41% of farming households, commonly borrowed money or food from neighbours and relatives, and 90% of the pastoral households reported that this networking occurred to a greater degree during the drought than during years of average rainfall. Ninety per cent of pastoral households reported no internal conflicts over resource allocation; the few problems included disputes over water rights. External altercations occurred between the Boran and agropastoral Gujji to the north, when the Gujji attempted to move livestock into the Beke Pond area (Webb et al, 1992).

6.3.3 Drought effects in 1990–91

During interviews with 30 Borana leaders during September 1989, many expressed a concern that the cattle density was high enough so that the production system was again vulnerable to a year of below-average rainfall (D. L. Coppock, ILCA, unpublished data). One key insight from respondents was the observation that the average to above-average level of rainfall received during the long rains of 1989 had been insufficient in eliciting "normal" rates of milk production or compensatory growth in cattle recovering from the 1988–89 dry season. This was interpreted as suggesting that the cattle population density had grown to the extent that forage competition among cattle was acting as a major force and that this would have repercussions for cattle survival in the coming dry season of 1989–90. Indeed, during the 1989–90 dry season at least 15 000 head of cattle reportedly died in the ILCA study area as enumerated in extensive surveys by SORDU (unpublished data). This was interpreted to be a density-dependent population response in an average rainfall year, with more of a "fine-tuning" character in which about 5% of the cattle population died. In contrast, no significant cattle die-off had occurred since the second drought year in 1984.

The Borana leaders also expressed concern about maintaining the integrity of traditional drought reserves (D. L. Coppock, ILCA, unpublished data). According to respondents, drought reserves surrounding large well systems to the east had been recently subjected to unrestricted grazing in dry seasons of average rainfall years and were also the focal points for new settlements. This, in part, was a reflection of seasonal forage deficits in support of a high density of cattle and dwindling settlement options for larger numbers of people. Depletion of the forage in these reserves would then restrict use by *forra* cattle during the first year of a drought and perhaps lead to a more precipitous decline in the cattle herd.

There are no formal data available to document the effects of the 1990–91 drought, but it was reported that losses of cattle were on the order of 50% of pre-drought holdings (C. Fütterknecht, CARE-Ethiopia, personal communication). The short rains of 1992 were also deficient and led to more deaths of immature cattle (C. Fütterknecht, CARE-Ethiopia, personal communication). Part of this massive cattle die-off had been speculated to be related to the coincidence of drought with an epidemic health problem, but this has not been confirmed (C. Schloeder, Ethiopian Wildlife Conservation Organisation, personal communication). Emergency feeding for the Boran was re-instated by CARE-Ethiopia in 1991 and is expected to continue into 1993; 100 000 people were receiving food aid in November 1992 (C. Fütterknecht, CARE-Ethiopia, personal communication). Problems for people were compounded by proliferation of weapons resulting from the demise of the previous government in June 1990. Numerous and violent clashes among a half dozen ethnic groups have been reported, including skirmishes between the Gabra and Boran and the Garri and Boran (C. Fütterknecht, CARE-Ethiopia, personal communication; Eshetu Zerihun, ILCA, personal communication). Lack of vehicles and fuel in 1990–91 also hindered delivery of food relief and cut market linkages between the southern rangelands and southern highlands. Local farmers in the rangelands were observed to deplete their seed reserves and prices for maize reportedly exceeded EB 6/kg the highest price in recent times (C. Fütterknecht, CARE-Ethiopia, personal communication).

6.4 Discussion

6.4.1 Drought impacts on livestock

Compared to the dry season in an average rainfall year, the net production impact of the 1983–84 drought on Borana households found by Donaldson (1986) was a 92% reduction in milk offtake for human consumption due to a 90% reduction in the number of cows in milk and a 65% reduction in offtake per lactating cow. The major effect was on calving percentage owing to poor nutrition. Around 60% of the pre-drought inventory of cattle was lost due to mortality (largely cows and immatures) and from the sale of males and other followers to purchase grain. Drought-related animal losses appeared to vary according to region (Cossins and Upton, 1988a). It is assumed that calves are highly vulnerable because of restricted milk supply and immobility. Milk cows may be more vulnerable owing to the energy demands of lactation and because they are kept near encampments where forage is commonly depleted. Prime cows are often the last animals to be sold because of their high future production value and pastoralists retain them in the hope that the next rainy season will be good (Coppock, 1992b).

The lower death rates for males is a testament to their value as a risk-mitigating investment (de Leeuw and Wilson, 1987). Seemingly non-productive, mature male cattle held in large numbers have been traditionally regarded by pastoral development agents as a commodity of little apparent value (D. L. Coppock, ILCA, personal observation). This view is inappropriate, however, given the high value of males for offsetting asset losses during drought and as item to trade for cows during post-drought recovery on the Borana Plateau (see Section 5.4.5: *Cattle growth and implications for breed persistence*).

Small ruminants appear to have fared better than cattle during the 1983–84 drought. In part this is probably because of their lower absolute nutritional requirements and mixed food habits that include drought-resistant browse (see Section 3.3.5.1: *Livestock food habits*).

There was no evidence that camel mortality rates were appreciably lower than those for cattle in the Beke Pond area. There was evidence that camels were superior to cattle in terms of maintaining milk production. Such conclusions, however, must be tempered in light of the accuracy of verbal recall data. Overall, there is some support for these findings concerning drought impacts on livestock from the literature, but researchers also suggest that there may be significant system-specific differences in response to drought.

The marked loss of cattle and the apparent greater susceptibility of cows and immatures to starvation and disease during droughts has been variously reported for other pastoral systems in East Africa in the 1980s. Rodgers and Homewood (1986) found a net 52% loss of cattle among the Maasai in semi-arid Tanzania, a 75% loss of lactating cows and a 20% decline in calving rate. Homewood and Lewis (1987) working in semi-arid Baringo, Kenya, revealed regionally variable loss of cattle, sheep and goats during the first nine months of drought that averaged 50% overall for each species. In the next four months of drought per cent loss of remaining animals was less than one-half or one-third of that for the first period for cattle and smallstock overall, and there was also evidence that some herds had begun to recover. Calving rates ranged from 70 to 90% before the drought, but declined to 64 to 77% during the drought; these relatively high rates may be related to the moderate density of stock in the study area before the drought. A case study revealed that cow mortality was 62%, with 88% for calves <1 year old (Homewood and Lewis, 1987). The percentage loss of cattle for a given region during the first nine months of drought was positively correlated ($P<0.01$) with cattle density at the start of the survey, suggesting that density-dependent factors were operating. This relationship was not found for small ruminants (Homewood and Lewis, 1987). In a study of five Turkana herd owners in very arid northwest Kenya, McCabe (1987) calculated net drought losses of 63% for cattle, 45% for camels and 55% for smallstock. Most of these animals died of starvation and disease. Calving rates declined to 24% for cattle at the peak of the drought and lactating cows were particularly vulnerable to starvation. Male cattle were depleted as a result of slaughter and sale to purchase grain. Relatively more small ruminants than cattle or camels reportedly died of starvation and this was attributed to their reduced mobility in this patchy, arid environment. Fratkin and Roth (1990) noted that camel keepers tended to lose fewer stock than keepers of cattle or small ruminants among the Ariaal of arid Kenya. Grandin et al (1989: p 256–258) reported for Maasailand in semi-arid Kenya that household cattle herds declined by over 40% on average as a result of drought and most of these deaths were caused by nutritionally mediated diseases. Cows and immatures ≤1 year of age died most readily while older immatures and adult males had the highest survival rates. Aside from an outbreak of Nairobi sheep disease which reduced some flocks, small ruminants were largely unaffected by drought compared to cattle and played valuable roles as food and marketable commodity (Grandin et al, 1989). The situation observed by Grandin et al (1989) seems to be similar to that for the Boran and this may be related to general similarity in the semi-arid environment and production systems between the Kenya Maasai and the Boran (see Section 4.4.2: *Economic comparisons among pastoral systems*).

That the cattle herds in the southern rangelands may have recovered from drought much more quickly than predicted from computer models is not surprising. Herd growth rates on the order of 10% per annum have been observed in favourable situations elsewhere (see review in Mulugeta Assefa, 1990). Assuming that cow mortality rates reported by Donaldson (1986) and Cossins and Upton (1988a) were accurate the discrepancy probably stems from two main issues. First, the models used production values for an average rainfall year in 1981–82. It is now known, however, that although 1981–82 was a time of average rainfall, it was also a time of high stocking rates and these high stocking rates probably reduced cow productivity through forage competition (see Section 7.2: *A theory of local system dynamics*). Therefore, actual calving rates in 1985–87 during the time of average rainfall but lower cattle density could have been markedly higher than the 75% recorded in 1981–82. Second, in post-drought periods the Boran reportedly actively trade mature males for milk cows from the southern highlands. Although these cows may be somewhat less durable over the long term than the range-adapted Boran (see Section 5.4.5: *Cattle growth and implications for breed persistence*), they may give the system a considerable boost when resource availability is high. It is this practice of trading for presumably inferior highland genotypes that has led to official concern about dilution of the valuable Boran breed (see Chapter 8: *Synthesis and conclusions*).

6.4.2 Wealth effects on herd losses

That drought has a greater impact on the assets of poor Borana and Gabra households compared to those of the middle and wealthy classes has been reported for other groups. Grandin et al 1989 (pp 256–258) found that the wealthy Maasai had a net loss of 40% of cattle holdings (range 18 to 60%), while the poor lost 70% (range 30 to 90%). Fratkin and Roth (1990) also noted that the 1984 drought exacerbated wealth differentiation among the Ariaal of arid Kenya. Despite large animal losses the wealthy tended to remain so while the middle class and poor became poorer. Although the need for poorer households to sell or slaughter a higher percentage of stock than the wealthy is straight forward and is because of lower per capita food production among the poor, it is less clear why the herds of the poor should have higher mortality rates. Sperling (1989) speculated that the herds of wealthier households should have lower mortality rates because the animals would be milked less intensively and thus have more body reserves to endure stress. She also noted that the wealthy can better afford veterinary care and may distribute their animals to a greater extent during drought than poorer households.

The findings of Grandin et al (1989) and Fratkin and Roth (1990) were interpreted to indicate that the strategy of attempting to maximise herd size so as to increase the likelihood that they will survive in the system after drought is valid. Although the wealthy suffer larger absolute losses compared to their poorer counterparts, they usually retained a sufficiently large nucleus herd to rebound in an efficient manner while the poor may lose enough to be pushed out. This is also a valid hypothesis for the motivations of the Boran, who reportedly desire large cattle herds (Coppock, 1992b). Their stated primary motivation for cattle accumulation, however, is to accrue social and economic status and not to mitigate drought (see Section 4.3.4.7: *Marketing attitudes*). Importantly, most of the Borana pastoralists have only livestock assets to buffer them from drought, in contrast to the farmers who can sell assets such as farm implements and personal effects in addition to animals when in dire need of cash (Corbett, 1988; Webb et al, 1992).

6.4.3 Decline in terms of trade

The decline in terms of trade between live animals and grain observed by researchers in the central region of the Borana Plateau equates to a 70% reduction in the monetary value of cattle, a 150% increase in the price of grain and 90% net loss in pastoral purchasing power. This may represent the worst local terms of trade on the plateau, as cattle losses in the central region were the highest reported (Cossins and Upton, 1988a: p 124).

Solomon Desta et al (nd) recorded prices for livestock products and cereals in five to seven markets throughout the southern rangelands during March and April 1984 when the drought was entering the second year. They compared these findings to pre-drought prices and found that, overall, cattle prices declined by 26 to 45% and grain prices increased from 20 to 103%. In contrast, the price of milk and butter (which by the middle of the drought were in very short supply) increased by an average of 142%. Price changes over the same period for animals were –40% (bulls), –38% (heifers), –30% (steers), –46% (cows), –34% (goats) and –35% (sheep). Detail price changes for cereals were +86% (maize), +82% (sorghum), +42% (teff), +57% (barley) and +45% (wheat). For animals these data can be interpreted as suggesting that cows suffered the greatest relative fall in price, possibly because of their increased vulnerability to drought. No prices were reported for calves and it is likely that supply was small and there was no effective demand. Somewhat surprising was the large drop in small ruminant prices which belies the notion that they would maintain their market value during drought because they could persist better in the local environment. There were no prices reported for camels. Although some Boran probably wanted to have milk camels at this time, there may not have been sufficient demand for these animals which normally cost at least twice as much as cows (see Section 4.3.4.6: *Prices*). The Gabra may also have restricted the flow of camels to market. It has been reported that if a Gabra were forced to sell a camel, his peers would try to assist him so he would not have to sell, or would ensure the camel was purchased by a wealthier individual and kept within the Gabra clan network (Coppock, 1988). Thus, except for small quantities of milk and butter, the majority of pastoralists had no animal resources that did not drop markedly in value during the drought. Dairy sales may have been very important in peri-urban locations during this period as they partially substitute for live animals sales in average rainfall years (Holden and Coppock, 1992). Paradoxically milk is commonly sold in time of milk scarcity because favourable terms of trade permit the purchase of a survival ration of energy in the form of grain (see Section 4.4.10: *Dairy marketing*). Regional differences may have given some pastoralists an advantage in procuring cheaper sources of carbohydrate compared to grains. Households in the upper semi-arid zone near Beke Pond commonly mentioned that *enset* (or false banana) was cheaper than maize during the drought (D. L. Coppock, ILCA, unpublished data).

In summary, patterns observed here support the axiom that a decline in pastoral terms of trade is a consequence of drought (Toulmin, 1986: p 2; Moris, 1988: p 291). More severe drought situations have been reported elsewhere in East Africa where grain is only sporadically available and in these cases pastoralists are commonly unable to procure grain regardless of the low value of their livestock (Sperling, 1989).

6.4.4 Traditional drought-mitigation tactics

As one of the first management responses to deficient rainfall, the dispersal of cattle from home-based *warra* herds to satellite *forra* herds is an attempt to expand grazing area in relation to a decline in net primary production (Donaldson, 1986: Cossins and Upton, 1988a). Herd segregation and reliance on fallback regions or drought reserves is a common traditional response to drought in African pastoral systems (McCabe, 1983, 1987; Homewood and Lewis, 1987; Moris, 1988; Grandin et al, 1989; Sperling, 1989). As on the Borana Plateau, cattle and camels are usually widely dispersed while small ruminants tend to be kept nearer to home areas (McCabe, 1987; Homewood and Lewis, 1987; Grandin et al, 1989). Moris (1988) noted the reduction in traditional fallback areas owing to population growth and land alienation, and the threat this poses to pastoral drought endurance and subsequent recovery. Grandin et al (1989: pp 258–259) considered improved management of fallback areas in terms of tick and disease control as a research priority to reduce cattle losses during drought. The overall pattern of use by the Boran of internal fallback areas at the periphery of the plateau during 1983, and of external areas in the southern Ethiopian highlands and northern Kenya during 1984, suggests that constraints on use of fallback areas will be affected differently by internal and external forces. The use of fallback areas for settlement and unregulated grazing by the Boran is potentially dangerous as cattle herd crashes could occur if fallback areas are not "reclaimed". High population growth rates among neighbouring peoples (exceeding 3% per annum in many cases (EMA, 1988)) along with a proliferation of weapons suggests that use of external fallback regions will be more constrained in future. This loss of fallback areas may constitute the most immediate threat to growth and sustainability of the Borana system (see Chapter 8: *Synthesis and conclusions*).

At the household level, Donaldson (1986), Cossins and Upton (1988a), Coppock (1988) and Webb et al (1992) observed that internal adjustments by the Boran in response to restricted resources included the following tactics (1) Youths were dispersed for *forra* herding, which decreased food demand at encampments; (2) young children were given priority to receive milk while older youths and adults consumed more grain, meat, blood and other commodities; (3) more income was allocated to food purchases, along with attempts made to diversify income-earning activities, intensify social networking, and increase efforts to collect bush food and consume other unusual food items; (4) older adults voluntarily received restricted food rations; and (5) some older individuals emigrated to famine relief camps. At the encampment level, 27% of the households in 60 encampments moved locally in response to drought, but no mass migrations were observed (Coppock and Mulugeta Mamo, 1985). Opportunistic cultivation of maize was commonly observed as a post-drought response in 1985 to compensate for a lag in milk production (see Section: 4.4.1.1: *Pastoralism and cultivation*).

Most of the adjustments listed above have been observed in other pastoral systems. That the milk-dominated diet of pastoralists is subsidised with nonpastoral grain and an increased use of such ancillary pastoral foods as blood, meat and native plant material during drought is well known (Ellis et al, 1986; Sperling, 1989). Sperling (1989: p 269) noted that use of collected forage has declined among the Samburu in the last few decades because of loss of land, livestock pressure and purchased grain which has gradually replaced these items in the diet. Traditional knowledge of foraging has thus been lost to a large extent and taste preferences have moved towards grain. One example of the effects of livestock pressure is the use of dry dehiscent acacia fruits. Before the 1940s these fruits were a dry-season staple while today they are allocated only as a critical dry-season feed for livestock (Sperling, 1989: p 269). Dessalegn Rahmato's (1987) study of farmers in Wollo, Ethiopia, during the 1984–85 famine (cited in Corbett, 1988: p 1104–1105) noted a reduction in: (1) food variety and quality and (2) number of daily meals. Finally, the need for pastoralists to seek employment or engage in otherwise unusual economic activities during drought is also common (Campbell, 1984; Mortimore, 1987; Hay, 1986; see Section 4.4.1.1: *Pastoralism and cultivation*). Gifting and social networking among pastoralists is frequent and regarded as a social tactic to ameliorate risks; networking may increase among households during times of stress (Campbell, 1984; Galvin, 1985; Nestel, 1985).

There does not appear to be much literature on food allocation within pastoral households during drought. It is thus unclear whether the Borana practice of buffering young children and sacrificing elders is unusual or not. One implication of this practice, however, is that children less than five years of age may not be a suitable group to monitor in nutrition or anthropometric surveys that seek to detect indicators of famine onset or drought recovery (D. L. Coppock, ILCA, personal observation).

Human response to drought can be characterised as a hierarchy of adjustments over time. Corbett (1988: pp 1107–1108) proposed a framework for subsistence farmers which consists of three major stages:

1) Insurance stage: households first attempt to buffer themselves by selling small ruminants or other "less essential" and more readily replaceable animals, reducing food demand; collecting wild foods; conducting inter-household transfers of assets and loans; increasing production of "petty commodities" for sale; migrating in search of employment; and selling personal possessions.
2) Crisis stage: households then begin to dispose of productive assets which may include larger, more durable livestock such as cattle; sell agricultural tools; seek credit; and initiate further reductions in food demand.
3) Distress migration stage: people embark on mass migrations in search of food. This is a stage at which numerous deaths can occur.

Based on this model and observations in 1983–84, it is hypothesised that, on average, pastoral families in Borana probably spent most of the drought in the insurance stage, with the crisis stage encountered only when households were forced to sell prime cattle or camels, commonly during the second drought year. There was no distress migration stage in Borana during 1983–84 (Webb et al, 1992). In contrast to Borana, drought impact in the Ethiopian highlands commonly appeared to elicit distress migration among farming peoples (RRC, 1985). It is likely that, simply because of a lower number and diversity of livestock holdings, poor pastoralists entered the crisis stage considerably sooner than the middle class or wealthy. A third consecutive year of drought would probably elicit a distress-migration stage in the Borana system. An analysis of the numbers of animals the various wealth classes would need to sell to endure two- and three-year droughts is reported in Section 7.3.3.7: *Mitigation of drought impact.*

As discussed in Section 4.4.4: *Traditional marketing rationale*, the Boran appear to sell cattle mostly when they have an acute need for money. Their ultimate goal is not income generation but animal accumulation for status. They thus try to endure periods of stress so they do not have to make a "withdrawal" from their pool of herd capital. That households with marketable animals restrict food intake and undergo other severe hardships during drought (Webb et al, 1992) is hypothesised to be a manifestation of this behaviour. When given no other income-generating option, the Boran reportedly prefer to sell mature male cattle because the gross income received allows them to purchase food plus replacement calves; and thus attain two goals, namely commodity procurement and herd building. Because of a lower diversity and number of cattle, the poor are often forced to sell more immature cattle which permits only commodity procurement. Diversification of the traditional economy into small ruminants and cultivation, in part, reflects attempts to substitute other products and food-procurement activities for sales of cattle (see Section 4.4.4: *Traditional marketing rationale*).

The predominant management behaviour may thus be described as "optimistic gambling", in which the hope is that the next wet season will be good and that households can survive without having to sell cattle. The Boran do not seem to sell in anticipation of a future crisis, but instead wait until they have no other recourse. To illustrate, they appear to understand the implications of seasonal fluctuations in terms of trade of livestock for grain, but do not sell cattle at the time of year which would maximise their returns. They merely wait until they have no choice, regardless of how detrimental the terms of trade happen to be (Coppock, 1992b). Overall, this behaviour probably has implications for delaying cattle offtake during the initial stages of drought, which promotes the maintenance of higher than appropriate densities of cattle that rapidly consume forage in fallback areas and accelerate negative, density-dependent feedback on the system. These effects manifest themselves in lower milk production, poorer animal conditions and higher mortality rates (see below). That per cent loss of cattle to mortality during drought was at least three to four times higher than per cent cattle sold and slaughtered. During drought, most dead cattle are speculated to be completely lost to households in economic terms because animals on *forra* die far from encampments and the meat spoils rapidly. This large loss of capital assets would justify some degree of investment alternatives other than in male cattle for risk mitigation, at least for the wealthy and middle class (see Section 7.3.3.6: *Cattle marketing*). The "optimistic gambling" mentality also presents important constraints for interventions such as grain storage in normal rainfall years (see Section 7.3.3.7: *Mitigation of drought impact*). Certainly, low livestock prices are another disincentive for selling cattle during drought. Although the Boran hope to avoid cattle sales, when they sell they seek higher prices which enable them to sell fewer head over the long term (see Section 4.4.4: *Traditional marketing rationale*).

The scope of the famine in the southern rangelands during 1983–84 was far less than that observed within the mixed farming systems of the northern Ethiopian highlands (RRC, 1985: Webb et al, 1992). Livestock assets thus served effectively to buffer most pastoralists during the early stages of drought (Webb et al, 1992). The counter to this, however, is that purely pastoral systems probably have a longer drought-recovery period; the best situation may be an opportunistic mix of farming and pastoralism in drought-prone environments (Campbell, 1984). The size of the famine relief camps in the southern rangelands was relatively small in 1983–86, with about 12 000 occupants in total for two camps near Yabelo and Mega. This may have represented 18% of the local population, but assessments are complicated because of immigrants from as far as Kenya resided in these camps (D. L. Coppock, ILCA, personal observation). Again, mortality due to famine appeared quite low at all 65 encampments studied by ILCA. This small sample may not be representative of the southern rangelands overall, however; human mortality may have been more pronounced in remote locations (B. Lindtjφrn, University of Bergen, personal communication).

The apparent widespread occurrence of diet restriction and human morbidity belies the reported increase in family size due to childbirth among a high percentage of sample families at Beke Pond (Coppock, 1988). However, human reproduction under stress is not unusual. For example, conception and births commonly occur in famine relief camps (C. Toulmin, University of East Anglia, personal communication). Research is required to ascertain what social factors contribute to increased reproduction during drought, as the Boran have traditionally practiced various forms of population regulation under stress in the past (Asmarom Legesse, 1973: pp 154–155; Helland, 1980b; see Section 2.4.3: *Human population growth*). Such practices have been found to decrease with the decline in traditional social values that accompanies commercialisation (Swift, 1977: p 276). Perhaps a related explanation deals with privileges afforded families with infants during drought. Informants reported that it was easier to obtain food relief on the Borana Plateau if a person had a young infant (D. L. Coppock, ILCA, personal observation).

6.4.5. Equilibrial versus non-equilibrial population dynamics

There has been recent debate concerning the degree to which climate, pastoralists and their livestock cause apparent degradative trends in rangeland resources. The mainstream view has been that heavy grazing by livestock, commonly exacerbated by inappropriate development such as proliferation of water points or extensive veterinary campaigns in the absence of stimuli for animal offtake, has served to cause erosion and detrimental changes in vegetation, reducing system productivity and sustainability over the long term (Lamprey, 1983). Another view is that changes in vegetation are more commonly driven by medium and long-term rainfall trends and that livestock play a relatively minor role in vegetation change; i.e. livestock are merely "along for the ride" and are also victimised by the vagaries of rainfall (Horowitz and Little, 1987; Ellis and Swift, 1988). Implicit in the first model is the assumption that livestock populations are tightly coupled to the vegetation.

These systems are regarded as equilibrial in the sense that heavy grazing by livestock can affect a negative trend in forage production, which eventually loops back to reduce animal performance and numbers. Animal performance equates to primary production and thus internal interactions are important. Concepts such as carrying capacity were developed for managing such systems. Berryman (1989) argues that the defining process for equilibrial systems is the occurrence of density-induced negative feedback.

Implicit in the second model is the assumption that livestock never are able to reach densities at which they fundamentally affect vegetation. Plant production, cover and species composition are more affected by annual rainfall or other external events than livestock and vegetation. Feedback loops are thus tenuous but may change in intensity depending on sequences of higher or lower rainfall years. The system is more chaotic and nonequilibrial. Concepts such as carrying capacity are less relevant for the management of these systems because stocking rates have little influence on vegetation performance from year to year.

Behnke and Scoones (1991) attempted to synthesise the results from several papers that examined equilibrial and non-equilibrial system phenomena in African rangelands. Coppock (1987b) concluded that the Borana system appeared to be equilibrial in light of cattle population dynamics observed from 1982–1989. Loss of internal and external fallback regions for use during drought should increase density-induced negative feedback on the cattle populations. He also hypothesised that both equilibrial and non- equilibrial pastoral systems exist in East Africa. The equilibrial system in the semi-arid southern Ethiopian rangelands is fundamentally defined by a more favourable rainfall regime (i.e. 600 mm/year) in which frequency of severe drought is low enough (i.e. once in 10–20 years) compared to cattle generation time (i.e. four years). Epidemic diseases are also apparently under control. There is thus a high probability that cattle can reach population levels that ultimately make them susceptible to modest fluctuations in rainfall in dry years, resulting in competition for forage. Perennial grasses and woody plants dominate the system on fine-textured soils and their prevalence over the medium to long term is probably dependent on cattle-stocking rates, especially during episodic high-density phases of the cattle population (see Chapter 3: *Vegetation dynamics and resource use* and Section 7.2: *A theory of local system dynamics*).

In contrast, the very arid pastoral system of north-western Kenya in South Turkana has a non-equilibrial character (Ellis and Swift, 1988). Droughts may occur at a high frequency which commonly disrupts growth and survival of slow-maturing larger species such as cattle and camels. The low annual rainfall in South Turkana (350 mm) has resulted in an annual community of grasses produced from seed in a "boom or bust" mode depending, almost exclusively, on annual rainfall. Linking cattle density to annual plants production would therefore be tenuous. Even if livestock were periodically to attain high densities in South Turkana, the dominance of flat terrain and sandy soils at lower elevations would make the system relatively immune to livestock-induced erosion and degradation. The key concept is that, considering the contingencies of landscape and soil erodibility, systems with an annual rainfall of more than 450 mm on hilly, fine-textured soils with perennial vegetation should exhibit equilibrial properties; those having less rainfall on flat terrain with coarse soils and annual vegetation should be somewhat less equilibrial (Coppock, 1987b). Equilibrial systems behaviour occurs when people and livestock are spatially confined (as in Borana), essentially creating an unstable "pressure cooker".

In this chapter cattle population dynamics in response to drought were interpreted to illustrate several important interactions involving pastoral households, regional populations and ecosystem function. A lack of empirical information concerning resource allocation among households, or response of regional marketing networks meant that these important issues could not be addressed. The total picture is thus incomplete.

Any attempt to understand trends towards increased frequency of famine, poverty and environmental degradation in the southern rangelands must include consideration of the population dynamics of people in conjunction with those of cattle. That the human population may have remained stable, or even have grown slowly, during the 1983–84 drought, while there was dramatic loss of livestock assets and production resources, is a crucial finding. The sustainability of the system is utimately linked to an inappropriately high density of people and this threshold may have been exceeded within the context of our study period during 1980–91. A global synthesis that unites these concepts is provided in Section 7.2: *A theory of local system dynamics.*

Chapter 7

Development-intervention concepts

Summary

Material in this chapter reviews: (1) contemporary issues in African pastoral development; (2) a development philosophy appropriate for the Borana situation; (3) perceived impacts of interventions implemented in the southern rangelands since the 1960s; (4) a mechanistic and comprehensive theory within which future social, economic, ecological and agricultural dynamics of the system can be predicted; and (5) a practical framework for development impact which employs a systems approach combined with commodity-based research and insights derived from local development experience.

Despite spending millions of dollars on infrastructural improvements and livestock sevices in the southern rangelands since the 1960s, range development planners concede that the impact of interventions has been far below their expectations. Planners had assumed that once animal-health status was improved, and market outlets were available by the late 1970s, dramatic increases in cattle offtake for domestic consumption and export would occur. This was supposed to lead to higher incomes and an improved standard of living for the Boran. Instead, the net result appears to be a larger population of cattle capable of degrading the land and a human population increasingly dependent on relief and rehabilitation. This negative outcome is consistent with the mainstream view of pastoral development problems observed throughout Africa. While the situation for the Boran is indeed deteriorating today, it is argued that past interventions had value by helping delay an inevitable decline in the production system that ultimately results from rapid growth of a human population that is dependent on a finite resource base. It is postulated that impact of future interventions can be maximised if implementation is properly timed with respect to population pressure. Thus population pressure can create new opportunities for positive change.

Rather than discount the value of past interventions, Borana leaders have noted numerous positive impacts on their lives from veterinary campaigns and the development of roads, ponds and markets. Population studies suggest that while marketed offtake of cattle has been slow to respond to improved infrastructure, it should greatly increase by the turn of the century as a result of population pressure and food deficits which will force the Boran to trade more animal products for cereals. Increased dependency on external resources, however, will be very dangerous for the Boran if markets do not operate efficiently and at favourable terms of trade.

Underutilised in the past, roads and markets will become the future lifeline for Borana society. The ponds and veterinary services offered during the 1970s and 1980s have reportedly delayed the onset of poverty for many households by improving access to new land and providing more cattle. It thus appears that increased cattle production from extensive interventions tended to be absorbed by a growing population for subsistence rather than marketable production. Opportunities to extensify further are now limited, however, and windows are opening for the application of new policies and technical innovations which were nonexistent a decade ago. Increased bottom-up demand for interventions will result from heightened human competition for resources. Use of an interdisciplinary systems approach suggests that changes in Borana society, economy and environment are somewhat predictable and can thus help shape a framework for development intervention.

Based on seven years of observation, it is hypothesised that the production system is subjected to two simultaneous processes: (1) a long-term trend which results from a declining ratio of cattle to people; and (2) short-term cycles which occur as a result of variable stocking rates of cattle. The long-term trend occurs because growth in the human population is rapid and steady while growth in the cattle population is limited primarily by scarcity of land. The short-term cycles occur because a two-year drought can reduce total cattle inventory by over 50%. Stocking rates can thus vary from <10 head/km^2 during early years of drought recovery to >20 head/km^2 a few years later if rainfall during the intervening period is adequate. These periods are referred to as the drought-recovery phase and high-density phase, respectively. This dramatic shift in stocking rate is postulated to cause large variation in livestock output per head and per unit area. Milk output per cow gradually declines as a function of an increasing stocking rate; from this it is inferred that cow productivity is strongly influenced by forage competition. Milk output per unit area, however, which reflects stocking rate of cows as well as productivity per cow, is the most important variable. Milk output per unit area probably gradually rises during drought recovery, briefly peaks and then declines as a result of forage competition among cattle. This optimisation pattern is postulated to

drive a cycle of short-term social and economic adjustments by the Boran.

In the absence of development interventions, there should be a number of predictable natural outcomes for the Boran over the long term from existing conditions. These have been deduced from observations in the southern rangelands as well as from the pastoral literature. They include: (1) an increasing annual deficit in food energy as produced by traditional means, for the people that will approach 60% by the turn of the century; (2) a permanent and expanding effort to cultivate; (3) increased offtake of cattle to buy grain; (4) annexation of higher-potential land for forage reserves serving calves and immobile cows; (5) increased emigration of young males leading to key labour shortages; (6) increased wealth stratification; (7) a growing population of peri-urban poor dependent on dairy sales for survival; (8) increased interest in small ruminant and camel production; (9) an increased milking intensity of cows and enhanced percentage of cows in the regional herd; (10) a decreasing percentage of mature male cattle as a result of increasing sales and increases in cows which will reduce risk-mitigation capability of households; (11) a decline in the use of bush foods; (12) a decline in traditional milk processing because of a lower milk surplus; (13) increased risk of environmental degradation in the form of bush encroachment; and (14) threats to the inter-generational transfer of social mores, leading to uncertainties in the maintenance of traditional rights and responsibilities. Dynamics focusing on food procurement are attributable to a declining per capita supply of cow's milk. Increased efforts by the Boran to sell dairy products and produce cereals or small ruminants are all hypothesised to result from attempts to engage in alternative activities which allow them to avoid or delay selling cattle, which are the major form of wealth generation and insurance and social security in the society.

It would be difficult to observe long-term trends from year to year because the short-term cycles are superimposed over the long-term trends and confuse interpretation. The interdrought cycle is speculated to result from adjustments by the Boran to secure resources when facing annually variable constraints on their food supply. The drought-recovery phase was apparently observed during 1985–87 and was characterised by: (1) increasing rates of milk output per unit area due to a growing stocking rate of cows; (2) aggressive and opportunistic production values being manifested by households seeking to rapidly rebuild their cattle herds; (3) intensive efforts to cultivate cereals to make up for milk deficit per unit area; (4) extensive recovery of the grass layer from previous heavy grazing, the extent of recovery being dependent on rainfall; (5) increased sales of milk from peri-urban households needing grain to cover large deficits in food energy; (6) increased sales of small ruminants to buy grain; and (7) traditional, reciprocal grazing rights among territorial groups being honoured, allowing unrestricted access.

Near-recovery of per capita milk production following the 1983–84 drought is presumed to have occurred around 1988 when the number of lactating cows peaked, but before density-dependent interactions took hold. Full recovery to pre-drought levels would not have occurred, however, if the steady growth in the human population during the interim had not lowered the ceiling on per capita yields. This recovery year was a time of the lowest annual food-energy deficit for the Boran in the interdrought cycle. They must have still needed to buy or cultivate cereals, but to a slightly lower extent compared to 1985–87 or 1989–91 (below).

The high-density phase is postulated to have occurred from 1989 until the severe drought year 1991. This was probably characterised by: (1) declining rates of cattle production per head and per hectare due to increasing forage competition; (2) more conservative production values of wealthier households in response to increased production risks and social pressure from their peers to destock; (3) re-initiated efforts to cultivate cereals more intensively; (4) heavy grazing pressure and the increased likelihood of widespread establishment of bush seedlings, the latter dependent on rainfall; (5) increased sales of milk and butter from peri-urban households needing grain to cover food-energy deficits; (6) increased sales of small ruminants and cattle to purchase grain; and (7) reciprocal grazing rights being periodically refused among territorial groups.

The development philosophy to be pursued in this system is one that first and foremost must achieve security for the Boran in terms of food procurement and asset accumulation and diversification to mitigate risks. Secondary goals would be to promote better life-style choices through access to education and local urban development. Other goals include use of livestock assets to achieve improvements in access to water and other basic essentials of day-to-day life. While the challenges are daunting, changes are feasible here because of two factors: (1) the Boran have the capability to rapidly generate capital assets in the form of livestock; and (2) the Boran have repeatedly demonstrated open-mindedness in response to appropriate innovations.

The development problem can be initially confronted by combining strategies to improve cattle production in conjunction with a fundamental shift in how animal assets are marketed and utilised. Because of these development priorities, system sustainability is first defined in terms of per capita production of milk and per capita accumulation of male cattle as assets.

Protecting the environment and measuring environmental sustainability is very complex, and is a goal that can only be addressed after acute human needs have been met. At present per capita food production and asset accumulation are in a decline as spurred by human population growth. Sustainability of these attributes could largely be enhanced by: (1) alternative investments for a portion of the cattle portfolio; and (2) increased rates of emigration of pastoralists out of the system.

Specific means to initiate development action must address the increasing need to: (1) provide more human food in all types of rainfall years; (2) stabilise the system in response to drought through risk management of herd assets; (3) focus on improving aspects of livestock production that are already intensive and have a lower risk; (4) make more efficient use of existing resources; (5) facilitate use of livestock assets for economic growth and community development; and (6) nurture and complement traditional aspects of social organisation to promote indigenous management of resources and protect valued aspects of the culture.

A review of component research and recent development experience suggests that the following intervention concepts are most appropriate for Borana (1) promotion of monetisation, risk management of herd assets and improved human welfare through projects to maintain wells and ponds using heavy machinery being funded by livestock sales of the wealthy and middle class; (2) promotion of human welfare, improved labour efficiency, and risk management of herd assets by extending cement cisterns to increase water supplies to households and calves and to be funded by livestock sales; (3) promotion of grazing management schemes tailored to meet the needs of specific communities; (4) rehabilitation of bush-encroached areas using prescribed burning, arboricides and charcoal production to recover labour costs; (5) hay making with local grasses to improve nutrition of hand-reared calves and reduce rates of calf mortality; (6) use of small quantities of local legume forage including acacia fruits and leaves to provide protein supplements to calf diets based on grass hay; (7) improved management of cultivated fields in appropriate sites including diversification with cereals such as cowpea (*Vigna* spp) with its seeds for human consumption and residue for supplementing calf diets based on grass hay; (8) provision of acaricides in a way that protects cow udders from tick damage and thereby promote milk production; (9) promotion of herd diversification to include more small ruminants and camels to be achieved, respectively, by improvement in the delivery of veterinary services and access to camel markets; and (10) promotion of local below-ground grain stores and/or regional grain stores funded through livestock sales.

The impact of technical interventions would be enhanced within a framework of policies and procedures that facilitate: (1) access of pastoral development projects to modest amounts of foreign exchange to support acquisition of fuel, spare parts, chemicals and veterinary inputs; (2) timely collection and proper administration of funds collected from organised livestock sales in support of community development projects; (3) local and interregional trade in grain, livestock, dairy products, cement, hand tools and other basic essentials; (4) allocation of appropriate sites to be used for sustainable cultivation and charcoal production by pastoralists; (5) risk management of cattle assets including alternative investment for wealthy and middle-class households in the form of simple savings accounts in banks; (6) provision of employment on public works projects during the second consecutive year of droughts; (7) establishment of a reasonably staffed and equipped range development agency within the Ministry of Agriculture with a mandate to work in partnership with the pastoralists to find and prioritise solutions to felt needs of the community; and (9) education of pastoralists and stimulation of local urban development that would improve the likelihood that pastoralists could successfully emigrate out of the traditional system. A scrutiny of these technical and policy interventions strongly suggests that most of the ultimate constraints to effective implementation lie outside, not within, the pastoral system.

The intervention philosophy is based on meeting bottom-up demand for technology and services that the Boran are willing and able to pay for through livestock sales. This is the perfect test criterion for judging whether a certain intervention is meeting priorities of the people. Many ideas that originated from top-down thinking have failed in the 1980s. Such attempts usually fail because they lack a practical appreciation of people's priorities and constraints. For example, interventions using animal-drawn pond scoops to maintain ponds were promoted to save foreign exchange required for maintaining heavy machinery. The scoops tuned out to be inappropriate because the Boran appear unwilling to risk valuable animals in extensive communal work commitments. By contrast, use of animal traction for short-term cultivation should be very successful. Forage improvements based on exotics have also commonly yielded disappointing results due to constraints of rainfall and air temperature. Exotic forages also have the limitation of not directly meeting their needs in terms of more food for themselves or in helping them manage existing resources more efficiently. That is why local range-management tactics such as extension of dual-purpose cowpea and efforts to improve cereal crop development on appropriate sites should be very successful. Forage intervention should also be focused on low-input strategies to make better use of valuable indigenous grasses and trees. While the trees have the disadvantage of low and variable productivity, they persist well in the environment. Hay-making is an excellent example of a bottom-up solution to a calf management problem using local resources. Hay-making can result in marked nutritional improvement for calf performance, it is an easily transferred innovation and converts a communal grazing or cut-and-carry resource into a private resource. Strategies to enhance cattle growth to improve lifetime performance were also found to be ill-conceived in terms of a lack of an appropriate social or ecological perspective and were deemed far too risky for implementation.

In essence, there is no long-term cost for cattle production accruing from levels of milk offtake that averaged 170 litres/head/lactation. Compensatory growth in young cattle is a powerful attribute that may often overcome the effects of early nutritional deprivation due to milk restriction. Mitigating calf mortality, in contrast to speeding up growth, is much more appropriate culturally, ecologically and economically.

Drought-mitigating tactics based on fodder reserves of *Atriplex* and *Opuntia* spp were also found to be ill conceived. Although also beset by daunting constraints, alternative investment for a portion of cattle assets in the form of simple saving accounts for households is the only dramatic means to quickly achieve increased rates of cattle offtake, faster herd turnover, increased animal production, stabilisation of the cattle population in response to drought, improved risk management of assets for households, minimised risk of famine by fair terms of trade, and encourage economic growth for households and local urban centres. This strategy could be most effective if managed in the form of a sustainable yield scenario with the regional herd held at <20 head/km^2. The biological and ecological postulates that underpin this strategy would hold true because high stocking rates can reduce animal production and increase pastoral risks. The system thus exhibits strong equilibrial characteristics.

Use of the dynamic systems model involving long-term trends and short-term cycles, in conjunction with commodity-intervention concepts, reveals that windows of opportunity for different interventions may be gradually closing, gradually opening, or opening and closing in a cyclic or episodic fashion. Windows of opportunity based on system extensification or utilisation of traditional surplus products are closing; these include prospects for new large-scale water developments and milk-processing technologies. Wheras windows of opportunity based on system intensification and marketing are gradually opening; these include interventions for cultivation, calf management, water management, site reclamation, grazing management, dairy and livestock marketing, risk management of livestock assets, herd diversification and promotion of human development through education.

The short-term cycles will affect the success of these interventions. Those interventions dependent on low stocking rates for their success (such as site reclamation) would be most effectively carried out during a drought-recovery phase of the cattle population wheras those dependent on high stocking rates for their success (such as livestock-funded water development and grain stores, banking of livestock assets, grazing management, hay-making etc) should be promoted during high-density phases of the cattle population. Some interventions would thus be adopted, dropped and re-adopted as part of a cyclic process. This illustrates that pastoral development activities should be opportunistic and planned around anticipated, but probabilistic, dynamics of the production system. This also illustrates that systems and commodity research should be run in parallel to gain insights relevant to achieving development impact. The commodity work helps us understand what and how to implement. The systems work helps us understand when to implement commodity interventions and why.

7.1 Introduction

This chapter unites concepts from previous chapters with practical ideas for development intervention among the Borana pastoralists. The practical ideas are based on information generated from development experiences as well as technology-based research. This synthesis is the critical contribution of this systems study to the pastoral development literature. A new development approach is forwarded that outlines intervention opportunities that change in relation to short-term cycles and long-term trends that are produced by population dynamics of cattle and people. The synthesis is preceeded by: (1) brief review of the debate regarding the effectiveness of pastoral development strategies in Africa; (2) a statement of development objectives appropriate to the Borana situation; and (3) a description of recent and anticipated changes in the Borana system. The structure of this chapter differs from others in that studies are reported as units in full (i.e. including methods, results and discussion) as they pertain to a hierarchy of intervention concepts.

7.1.1 Issues in pastoral development

Sandford (1983a: pp 11–19) interpreted what he felt was the "mainstream view" of pastoralism and rangeland dynamics commonly held by researchers, policy makers and developers. One cornerstone of this view is that traditional pastoral strategies for livestock production and land use are inappropriate in relation to promoting commercialisation and change. In addition, pastoral livestock are thought to pose a great threat in degrading rangeland environments because of the apparent reluctance of pastoralists to market animals and destock. This situation is exacerbated by veterinary campaigns and water developments that serve to increase livestock population in the absence of increased offtake.

Despite the prevalence of this view, Sandford (1983a) noted that it is supported by flimsy evidence. Ellis and Swift (1988: p 451) stated that perceptions of pastoral systems emphasise negative features such as low productivity, overstocking, range degradation and drought impacts. They also remarked that after years of apparently ineffective interventions in pastoral systems, African governments, donors and research organisations appear to be giving up any hope that they can relieve these problems. Jahnke (1982: pp 102–103) thus concluded that the scope for pastoral development is extremely limited. In his review he noted the relatively high efficiency of traditional pastoralism in extracting livelihood from marginal environments and advocated the priority need for human rather than livestock development so as to facilitate emigration of excess pastoralists to gainfull employment outside of pastoral systems. Otherwise, development, he felt, must take on a defensive stance by reducing effects of drought and overgrazing and by improving the pastoral subsistence base through introduction of grain. In effect, Jahnke (1982: p 103) noted that pastoralists are relegated to the "waiting room" of development, with policy makers only able to implement relief and rehabilitation measures aimed at mitigating the effect catastrophes.

One interpretation of the above synopsis is that pastoralists and pastoral systems are relatively static in terms of the perserverance of traditional norms and modes of production. Experiences cited throughout this volume, however, attest to significant changes in the pastoral lifestyles under pressure on the Borana Plateau and elsewhere. Unfortunately, most of these changes have apparently been negative (in terms of human welfare). Human population growth, drought, inappropriate water development, land appropriation, peri-urban influences and even livestock commercialisation have reportedly contributed to an increased pauperisation, wealth stratification and the cultural alienation of pastoralists (Swift, 1977; Evangelou, 1984; Salih, 1985; Moris, 1988).

Perhaps the best documented example of pastoral change over time is provided by Kenya's Maasailand (Evangelou, 1984; Solomon Bekure et al, 1991). Ensconced within one of sub-Saharan Africa's healthiest economies, with a well-documented increase in commercial livestock activity, it is still difficult to ascertain whether the Maasai are "better off" today than several generations ago. It is thus apparent that while the scope for internal change, primarily driven by human population growth, is significant in pastoral systems the ability of African societies at large to facilitate absorption of pastoralists and buffer pastoral systems from destructive effect of perturbations remains low.

Central to pastoral development, yet often ignored, is the problem of modernising subsistence societies in general. Smooth and yet rapid transitions are probably unprecedented. The complex social, cultural and productive features of pastoral systems adapted to risky rangeland environments are well documented (Jahnke, 1982: pp 74–77). But these are commonly inimical to those features required for commercial transformation (Behnke, 1983; 1984; 1987; Coppock et al, 1985). One key difference is population density; while ratios of people to head of livestock in commercial beef systems may be on the order of 1:50, most African pastoral systems have a ratio of 1:5 or less (Coppock et al, 1985). Pastoral systems are densely populated with people, and a large segment of the population would have to be removed, for example, for commercial ranching to be successful.

It is instructive to remember that range development in the Western world was achieved largely through warfare. Indigenous subsistence peoples were defeated and replaced by colonisers having radically different production rationales and resources. The social cost of "development" to these indigenous peoples has been veritable extinction. Western models of change are thus an inappropriate ideal for the transformation of traditional African pastoralism (Sandford, 1983a: p 6). Even if only viewed on moral grounds, contemporary development of African pastoralism faces the challenge of facilitating gradual economic transformation within the context of conserving valued aspects of pastoral cultures. It is apparent, however, that in many cases little sustainable facilitation really comes by as a result of pastoral development projects and pastoralists are therefore left to their own meager devices to cope with change (Boserup, 1965: Evangelou 1984; Solomon Bekure et al, 1991).

This lack of facilitation of change is not unique to pastoral systems, as there are few concrete examples of successful livestock commercialisation elsewhere in sub-Saharan Africa. Jahnke (1982: pp 164–171) pointed to smallholder dairy development in the Kenyan highlands as one of the only well-documented success stories and he detailed the complex history of political and economic pre-conditions, both on national and local levels, that led to the impact there. This is instructive in that it illuminates the fact that preconditions exist for technological impact and economic development. For the Kenyan highlands, these social and economic preconditions were necessary for impact even when market access was good, ratios of labour to land were high and forage and water resources were abundant. This illustrates another problem related to interpreting development impact: successful livestock development is typically equated with a higher level of intensification (i.e. stall-feeding and other aspects of intensive management).

It will be argued here that increases in the number of animals in low-input systems is another form of development. This is especially true in situations where low-input production values dominate, as is especially the case for pastoral situations where intensification is inappropriate because risks of losing hard-won production improvements can be very high. Thus the objectives and measures of development impact must be redefined for pastoral systems. Finally, pastoral development projects so far have been essentially "experiments" on societies, with careful articulation of goals and monitoring of impact to test hypotheses and assumptions that underly expectations of impact and change rarely taking place (Helland, 1980a). So it is not surprising that perceptions of causes and effects of pastoral development tactics remain unclear. And the main value of long-term integrative studies such as this is to provide a framework for better understanding cause and effect in complex systems.

7.1.2 A development philosophy appropriate for the Boran

In some important respects the Borana pastoral system is unusual and some of the possibilities for development intervention are directly linked to these characteristics. As reviewed in Chapter 2: *Introduction to the Borana Plateau: Natural resources and pastoral society*, the relatively predictable rainfall and labour coordination required to operate the deep wells have encouraged a somewhat stable and territorial subdivision of grazing and water resources, this in turn is supported by a sophisticated tradition of legal and social values. Tapping into this network and using development tactics that complement and facilitate traditional resource-use strategies would be the key to success in many development programmes. Because of the current situation of overcrowding and instability (see Chapter 6: *Effects of drought and traditional tactics for drought mitigation*), the upcoming decade may offer the best opportunities for constructive development interaction. This is because the society at large perceives a need for change as a result of population pressure (Coppock, 1992b).

Jahnke (1982: p 101) noted that an appropriate end point of pastoral development may be seen as a situation in which "...the pastoralists manage their own resources at a higher level of productivity and in accordance with ecological principles of sustained yield, while basically maintaining their characteristic life style." It is agreed that this is a desired goal of the Boran. Development should be viewed, however, more as an evolving process rather than as an end point, but with some framework for evaluation. The end point of Jahnke (1982) could be amended to include that the Boran should be better fed, clothed and housed as culturally appropriate, gain more reliable access to health care, be subjected to less drudgery in terms of labour, have more options to help them manage the risk to their capital assets (livestock) and enable them to make lifestyle choices (pastoralism or not). This broader definition of the end point is consistent with both human and livestock development, since livestock represent the source of capital with which living standards can be improved. More importantly, with this approach livestock development is not narrowly viewed as merely increased animal offtake, a reduced calving interval or other technical aspect of livestock production while changes in human welfare could be monitored and progress towards "development" be periodically evaluated.

The ability to attain this ideal end point is constrained by internal and external factors as well as their interactions, as will be shown in this chapter. Household-intervention concepts have been tailored for the Boran in recognition of the following priorities: (1) that there is an increasingly acute need for more human food in the system in all types of rainfall years; (2) that there is a need to stabilise the production system in relations to drought; (3) that opportunities exist to improve aspects of livestock production that are already intensive and have a lower risk; (4) that opportunities exist for more efficient use of forage, water and labour; (5) that there is a chance to facilitate using livestock assets for risk mitigation and community development projects; (7) that the opportunity exists for promoting appropriate levels of livestock turnover and monetisation in the society; and (8) that it is possible to nurture and complement traditional aspects of social organisation so as to facilitate opportunism, help enforce appropriate use and maintenance of land and water resources and protect the economic rights and roles of women.

Implicit in this development strategy is the promotion of system sustainability. Sustainability, however, is a complex concept subjected to many interpretations. Sustainability may be described as a stable or upward trend in a key resource over the long term. Disciplinarians may view soil, plants or livestock performance as key indicators of sustainability while systems scientists see sustainability more as a composite attribute that integrates several variables. For example, Flora (1992) considers a system sustainable when the positive attributes of various agricultural, ecological and social variables are concurrently optimised.

Material reviewed in Chapter 3: *Vegetation dynamics and resource use* and Chapter 5: *Livestock husbandry and production,* suggests that the central Borana Plateau has endured a large degree of livestock-induced bush encroachment and erosion. Livestock has also been reportedly lost to tick infestation. If sustainability were defined as maintenance of resources in support of livestock production, it would be tempting to speculate that the Borana system is in a downward trend, although much of the lost land could be recoverable (see Section 7.3.1.4: *Site reclamation*). Despite this circumstantial evidence, documenting further change in soil and plant resources that could affect sustainability of the system would be very difficult. In part this is due to the dynamic nature of grazing pressure and plant community response (see Section 7.2: *A theory of local system dynamics*).

Since the dominant problem in the system today is food and economic security for people, a simpler and more direct measure of system sustainability could involve per capita production of milk and animals on an annual basis. The milk would be a measure of food security while animal numbers measure economic growth in the durable assets. These sustainability indices are thus influenced by human population as well as livestock output. For example, increased animal production, or increased human emigration, would increase either index of sustainability. It is note worthy that per capita cash income is not considered as a viable measure of sustainability here. Increasing incomes mean little if markets are unable to meet demands for consumer goods. And markets can be unreliable as a result of transport and infrastructural constraints; such problems have recently driven up grain prices and have put human lives in jeopardy (see Section 6.3.3: *Drought effects in 1990–91*). It is argued that using human and livestock-based indicators simplifies interpretation of the acute nature of system sustainability; this is most effectively illustrated using empirical population and production models (see Section 7.2: *A theory of local system dynamics*).

7.1.3 Review of pastoral systems dynamics and past interventions

As in many African range development projects, the first priorities in the southern rangelands were construction of ponds starting in 1965 to allow pastoral herds to expand into underutilised savannah to the north (i.e. areas not served by wells), improvement of infrastructure (roads, and livestock markets) starting in 1974 and implementation of veterinary campaigns in 1974 (see Section 1.4.2: *History of lowlands development and the TLDP*). The overall philosophy was that these improvements would lead to increased cattle offtake, with a strong emphasis on increasing live animal exports. There has not, however, been any evidence that this strategy was successful. The concensus among Ethiopian range professionals has been that the interventions have merely permitted a larger cattle herd now to roam the southern rangelands, placing the environment at greater risk of degradation (see Section 1.4.4: *Has national range development been successful?*).

One irony, then, is that in the eyes of local leaders, the infrastructural improvements have had a wide array of positive social, economic and animal production effects (D. L. Coppock, ILCA, unpublished data; Coppock, 1992b). Thus both time frame and human population factors must be taken into account for a proper evaluation. That the Boran were very isolated from the rest of Ethiopia even as late as 1980 cannot be overemphasised. For example, an informant who purchased livestock for ILCA trials in 1981 noted that herd owners in more remote locations often could not even discriminate among various denominations of Ethiopian paper currency (D. L. Coppock, ILCA, personal observation).

The tarmac road from Addis Ababa to Moyale, completed in 1976, has led to immigration by highlanders that has contributed to the substantial growth of towns such as Yabelo, Mega and Negele (Solomon Desta, TLDP economist, personal communication). The urban-based demand for meat, milk and butter has consequently also grown in the southern rangelands, as prices have reportedly gradually increased during the 1980s (D. L. Coppock, ILCA, personal observation).

Today, local market centres such as these provide opportunities for Borana women to sell dairy products and buy grain in a vital link for food security that was not needed a generation ago (see Section 4.4.10: *Dairy marketing*). Far from displaying conservative attitudes, Borana leaders emphasise the critical importance of markets to their wellbeing today and in the future, and complain that market access is still insufficient. This changing attitude is related to population pressure and the evolved dependence of the Boran on nonpastoral sources of food available at favourable terms in exchange of animal products (Coppock, 1992b; see Section 4.4.4: *Traditional marketing rationale*).

Immigrants to the towns have introduced farming and animal draft technologies that the Boran are readily adopting, and while this may have some negative environmental possibilities, it can lead to pockets of agropastoralism that provide new options for destitute pastoralists (Section 4.4.1.1: *Pastoralism and cultivation*). Elders also reported that the younger generations have been definetely influenced by urban trading and thus exposed to the idea that there may be easier and more profitable means of earning a living today than raising cattle. This has raised fears among the pastoral community that serious labour shortages will occur in the future as young men drop out of the traditional system (Coppock, 1992b).

In sum, this is all interpreted to illustrate on the one hand the key role of small towns as conduits of new ideas and technologies and on the other the flexible response of Borana culture in receiving the latter. These small towns developed largely as a result of infrastructure improvements.

Although the permanent ponds to the north have led to environmental degradation (see Section 3.4.1: *Ecology and land use*), they allowed hundreds of families to leave dilapidated areas in the central region and move out to the periphery to new and more productive locations (Billé and Assefa Eshete, 1983b). Although current prospects for improved productivity from livestock in the north are now declining due to population pressure [i.e. it has been recently debated whether a portion of the Borana households residing in *madda* such as Did Hara should be moved out of the area with government assistance (SORDU, 1991)], this intervention essentially provided a 20-year reprieve for households that migrated to Did Hara and for those that stayed behind in places like Medecho in terms of more per capita resources that likely enhanced cattle productivity.

Similarly, although some problems continue to be reported for ephemeral ponds constructed during the 1970s and early 1980s (Irwin, 1986a; 1986b; 1986c; see Section 7.3.1.1: *Water-development activities*), many of them have allowed improved use of wet-season range within a number of *madda* (Hodgson, 1990: p 24). Thirty Borana elders all reported the positive effect of veterinary campaigns on reducing risks of cattle epidemics and they concurred that as a consequence the cattle population has indeed increased (D. L. Coppock, ILCA, unpublished data). Offtake rates have apparently not increased in line with reduced cattle mortality afforded by veterinary campaigns. The critical effect of the veterinary campaigns has been to delay the onset of a higher incidence of poverty by preventing losses and providing the growing population with more animals for subsistence.

Reducing the risk of catastrophic losses of cattle to disease probably also improves planning horizons for households and sets the stage for increased commercialisation in the future. Whether growth in the livestock population also facilitated growth in the human population remains unclear. Borana respondents felt that recent higher rates of growth in the human population may be due more to there being no major disease outbreaks and less to having grain in the diets, famine relief, health interventions or a social breakdown of reproductive behaviour (D. L. Coppock, ILCA, unpublished data). It is more likely that a higher human population has allowed the society to keep more cattle; this could be related to increased availability of labour for watering cattle from the deep wells (Helland, 1980b).

Borana elders were concerned in 1989 about a cattle population that was on the verge of exceeding the resource capacity of their territory which was being increasingly crowded and circumscribed by other ethnic groups; their premonition was correct and large losses of cattle were reported as a result of insufficient rainfall (see Section 6.3.3: *Drought effects in 1990–91* and Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). Although such phenomena reveal substantial stress in Borana society, it will be argued later in this chapter that in fact stress offers a significant opportunity for introducing technical and economic interventions that otherwise may not be easily implemented.

In sum, Borana society is rapidly changing in response to contingencies of climate, population and external influences. Interventions such as development of ponds and veterinary service have probably increased the grazing area and livestock on it. These are, however, extensive interventions that are appropriate to conditions where intensification is risky and difficult. Evaluating these interventions in terms of cattle productivity per head or marketed offtake is not very relevant, even though these are the indicators commonly employed (Jahnke, 1982). These extensive interventions have probably facilitated the per capita acquisition of resources and thus delayed a wider onset of poverty. Limits to the benefits of such interventions have probably been reached recently. For example, there may not be any inaccessible areas anymore where water development could release pressure. When this point has been reached the extensive approach is no longer very useful and the Boran will inevitably become poorer unless some members diversify their economic activities internally or emigrate to another area. Hence this is the time when options for intensification such as land use and/or animal production, alternative investment and improved market access become important prospects that the people would be interested in.

Material reviewed in Section 4.4.2: *Economic comparisons among pastoral systems*, suggests that the Borana system currently represents one stage of a continuum of change precipitated by a higher human population growth rate than that for cattle and characterised by shifts in human diets from being dominated by milk to being subsidised by grain. This in turn sets the stage for other anticipated changes in economic behaviour. Although underpinned by differences in national and local conditions, it is speculated here that the Boran are one or two generations behind Kenya's Maasai on a continuum of change (Evangelou, 1984; Solomon Bekure et al, 1991). Using Maasailand and other semi-arid systems as a model, it may be expected that Borana society will undergo a similar sequence of change in the future in terms of household and livestock diversification and agropastoralism.

The challenge for development in the southern rangelands is to anticipate both positive and negative aspects of change and facilitate the former while minimising effects of the latter. The following points are presented under the assumption that: the future climate will remain significantly unchanged; the land area for Borana cattle cannot be expanded much further; gradual liberalisation of local and national policies evident in late 1990 (Ethiopian Herald, 1990) will continue; control of epidemic diseases for livestock will be maintained; the human population would continue to grow; and prospects for widespread emigration of the Boran out of the system will remain limited in the near future.

7.2 A theory of local system dynamics

This section describes a comprehensive theory within which the dynamics of animal production, range trend, socio-economic aspects of pastoral households and shifting development opportunities could be predicted, predictions tested and hence knowledge advanced. The theory is based on a series of hypotheses deduced from the literature and observations in the southern rangelands during 1980–1991 and the empirical model used in illustrating the theory is given below. The system's dynamics are divided into two components: (1) those due to continuous long-term trends; and (2) those due to short-term cycles driven by episodic events such as low annual rainfall. Understanding each component is relatively straightforward. Interpreting field data to test a component is made difficult because dynamics caused by the cyclic events are superimposed over those caused by the long-term trend.

7.2.1 Empirical modeling

Past and future dynamics of the Borana system are illustrated using a simple computer simulation model based on observed population trends of cattle and humans. The cattle population was observed during 1980–1991 to be periodically subjected to resource scarcity. Resource limitation is usually instigated by below-average rainfall, which is a variable external to the production system. The magnitude of the effects of low rainfall on the production system, however, is influenced by cattle stocking rate. Stocking rate is an internal system factor that dictates the potential intensity of forage competition among cattle (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). In any given year the cattle herd varies between a lower range of stocking rates following a multi-year drought, to a higher range of "ceiling" stocking rates that reflect a yearly variable carrying capacity during non-drought years. The higher the stocking rate the greater the risk of negative, density-dependent effects on the herd from low rainfall. This pattern is hypothesised to operate to a greater extent here than in more arid pastoral systems where the frequency of severe drought disrupts herd growth. It has also been hypothesised that the intensity of density-dependent interactions on the Borana Plateau is greater today than in the past because of the loss of traditional internal and external grazing reserves to population pressure, which limits management flexibility (see Chapter 8: *Synthesis and conclusions*).

In contrast to cattle, the human population may exhibit a rapid and steady increase in size regardless of annual rainfall (see Section 2.4.3: *Human population growth* and Section 6.3.2.2: *Human welfare*). Patterns of marketing behaviour are predicted based on the attempts by the Boran to make up for annual deficits in food energy by selling livestock and livestock products to buy grain. Annual food-energy balances for the human population in the 15 475-km^2 study area were calculated as functions of annual fluctuations in cattle numbers and productivity in relation to a steady growth in food demand by the human population.

The computer-simulated model was parameterised using data collected in the southern rangelands along with some simplifying assumptions. The model was run for 25 years representing the period 1982 to 2006. This period includes the drought of 1983–84 as well as a hypothetical drought in 1995–96, with all other years assumed to have average rainfall. The modeling work was conducted just prior to the 1990–91 drought. While this affects the accuracy of year-to-year predictions when model results are compared with the field situation, it does not undermine the general validity of the approach.

The pre-drought herd size in 1982 was derived from aerial surveys of Milligan (1983) and drought impact and initial recovery of cattle numbers during 1983–86 were derived from herd monitoring results of Donaldson (1986) and aerial surveys reported in Cossins and Upton (1985: p 139) and Assefa Eshete et al (1987: p 9). Herd growth in average rainfall years during interdrought periods (i.e. 1986–1994; 1997–2006) was assumed to be density dependent (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). The first year of drought recovery (i.e. 1985 or 1997) was assumed to have herds showing an annual growth rate of 10.4%, evident from aerial survey data from 1985–86 and found to be an upper limit of growth in other modeling work (Mulugeta Assefa, 1990: p 135). Herds in subsequent drought-recovery years (1986–89; 1998–2001) were assumed to have an annual growth rate of 8% (Mulugeta Assefa, 1990: p 135). The high-density phase was assumed to be reached when the herd size went over 300 000 or 19.4 head/km^2 following a guideline on an upper limit for carrying capacity for the semi-arid zone from Pratt and Gwynne (1977: p 112; also see empirical observations confirming density dependence in Section 6.3.3: *Drought effects in 1990–91*). According to the model the cattle herd crossed this threshold of 300 000 head in 1989 and 2001. Herds in subsequent high-density phases (i.e. 1990–94; 2002–2006) were arbitrarily assumed to have net rates of growth that gradually declined from 6 to 2% per annum. Relative impacts on the cattle herd of the projected 1995–96 drought were assumed to be similar to those observed in 1983–84 and 226 000 head was assigned to be the post-drought stocking rate in 1997.

The optimal percentage of mature cows in the regional herd during average rainfall years was expected to vary between 45% (Cossins and Upton, 1988b) and 50% (Solomon Desta, nd), with the latter figure presumed to be more likely over the long term as demand for milk increases with human population growth. If the proportion of cows were to exceed 50%, it is envisioned that although milk supply would improve, the cost would be more limitations on investment and risk-mitigating capability since fewer mature male cattle could be maintained (Coppock, 1992b). The proportional decline of mature cows in the regional herd from 45 or 50% in average years to 38% during the peak of drought was inferred from Donaldson (1986).

The fraction of mature cows in milk was assumed to be 0.75 before the 1983–84 drought (Cossins and Upton, 1987) and during other years of drought recovery. During high-density phases, however, this fraction was assumed to be density dependent and was arbitrarily reduced by 0.01 unit each year to a low of 0.68. Milk yield per milking cow was quantified in energy terms as 840 MJ GE/cow/year (Cossins and Upton, 1988b) and this was initially used in pre-drought 1982 and in drought-recovery years. A linear decline from 840 to 420 MJ GE/cow/year (Donaldson, 1986) was assumed during the first to the second drought year. During the high-density phases milk production was assumed to be density dependent and was arbitrarily reduced by 2% each year to a low of 722 MJ GE/cow/year. Total annual energy production from milk was calculated as the number of milk cows times yield per cow.

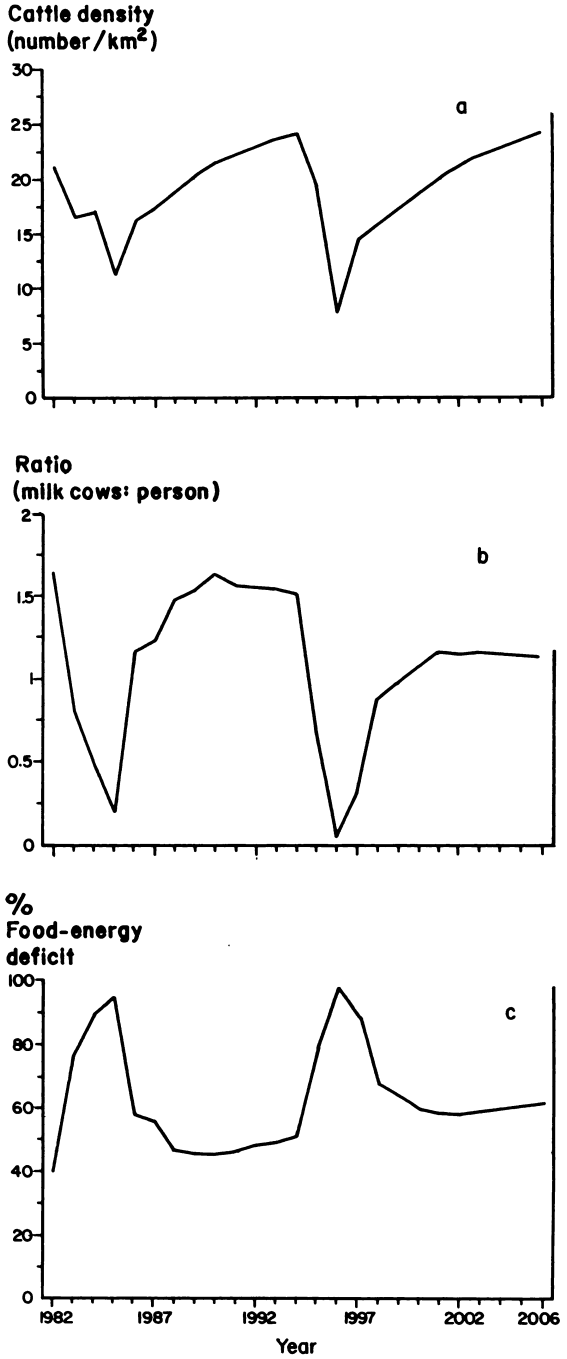
The most accurate statistics for the human population were assumed to be those of Assefa Eshete et al (1987: p 11) for 1986, which relied on aerial counts of huts along with a ground truth of 4.5 persons per hut based on a survey of 60 encampments (600 households) by Coppock and Mulugeta Mamo (1985). It is important to note that these data yielded a baseline population of about 66 000 people for the study area during 1982. This is roughly 60% of the 108 000 estimated by Upton (1986a). The main difference in the calculations originated from variation in the estimated number of occupied huts per unit area obtained by aerial survey. The number of people per hut were more similar, as Upton (1986a) used an estimate of four persons per hut, comparable to the 4.5 of Coppock and Mulugeta Mamo (1985). Estimates of Milligan (1983), cited in Upton (1986a), were based on 1.7 occupied huts/km^2. Assefa Eshete et al (1987) estimated about 1.1 occupied huts/km^2. While these discrepancies will remain unresolved, the research theme remains the same: the steadily increasing dependence on nonpastoral foods by the Boran because of human population growth exceeding the traditional support capabilities of the system.

A net annual growth rate of 2.5% was assumed for the human population in average rainfall years (Lindtjørn, University of Bergen, unpublished data) and this was assumed to be density independent. The human population growth rate assumed during drought was 1% per year (see Section 6.3.2.2: *Human welfare*). Using the baseline year of 1986 and the growth rate of 2.5%, figures for the human population were back-calculated to estimate how long it is likely that the Boran have been forced to supplement milk-deficient diets with grain. Human immigration and emigration for the pastoral sector were assumed to be neglible overall (AGROTEC/ CRG/SEDES Associates 1974f; see Section 2.4.3: *Human population growth*). The total annual energy requirements for the human population were calculated by multiplying population size times 2336 MJ GE/person/year (FAO/WHO (1973) cited in Upton (1986a): p 21).

Annual dynamics of populations, milk-energy yield and human energy demand derived from these calculations are shown in Table G1, Annex G. Figure 7.1 (a,c) depicts dynamics for the cattle population and food-energy deficit. Assuming the cattle population periodically reached 275 000 head prior to the 1980s, and that 45% of these were mature cows with 0.75 in milk and a milk yield 10% higher than the maximum in the 1980s, it is apparent that this level of cattle productivity could fully support some 37 000 people. This suggests that the Boran have been increasingly dependent on grain since around 1960. This is in contrast to the projected dynamics of annual energy deficits from 1982 to 2006 (Figure 7.1c). Even in 1982 the population needed 40% of their energy from grain (note that 32% of dietary energy was provided by grain in household surveys summarised in Figure 6.2a).

Examination of the interdrought periods indicates that the energy deficit will increase to a minimum of 46% in 1986–1994 to 58% in 1998–2006. This is primarily due to a steady increase in the size of the human population. These low points (or troughs) in interdrought periods are bounded by gradual post-drought declines and pre-drought increases in energy deficits (Figure 7.1c). These were caused, respectively, by gradual recovery of milk-production potential or by subtle increases in density-dependent interactions which reduced milk production. Droughts, in contrast, are times of sharp increases in the milk-energy deficit, primarily

Figure 7.1. (a–c) *Empirical modeling results for: (a) cattle stocking rate; (b) ratio of milk cows per person; and (c) per cent annual food-energy deficit for the Borana system as located within a 15 475-km^2 area in the southern rangelands during 1982–2006.*



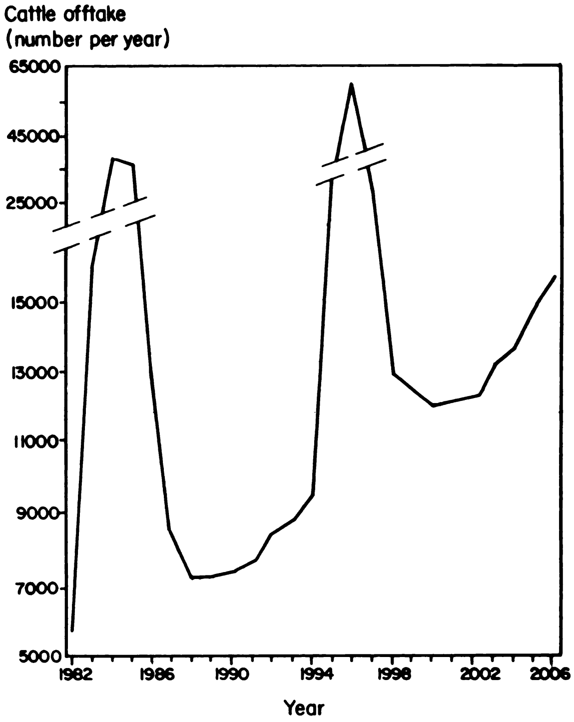
Source: Coppock (1993c)

caused by a reduced calving percentage, and secondarily by a decline in the milk yield per lactating cow (see Section 6.3.1.2: *Cattle productivity*). The peak milk-energy deficit of 92% in the 1983–84 drought is similar to the 85% deficit observed in late 1984–85 (see Figure 6.2b). People survive an 85% deficit by collecting bush foods, buying more grain and reducing food intake (see Section 6.3.2.2: *Human welfare*). It is notable that the projected energy deficit grows during the 1995–96 drought and this is due to the increase in the human population.

Using milking cows per person as a proxy for per capita milk production, the system appears unsustainable in terms of food security (Figure 7.1b). The long-term decline results from human population growth in conjunction with constraints that limit the size of the regional herd with cows not exceeding 50% of the regional herd. The decline would continue until rates of human mortality and emigration balanced rates of birth and immigration. The slope of the decline could be lessened if cows made up an increasing portion of the herd, but this would compromise the economic assets stored as male cattle for drought endurance and recovery, for example. Increasing the proportion of cows is hypothesised as a stimulus to the Boran's practice of trading bulls for cows with highlanders during drought recovery (see Section 5.4.5: *Cattle growth and implications for breed persistence*). Dynamics for per capita holdings of male cattle are not illustrated but the pattern would be similar to those in Figure 7.1b. Drought-induced mortality rates for mature male cattle in 1983–84 (22%) were roughly half of that for mature cows (45%); thus the deep drops in the per capita asset index due to drought would not be as severe as that for cows. Similar perspectives have been forwarded for other pastoral systems (see Figure 3.3 on p 26 in Grandin (1991)).

The implications of cattle offtake to buy grain to make up energy deficits are displayed in Figure 7.2. The analysis assumes that the sale of one 250-kg animal will enable the purchase of 625 kg of grain during average rainfall years but that these terms of trade will change in a linear fashion to 209 kg of grain per animal at the peak of a drought (see Section 6.4.3: *Decline in terms of trade*). This fall in the terms of trade is more conservative than the 75 kg of grain/animal reported in Cossins and Upton (1988a), and is a compromise between this value and higher estimates of Solomon Desta et al (nd). While an offtake of 5516 head (1.7% of total inventory) would enable the purchase of the grain requirement in 1982, this increases to a minimum of 7200 head (2.5% of inventory) and 12 000 head (4.1% of inventory) during the 1986–1994 and

Figure 7.2. *Empirical modeling results for cattle offtake per year in support of grain purchases needed to make up energy deficits for a human population occurring within a 15 475-km² area in the southern rangelands during 1982–2006.*



Source: Coppock (1993c).

1997–2006 inter-drought periods, respectively. These are increases of 30 and 117% compared to 1982. Gradual declines and increases in cattle offtake in inter-drought periods reflect milk production dynamics (above). The overall increase in offtake over time reflects human population growth. Projected offtakes during drought are high both in 1983–84 (36 000 head or 16% of inventory) and 1996 (56 000 head or 46% of inventory). These are thought to be unrealistically high, however, because of a reduction in pastoral food demand and sales of alternative commodities where possible (Section 6.3.2.2: *Human welfare*).

The above analysis undoubtedly contains errors and assumptions that have not been rigorously tested. The overall conclusion, however, is that the Boran will become increasingly dependent on grain imports and this has implications for increased cattle marketing. The apparent trend of the system is towards unsustainability in terms of per capita milk production and asset accumulation; fewer assets imply greater risk of not recovering from drought, especially for poor and middle-class households (see Section 7.3.3.7: *Mitigation of drought impact*).

Per capita incomes will probably increase for the Boran, but they could also easily be victimised by risky markets and high grain prices. This could be mitigated, however, by activities such as cultivation and diversification into small ruminants for market (see Section 4.4.4: *Traditional marketing rationale*). Cultivation carries risks because less than 10% of the landscape may be suitable for sustainable farming (see Section 3.4.1: *Ecology and land use*). Likewise small ruminants are risky in light of the poor access to veterinary service (see Section 5.4.6: *Small ruminants*). The general pattern is testable as the interpretation given here is consistent with long-term trends reported for semi-arid Maasailand (Meadows and White, 1979; Grandin, 1987; Solomon Bekure et al, 1991).

7.2.2 Anticipated long-term trends

Long-term trends in the production system largely result from population dynamics of both cattle and people. Fundamental shifts in pastoral behaviour are predicted on the basis of the need to acquire more food energy from nonpastoral sources to make up for growing deficits in per capita milk production.

7.2.2.1 Cultivation

Some aspects of long-term change such as cultivation are well underway today. Although there has been sporadic cultivation among the Boran in the past (see Section 4.4.1.1: *Pastoralism and cultivation*), it is predicted that cereal cultivation will now become permanent in *madda* having higher rainfall and water-collecting landscapes that reduce risks of cropping. This will be a natural response of the Boran to per capita milk production declining below a minimum survival threshold. The human population will become increasingly settled in these farming areas and those involved in cultivation will be from all wealth classes with poor households that abandon the pastoral way becoming more common, however.

Draft technology using cattle and camels will expand in farming areas, with intensification of cultivation (including use of manure and better management of plots) taking place only when the best land is all filled, labour is not limiting and when production of grain is perceived by the Boran to decline as a result of reduced soil fertility (Hodgson, 1990). Extensive or low-input farming will thus predominate in the near future. Besides draft power, crop–livestock interactions will be dominated by feeding crop residues to cattle. Because these cultivated areas will happen to be closer to larger towns, and Boran nearer to towns are reportedly to be more amenable to social and economic change (Coppock, 1992b), it is speculated that these situations will offer special opportunities to introduce new technologies and management concepts that could facilitate development of agropastoralism first in certain suitable sites and later filtering elsewhere. Although range-development policy has never officially endorsed cultivation in the southern rangelands, the short-term alternative is widespread hunger and famine vulnerability among the Boran if cultivation is not permitted. Alternatives are discussed later in this chapter.

People in drier *madda* with less favourable landscapes for cultivation will continue to crop on an opportunistic basis only, with frequent failures. Hand cultivation of small plots may predominate and only opportunistic feeding of calves on crop residues will occur. But for the most part, households located in these drier areas will remain as pure pastoral operations.

7.2.2.2 Land annexation

As a response to overcrowding, fodder banks (*kalo*) have emerged during the past 20 years on the Borana Plateau (Menwyelet Atsedu, 1990; described in Section 7.3.1.2: *Grazing management*). *Kalo* are forage reserves "owned" by local residents that have been annexed from communal grazing resources at the *madda* level of resolution. It is understood that *kalo* are now a permanent feature of higher potential sites near encampments. Since nearly all encampments surveyed now have *kalo*, the rapid uptake phase of adoption may already be over (see the analytical framework in Rogers, 1983).

7.2.2.3 Labour availability

Despite a growing human population, 30 Borana elders expressed concern that labour constraints for livestock rearing were markedly worse in 1990 than in 1980 (D. L. Coppock, ILCA, unpublished data). The source of this problem is the recent increases in emigration rates for younger and poorer male Boran. This group represents the main labour pool for *forra* herding and raising well water, activities that are less suitable for women and children (see Section 4.3.2: *The encampment and the role of cooperative labour*). It is anticipated that emigration rates for this group and their male cohorts will continue to increase as the Boran become more aware of outside economic opportunities; and they acknowledge that, compared to their fathers and forefathers, they will have more difficulty gaining livestock wealth in the traditional system because of overpopulation. Emigration of mature males will place additional labour burdens on adult females, youths and children who are less able to leave the traditional sector (Coppock, 1992b). The increased burden of these activities could detract from women's substantial inputs into the management of both households and livestock (see Section 4.3.3: *The labour of married women*). Fear of labour shortages has contributed to reservations of sending children to school, but leaders acknowledge the increasing importance of education for their youth (D. L. Coppock, ILCA, unpublished data). Another outcome of key labour shortages may be increased human birth rates with families attempting to compensate for future labour shortages (Condon, 1991).

7.2.2.4 Wealth stratification

The decreasing ratio of cattle to people, in conjunction with drought and other perturbations, will serve to pauperise a growing proportion of the population. This is due to intensification of density-dependent competitive interactions (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). These interactions increase the risks of animal losses for all Boran but the chance that the poor could lose even the critical number of cattle needed for survival is greater (see Section 6.4.2: *Wealth effects on herd losses*). Below a certain threshold, household heads would have to decide whether to remain in the system or not. Male household heads could easily leave but women household heads may face greater difficulty doing so (above). This could contribute to a higher proportion of women heads of poorer households. Poorer families in food energy-deficit situations should move to peri-urban locations to sell dairy products to buy grain because their small herds prohibit animal sales (see Section 4.4.10: *Dairy marketing*).

7.2.2.5 Livestock and dairy marketing and herd diversification

The rate of livestock offtake will increase soonest in drier *madda* (i.e. where cultivation is not sustainable) as pastoralists are forced to buy more grain to supplement their diets. Increased rates of offtake may be delayed in *madda* with extensive cultivation but may eventually increase there also. Pressure to sell more cattle should manifest itself in several other ways: (1) younger male cattle will increasingly be sold compared to the past because of a gradual depletion of mature male stock traditionally preferred for sale (Coppock, 1992b); (2) where labour and disease risks permit, herd owners will attempt to produce more small ruminants as a replacement tactic to delay selling more cattle (Coppock, 1992b); and (3) additional emphasis may be placed on selling dairy products. Peri-urban dairy marketing will be far more prevalent than in the past, but flows of products will be highly variable due to climate, market access of households and wealth class (see Section 4.4.10: *Dairy marketing*).

If prices are allowed to increase for cattle to a level comparable with those offered by the cross-border black market with Kenya as appears feasible (Solomon Desta, TLDP economist, personal communication), the net effect will be: (1) for Ethiopia to harvest more cattle otherwise lost to Kenya; (2) other factors held constant, a substantial price increase may serve to reduce offtake rates overall given the relatively low need of pastoralists for cash income and increasing poverty of the society (Coppock, 1992b); and (3) herd owners whose main goal is to produce livestock for commercial sale will increase (see Section 4.4.6: *Market evolution)*. These persons often have strong links to the traditional sector, but are commonly urban-based and may be absentee owners in some cases. Although this activity will facilitate livestock purchasing by outsiders as adequate types and numbers of animals can be more readily delivered to buyers, commercial herds will increasingly compete with pastoral subsistence herds for resources.

7.2.2.6 Cattle herd composition

Increased rates of offtake may gradually decrease the proportion of male animals in cattle herds. This will also reduce security during drought, however, because males have important survival and trade attributes important for drought recovery. Households may increasingly trade Boran bulls for highland cows after droughts and the percentage of mature cows in the regional herd could slowly increase (see Section 6.4.4: *Traditional drought mitigation tactics*).

7.2.2.7 Miscellaneous household activities

Although some aspects of dairy marketing may intensify over time (see below), amounts of milk allocated for processing, especially for secondary products such as long-term fermented milk (*ititu*) and ghee (see Section 4.3.5.1: *Milk processing procedures*), will steadily decrease as a result of increased demand for fresh milk for home consumption or sale. This will arise from the gradual decrease in the ratio of milking cows to people. Use of non-dairy foods such as bush foods as dietary supplements for people will be undermined by the increasing reliance on grain; and with the traditional knowledge regarding them will thus be lost increasingly (Sperling, 1989).

7.2.2.8 Range ecology

In the absence of extensive range burning, the long-term trend will probably be for the woody population to gradually increase (see Section 3.3.2:

Long term vegetation change). Expansion of the woody segment of the vegetation may not be consistent over time, being instead a series of irregular grazing-mediated pulses (see Section 7.2.3: *Anticipated short-term cycles*). With the continued growth of towns, there will be increased local demand for firewood and charcoal and trees will probably be increasingly harvested by poor pastoralists and urban dwellers to generate income.

7.2.2.9 Social aspects

Recent political changes in the structure and emphasis of Peasant or Pastoral Associations in Ethiopia will initially result in a strenghtening of the traditional social institutions with which power has been shared in recent years (M. Bassi, Institute of Ethiopian Studies, Addis Abeba, Ethiopia, personal communication). Over time, however, this strengthening may be gradually undermined by defections of young men from the pastoral sector. This may threaten inter-generational transfer of knowledge of traditional rights and responsibilities among males (D. L. Coppock, ILCA, unpublished data).

Observations of Salih (1985) and Waters-Bayer (1988) suggest that as pastoral societies become more commercialised, men increasingly gain control over various aspects of dairy production and marketing previously in the domain of women. This possibility cannot be ruled out for the Boran.

7.2.3 Anticipated short-term cycles

Short-term cycles are best understood in relation to drought frequency. While these cycles may contribute to long-term trends in terms of wealth stratification, livestock productivity and marketing behaviour, they are most easily visualised as affected by density-dependent dynamics in the cattle population as driven by fluctuation in rainfall. It is important to recall that the cattle population can vary from <10 to >20 head/km^2 in just a few years. Elucidating the role of drought frequency in the regulation of livestock productivity, capital accumulation and loss, and environmental degradation is essential for understanding the dynamism of development opportunities and constraints. It is also important to note that these hypothesised patterns are probably relatively new developments to the cattle system connected with the removal of disease on the one hand and watering constraints in conjunction with a loss of grazing reserves on the other (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*).

These issues have been previously recognised, but they have not been looked into adequately to better understand pastoral development. As with the long-term trends hypothesised above, the following scenarios also assume that: (1) epidemic diseases of livestock will continue to be controlled; (2) labour constraints will have a relatively minor role in limiting animal numbers; (3) opportunities for land expansion remain minimal; (4) and the mortality of cattle in future two-year droughts will be similar to that observed in 1983–84.

To best illustrate the role of drought in Borana it is assumed that a two-year drought occurs once every 10 to 15 years and that cattle herds take about five years to recover their numbers (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). Thus, if droughts are 10 years apart the last five years preceeding the second drought will be the time when livestock populations are high enough to impact the perennial savannah; if droughts are spaced 15 years apart, the herds have 10 years to impact the environment. Thus, the longer the interdrought period, the greater the probability that impacts will be severe. This will be further complicated by whether the intervening rainfall is above or below average. If above average, some impacts will be less than if it is below average. (In the following discussion the five years of herd recovery will be termed as the drought-recovery phase, while the remaining period before the next drought will be the high-density phase).

7.2.3.1 Range ecology

If it is assumed that bush encroachment is encouraged by heavy cattle grazing (see Section 3.4.2: *Environmental change*), then the high-density phase will be the time when establishment of woody seedlings is most likely to occur. More seedlings may establish if the interdrought period is longer. Establishment may also be facilitated by above-average rainfall (Tamene Yigezu, 1990), but this would be true only to the extent that the grass layer is not in competition with seedlings.

The high-density phase will also be the time when livestock-induced erosion and changes in herbaceous composition and cover will most likely occur. The high-density phase will probably be the time when the pastoralists feel the greatest need to burn the rangeland in order to improve marginal grazing resources.

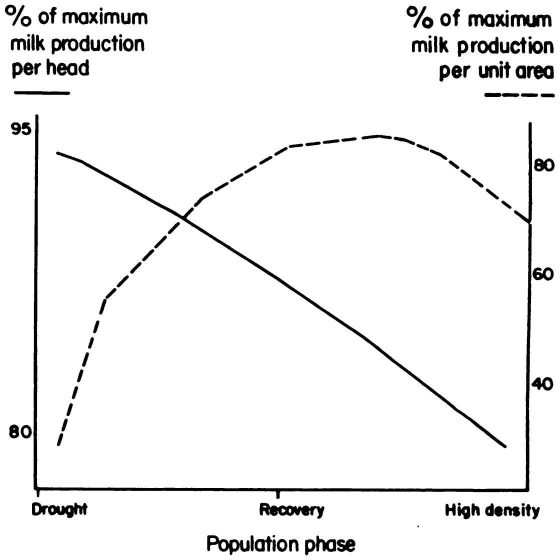
The standing crop of perennial grasses will be the highest throughout the year during the drought-recovery phase. The extent to which perennial grasses recover from grazing pressure during the previous high-density phase will be largely related to the chance that rainfall will be above average during the recovery phase. The worst scenario for the sustainable productivity of range vegetation is when interdrought periods are long and the rainfall is slightly below average, i.e. high enough for livestock not to die but low enough to not permit adequate recovery of vegetation from heavy grazing. If this happens for several interdrought periods in a row, it could translate into a long-term trend of declining range productivity. If interdrought periods are variable in duration and the volume of rainfall exhibits no clear trends, bush encroachment would occur in a series of irregular pulses.

7.2.3.2 Livestock productivity

Per head productivity of cattle in terms of milk output, calving rate, calving interval, average daily weight gain and nutritionally mediated calf survival rates will all be the highest in the recovery phase, even though affected by moderate seasonal fluctuations. This is deduced from producer surveys (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*) and literature that links animal performance with stocking rate (Jones and Sandland, 1974; Hart et al, 1988). Conversely, these production attributes will all be constrained to a greater degree in the high-density phase, when seasonal fluctuations in production will also be more pronounced. The environment will thus exert greater limitation over livestock productivity in the high-density phase. This control could be mediated through cattle nutrition. Seasonal limitation of nutrition in the drought-recovery phase will primarily be that of protein in dry periods. Minerals may constitute a minor problem during the later stages of the long wet seasons early in the recovery phase as well. In contrast, food energy will become the primary constraint during the high-density phase. At the highest densities of cattle, energy will be insufficient even during the long rains, and thus compromise compensatory weight gain, milk production and reproduction. It was during the high-density phase of 1981–82 that the unusual bimodal lactation curve of Boran cows was observed, probably indicative of a severe seasonal nutritional stress (see Section 5.3.2: *Calf growth and milk offtake*). It is hypothesised that the bimodal lactation curve is less likely to be observed during drought-recovery phases.

Cattle productivity per unit area, particularly in terms of milk, is hypothesised to be a major driving variable on human behaviour in the system. This is translateable into per capita milk yield at the household level of resolution. Cattle milk production per unit area, overall, will be the lowest in the first few years of the recovery phase and the highest during the first years of the high-density phase, after which it will gradually decrease because of density-dependent interactions (Figure 7.3). In contrast, nutritionally mediated productivity of browsing camels and goats, either per animal or per unit area, will be largely unaffected during the interdrought

Figure 7.3. *Conceptual model of milk production dynamics per cow and per unit area during an interdrought cycle of years having average rainfall..*



Source: Coppock (1993c).

cycle except for variation induced by fluctuation in rainfall but grazing sheep could suffer from competition from cows in the high-density phase (see Section 3.4.3: *Use of native plants*). The populations of camels and goats are assumed to be well below any limits imposed by availability of browse in the study area. Disease likely constitutes the most pervasive constraint regarding small ruminants and camels, regardless of population density and rainfall (see Section 5.3.7: *Ancillary livestock*).

7.2.3.3 Cattle herd composition

It has been shown that the composition of cattle herds changes to a higher proportion of male animals following drought (see Section 6.4.1: *Drought impacts on livestock*). Thus a higher proportion of males will characterise the drought-recovery phase and this will gradually lessen in the high-density phase. This contributes to the cycle of milk-production dynamics per hectare noted above, as mediated by resource competition between milk cows and other cattle.

7.2.3.4 Marketing of livestock products

Pastoralists sell livestock and dairy products primarily to buy grain to compensate for a shortage of milk. Thus, from hypotheses for livestock production (above), and assuming no cultivation for simplicity, the need to sell livestock and livestock products would decline sharply during a drought-recovery phase, bottom out briefly during one or two years of full herd recovery and then gradually increases again during the high-density phase as a result of a decline in cow productivity per unit area resulting from forage competition (i.e. compare Figure 7.1c on interdrought energy deficits with Figure 7.3 on cow productivity per unit area). Overall, the need to sell will increase if rainfall is below average during the entire interdrought period, and vice versa.

What to sell is a more complicated matter. Households located more than 30 km from market are probably relegated to selling only animals while those located within 30 km can sell both dairy products and animals, giving rise two subsystems. During the recovery phase, no herd owner will want to sell cattle (because what males they have they would want to trade for cows), and thus may opt instead to sell more fresh milk or small ruminants. Fresh milk, sold from a milk-deficit situation, will be the preferred sale item in the recovery phase in the peri-urban subsystem because per capita yields will be insufficient to make butter (see Section 4.3.5: *Dairy processing and marketing*). Poorer herd owners will always have fewer choices of what to sell compared to wealthy ones. During the high-density phase when capital accumulation and management risks are higher, wealthy herd owners may be more inclined to divert animals toward their social benefits (see below).

It is important to note that these cyclic patterns take place within a gradual long-term trend of increased per capita dairy marketing resulting from a declining ratio of cattle to people, which may be offset by cultivated food production depending on favourable conditions. It is predicted that there will be episodic increases in sales during drought-recovery phases in addition to the generally increased flow of dairy products associated with poor women residing near towns. This will also be influenced by the local contingenies of cultivation.

7.2.3.5 Land tenure

Denial of reciprocal grazing rights was observed in 1989–90 in heavily populated *madda* in the central plateau (D. L. Coppock, ILCA, personal observation). The long-standing tradition of allowing the cattle of nonresidents access to local *madda* resources, in return for future reciprocal access, has probably been fundamental in making diverse grazing and watering options available under times of stress (see Section 2.4.1.7: *Water resources*). Nevertheless it is predicted that denial of reciprocal grazing rights will become more common during dry seasons in the high-density phase while normal access will be granted during drought-recovery phases.

7.3 Review of intervention concepts

This section reviews intervention concepts based on development experiences backed up by research. Development and research are integrated because the most effective approach involved extension providing appropriate ideas for commodity-oriented research, not the other way around (see Section 1.4.7: *Interaction between research and development and project impact)*. Systems research was then used to generate the population-based models of long-term trends and short-term cycles (above). This was intended to provide insights as to when commodity-based interventions should be extended for maximum impact (see Section 7.4: *Component interventions and system dynamics).*

7.3.1 Range management and improvements

One fundamental goal of range management is to promote an optimal and sustainable level of animal production consistent with maintaining and/or improving a given forage base. This goal may be achieved in a hierarchical fashion (Pratt and Gwynne, 1977: pp 100–138). First, access of livestock to underutilised land must be achieved; and this is usually implemented through water development. Second, once access is secured the timing and intensity of herbivory may be regulated, which involves manipulation of the species, types, numbers and/or distribution of livestock. Third, some intensive inputs may be required to improve the level or distribution of primary production to increase carrying capacity. Fourth and lastly, additional intensive inputs may be required to rehabilitate sites in the event of failing to attain the second or third stages of the hierarchy. In this strategy extensive approaches precede intensive approaches (Herbel, 1983). This is an important point because African range development agents often focus more on intensive approaches consistent with expectations of higher-potential production systems in less risky environments. As a result they put fewer resources towards extensive management. It is thus understandable why efforts involving intensive interventions often fail (D. L. Coppock, ILCA, personal observation; see Chapter 8: *Synthesis and conclusions*).

Another major issue in African range management is the spread of cultivation. Cultivation is considered as a diversification response of pastoralists to a declining availability of food generated from livestock (see Section 4.4.1.1: *Pastoralism and cultivation*). At the worst, if cultivation is uncontrolled it could threaten dry-season grazing sites and threaten soil erosion (Moris, 1988; Scoones, 1991). If farming can be regulated to develop only in appropriate locations, it could complement livestock production, improve food security and open the door for other interventions dealing with crop–livestock interactions.

This review was organised in a hierarchical fashion according to the conceptual framework of Pratt and Gwynne (1977: pp 100–138) while at the same time attempting to merge range-management concerns with the needs of improved human welfare. As such it recognises that the constraints and objectives of range management in traditional pastoral systems are different from those in commercial ranching (Behnke, 1983; 1984; 1987). The review starts with a section on water development followed by material on grazing management, range improvements, and site rehabilitation.

7.3.1.1 Water-development activities

For pastoral systems improved access to land is most readily achieved through water development. In addition, if water development is designed to be ephemeral it can also be an element of the second stage of range management in terms of seasonal regulation of livestock density and distribution. For the Borana pastoral system, where water for people is in short supply and human labour is a critical input for watering animals, water development must also be more broadly defined in terms of improving human welfare through increased access to water for households and the need to improve labour efficiency. Ideally, the amount and temporal availability of water must only be sufficient to sustain a density of stock commensurate with optimal use of vegetation in a given area. Provision of water in excess of this amount can otherwise lead to environmental damage (Sandford, 1983b).

Extensive water systems for large stock and people

Lack of surface water is perhaps the most defining characteristic of the central Borana Plateau (see Section 1.4.2: *History of lowlands development and the TLDP*). Partly because the lack of water provided a traditional constraint on cattle numbers, the southern rangelands have been regarded as one of Africa's premier rangelands in terms of vegetation condition and trend (Pratt, 1987a). Starting in 1976, development efforts in SORDU were originally focused on expansion of the wet-season grazing area for cattle through construction of strategically placed ephemeral ponds that were intended to augment the traditional ponds system maintained by the Boran through hand labour. The new ponds were to have moderate capacities in line with promoting sustainable use of adjacent forage resources.

TLDP management was sensistive to problems of unregulated water development that had occurred in other African pastoral systems (Girma Bisrat, PADEP Coordinator, personal communication). Prior to undertaking this activity it was estimated that only 66% of the wet-season range was accessible to cattle because of scarcity of surface water (Cossins, 1983d).

Expansion of wet-season grazing was expected to: (1) prolong a higher level of wet-season nutrition for cattle for one to three more months each year (Cossins, 1983d; Girma Bisrat, PADEP Coordinator, personal communication); (2) promote higher levels of milk production (see Section 5.3.2: *Calf growth and milk offtake*); (3) improve conditions for animals as they enter dry seasons; (4) reduce pressure on dry-season range adjacent to the deep wells; and (5) help delay the large labour commitment for raising well water (Cossins, 1983c; see Section 2.4.1.7: *Water resources*). A secondary emphasis was placed on the maintenance and re-excavation of deep wells used in dry seasons. SORDU did most of the work involving deep wells, but ancillary contributions were made by non-governmental organisations such as CARE-Ethiopia and the Norwegian Church. The material here will only briefly highlight important perspectives related to large-scale water development. Readers should consult Section 2.4.1.7: *Water resources* for background on main types of water sources and their annual contribution to the production system. Other details on water resources may be found in AGROTEC/CRG/SEDES Associates (1974i), Cossins (1983c; 1983d), Donaldson (1983), Irwin (1986a; 1986b; 1986c), EWWCA (1987), Tilaye Bekele (1987), and Hodgson (1990).

The following review does not consider some 40 ponds constructed in projects involving the Ministry of Agriculture or USAID starting in the 1950s. Large permanent ponds such as Beke Pond constructed prior to the initiation of the TLDP have had considerable positive and negative impacts on the production system, outlined in Section 7.1.3: *Review of pastoral system dynamics and past interventions*. Boreholes and hand pumps have been recently recommended as a means to alleviate water constraints in urban situations (EWWCA, 1987) but have never been strongly considered for the pastoral sector. This is because development philosophy has focused more on augmenting traditional water resources and because pumps used to extract water from boreholes have commonly been unsustainable (Hodgson, 1990).

Ponds

SORDU constructed some 95 ponds, ranging in size from 10 000 to 60 000 m^3 capacity, during 1976–1986 using heavy machinery. SORDU bore all costs. Roughly 12 ponds were constructed to support three holding ranches (see Section 1.4.5.5: *Ranch development*) while the rest were built in the traditional pastoral sector. It was expected that the Boran would help maintain the ponds in the pastoral sector. While some ponds have been successful (see Section 7.3.1.2: *Grazing management*), major problems in sustaining the intervention have involved excessive losses of water through seepage and high rates of siltation through poor watershed management (Irwin, 1986a; 1986b; 1986c; Tilaye Bekele, 1987). Of 37 ponds constructed by 1982, 30% were judged as out of use, another 54% as silted-up but still in use and 5% with substantial seepage problems (Cossins, 1983d: p 6). In another sample of 38 SORDU ponds inspected in 1986, 17 (44%) were reported as nonfunctional or "doubtful" (Irwin, 1986a; 1986b). In contrast, only three of 14 ponds constructed by the joint Ministry of Agriculture/USAID activity were scored as nonfunctional (Irwin, 1986a; 1986b).

Failure of pond development at Dembel Wachu Ranch because of seepage problems (Cossins, 1983d) and difficulties in establishing ponds or boreholes at Wollenso Ranch (Menwyelet Atsedu, Colorado State University, personal comunication) seriously undermined implementation of the ranch concept during the 1980s. Some ponds were reportedly built having a larger capacity than warranted by the local ecology (Cossins, 1983d). Water development problems have thus involved both technical and social issues.

While there is evidence that permanent ponds to the north of the study area provided critical and sustained access to previously underutilised grazing resources (see Section 7.1.3: *Review of pastoral system dynamics and past interventions*), there are no hard data concerning to what degree the SORDU pond programme increased Boran access to wet-season range. Even if it is assumed that increased access is significant, difficulties in maintaining ponds suggest that it is not permanent. One of the key questions is why the Boran have apparently been reluctant to maintain SORDU ponds. A major part of the strategy was that the Boran would desilt ponds using large, metal cattle-drawn scoops (Cossins, 1983d; Abiye Astatke et al, 1986). SORDU hoped to promote this approach in order to reduce demand for foreign exchange for purchasing fuel and spare parts for heavy machinery. While the Boran are willing to train cattle to pull ploughs for cultivation, they have been far less willing to do the same for pond scooping (Hodgson, 1990). This is ironic in view of the fact that Boran have been observed to use pond scoops at their own initiative, to clean manure from cattle corrals manually (R. J. Hodgson, CARE-Ethiopia, personal communication).

These issues seem to bear on the reluctance of the Boran to maintain the SORDU ponds: the simplest hypothesis is that the Boran are unwilling to risk the condition and health of cattle for pond maintenance at stressful times of the year. Cattle have a high socio-economic value being highly prized household assets (Coppock, 1992b). Desilting pond using scoops is laborious, often requiring many days even for moderately sized ponds (D. L. Coppock, ILCA, personal observation). The best time of year to desilt ponds is the warm dry season when soils are dry and easier to handle. Since ponds are located far from wells and in sites where forage has been often depleted, it is difficult to maintain cattle at work sites in terms of providing adequate forage and water. This necessitates a work rotation for cattle that has been difficult to organise and sustain (R. J. Hodgson, CARE-Ethiopia, personal communication).

Since the Boran commonly desilt ponds in the traditional networks using their bare hands (see Section 2.4.1.7: *Water resources*), it is understood that they are willing to endure relatively worse personal hardships in terms of labour compared to what they are willing to subject their prized animal assets to. Camels have also been used to pull pond scoops. While technically feasible, camels are low in number on the central plateau and are roughly twice the price of cattle (see Section 4.3.4.6: *Prices*). Camel owners should be no more willing to sacrifice them for a community project than cattle owners, despite requirements for forage and water that make camels easier to manage at dry-season work sites (D. L. Coppock, ILCA, personal observation).

Finally, efforts have been directed at reducing the scoop size and weight by half with the thought that work animals would then be under less stress (R. J. Hodgson, CARE-Ethiopia, personal communication). However, this did not appear to elicit much more interest among the Boran in spite of the modest extension efforts made (D. L. Coppock, ILCA, personal observation). Compared to the apparent failure of the pond scoop, it is noteworthy that a hand-tools programme initiated by CARE-Ethiopia that sold shovels to the Boran was very successful (Hodgson, 1990). This may illustrate critical differences in technology uptake related to felt needs of the people. The pond scoop was created and implemented using a top-down approach that ignored the cultural values that the Boran have for cattle as socio-economic assets, not as work animals (see Chapter 8: *Synthesis and conclusions*).

Another constraint against participatory pond maintenance is the likely expectation of the Boran that since SORDU built the ponds for them for free, SORDU should also maintain them (Cossins, 1983d). This attitude may not have occurred if the Boran had paid or donated labour for the pond construction in the first place. That the Boran become conditioned to receiving "gifts" from development agents, and that this apparently lowers their initiative, has been observed (Hodgson, 1990). In the late 1980s, SORDU policy shifted to promoting a cost-sharing approach in which the Boran helped pay for maintenance of water resources through livestock sales. This is viewed as a positive step to encourage responsibility among the Boran for infrastructural improvements and to promote monetisation. It has been reported that *madda* residents in Did Hara began to collect substantial sums of money for SORDU to desilt large ponds using heavy machinery in 1989–90 (Shewangizaw Bekele, ILCA, personal communication). Following through on this initiative has been constrained by several factors, however: (1) fuel shortages at that time precluded the chance that SORDU could undertake the work quickly; (2) the longer such a project is delayed, the greater the chance that collected money would be pilfered by some Borana leaders; and (3) the 1990–91 drought subsequently devastated cattle herds (see Section 6.3.3: *Drought effects in 1990–91*). This meant that capital assets for large projects would have to be delayed until the next high-density phase of the cattle population, likely to start in 1996.

Wells

Efforts to improve well systems have focused on: (1) maintaining physical integrity of operational wells; (2) re-excavation of abandoned wells; and (3) improving efficiency of water extraction. There have been relatively few efforts to consider excavations of new wells. This is not surprising given the large size and depth of *tula* wells (see Section 2.4.1.7: *Water resources*).

Efficiency of water extraction involves every aspect of the operations from leaky buckets (*okole*) used to pass water up the human chains to leaky troughs (*fetchana* and *naninga*). The buckets have traditionally been made from buffalo or giraffe hide. Given the scarcity of these species today (see Section 2.4.1.6: *Native fauna*), there has been concern that replacing worn buckets will be increasingly difficult (Cossins, 1983c; Hodgson, 1990). Plastic or metal buckets may become the norm in the future, but they are often viewed as inferior in terms of ease of handling (Hodgson, 1990). Leaky troughs can be a serious source of inefficiency (Cossins, 1983c). SORDU and other nongovernmental organisations have helped provide cement to repair troughs which were traditionally reinforced with clay. Cement is an important technology that is widely appreciated by the Boran but remains difficult to obtain because of the country's low production (Hodgson, 1990). Cave-ins of well walls occur after heavy rains and projects have been regularly undertaken to reinforce well structures. Other popular projects have involved redesigning and/or adding more well-access ramps for livestock. These projects have commonly involved contributions by the Boran for buying materials and labour in the form of food for work (Hodgson, 1990).

Occasionally there is an initiative by a non-governmental organisation or government ministry that usually work outside of the southern rangelands to install diesel or solar pumps in wells to reduce the need for human labour. This is technically feasible in many wells except perhaps in situations where subsurface recharge rates are very low (EWWCA, 1987). There is a great excitement among the Boran when a demonstration pump is installed (D. L. Coppock, ILCA, personal observation); this is not surprising given the possible reduction in drudgery pumps could offer. Following a study, however, these initiatives have been dropped since 1980s. Diesel pumps were apparently installed in some wells at Dubluk in the late 1970s or early 1980s (Shewangizaw Bekele, ILCA, personal communication). One reported outcome was that influential people then gained control over the wells with pumps since they no longer had to coerce or carry favour among poorer labourers. That poorer people assist in watering herds of the wealthy in return for food and future calves is an important aspect of social leverage in the community (see Section 4.3.2: *The encampment and the role of cooperative labour*). It is thus not surprising that Boran leaders would favour the use of pumps more than the poor.

More recent initiatives have involved requests by the Boran for SORDU to use heavy machinery at 13 *tula* wells to lower their floors so as to reduce the shaft distance from well floors (where the troughs are) to the *ella* or water source by half (Tafesse Mesfin, TLDP General Manager, personal communication). This in turn would shorten the human chains required to lift water. While this could have similar negative effects on the social structure that installing pumps would, at some time SORDU does have to be aware of a looming labour shortages among the Boran in the future and seek a balanced approach to the problem (see Section 7.2.2.3: *Labour availability*). SORDU must also consider whether water development could help in the reclamation or expansion of key *forra* or drought reserve areas (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*).

In 1987–1990 there were numerous requests from the Boran for SORDU to assist with well maintenance and re-excavation using heavy machinery. Work was to be largely paid for by the Boran under the cost-sharing philosophy (above). Over three years activities involved 23 wells and the collection of the equivalent of USD 40 000 for operating costs from the Boran (Tamene Yigezu, SORDU manager, personal communication). Well re-excavations have been carefully considered in light of their potential for contributing to local overgrazing; the Boran may attempt, however, to re-excavate wells themselves if they do not get the cooperation from SORDU that they want (Bassi, 1990). It is hypothesised that the increase in requests to conduct well-related help during 1987–1990 reflected increased demand for resources from a cattle herd in a high-density phase. This was also a time when risky cattle assets might have been more readily given up by the wealthy to support status-giving community projects (see Section 7.4: *Component interventions and system dynamics*).

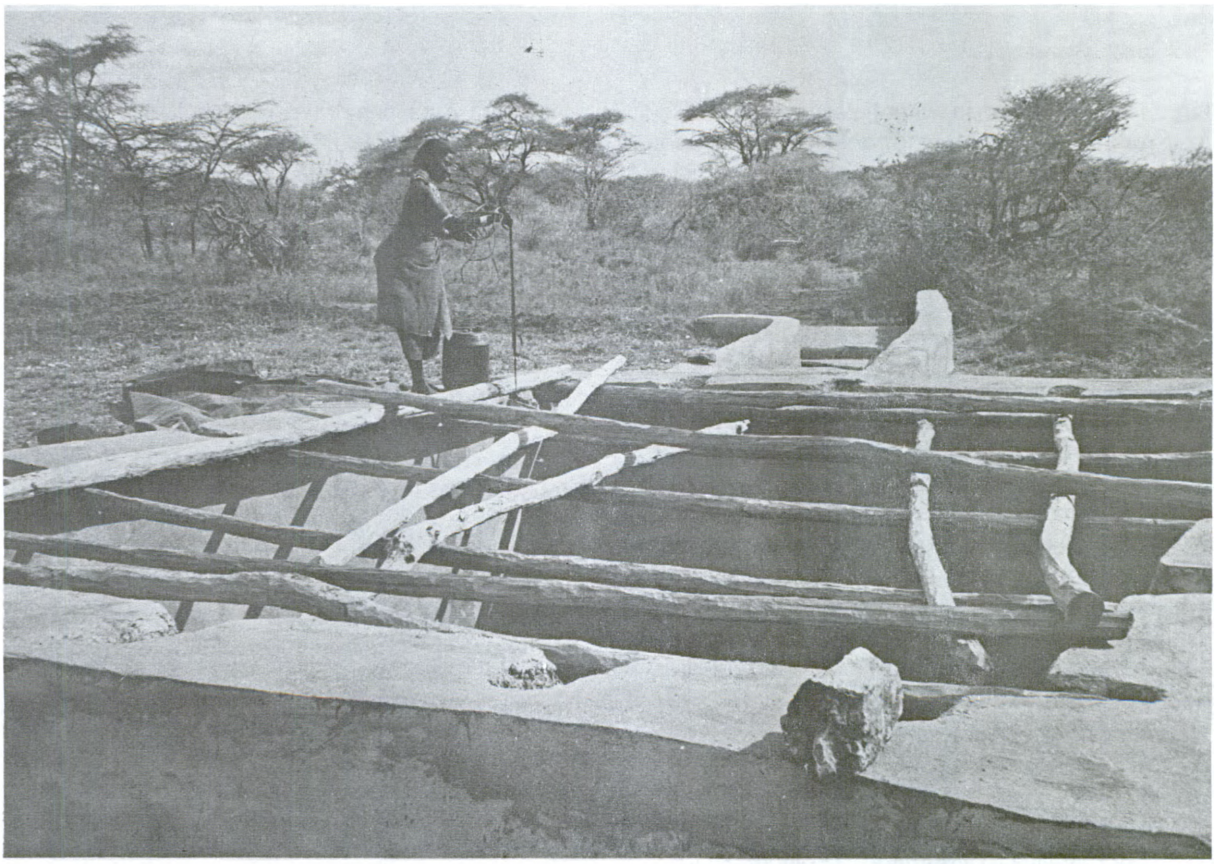
Local water sources for calves and people

Water tanks and holes

Although there was an emphasis at TLDP on building *birka* cisterns in Jirdu (Kidane Wolde Yohannes, TLDP Range Ecologist, personal communication), SORDU never promoted water-collecting structures among the Boran. As a result of extension efforts in 1986–87, CARE-Ethiopia responded to a felt need of the Boran for improved houshold access to water by initiating a cistern programme (Hodgson, 1990). The intent was that local cisterns could provide water for households and calves and hence reduce the drudgery of women who had to collect it from ponds and distant wells.

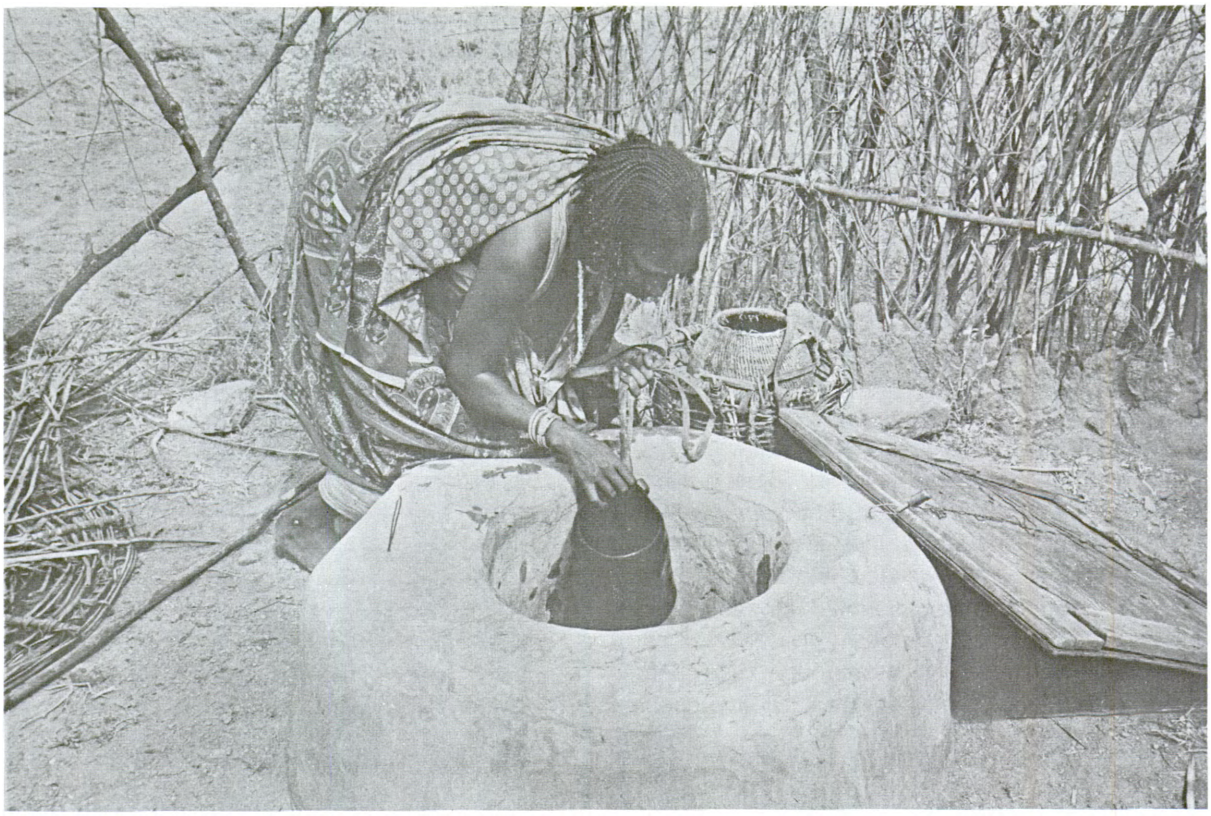
Construction aspects: Cisterns were either: (1) large, rectangular-shaped water tanks (90 000 to 150 000-litre capacity) for encampments; or (2) smaller, vase-shaped water holes (up to 5000-litre capacity) for one or more households (Plate 7.1a,b). The water tanks catch runoff from flat surfaces or

Plate 7.1 (a). *Water tank as promoted by CARE-Ethiopia in the southern rangelands.*



Photograph: Shewangizaw Bekele

Plate 7.1 (b). *Water hole as promoted by CARE-Ethiopia in the southern rangelands.*



Photograph: Shewangizaw Bekele

large rocky shelfs while water holes were to be filled from runoff or manually using containers to transport water from nearby ponds in wet seasons, i.e. using water otherwise lost to evaporation and seepage. Cisterns can have roofs (for the tanks) or lids (for the holes) made from local materials that reduce evaporation and fouling of water. The water tanks also have a cement channel and silt trap that funnel and hold water before it spills into the tank; water holes may also have these. The idea that water holes could be an appropriate intervention came from observations that women were filling underground grain stores (promoted earlier by CARE-Ethiopia) with hand-carried water (R. J. Hodgson, CARE-Ethiopia, personal communication).

It took several years to improve the design and minimise cracking of both types of cistern (Tesfaye Wogayehu, 1990). Materials required for a large water tank (with dimensions of 5 x 4 x 4 m) include about 50 kg of cement, clean sand, stone, nails, water and chicken wire. The size of a water tank is determined by the length of the warm dry season (typically 90 days), number of families in the targeted encampment(s) and daily water requirements per family (10 litres) and per calf (4–5 litres). An excavation is made in which an initial and final layers of pure cement sandwich five layers of a cement/sand mixture on the walls and floor. After three layers of a cement/sand mixture have set, one layer of chicken wire is nailed to the walls upon which the last two layers of cement/sand mixture are applied. Stone can replace chicken wire if necessary (Hodgson, 1990: p 31). Depending on the size, the total cost of materials, transport and masonry work for a tank ranges from EB 2300 to 3000, roughly the equivalent of selling six to eight bulls.

More details are provided in Tesfaye Wogayehu (1990). This information is reported here only to illustrate the complexity of construction. Once properly built the structure can last for many years with minor maintenance. CARE-Ethiopia has trained locals to undertake masonry work, but the degree of skill required is considerable. In contrast to water tanks, water holes require much smaller amounts of construction materials. Layering of the walls is similar to that for water tanks (Tesfaye Wogayehu, 1990). The cost for the holes is also much cheaper, less than EB 200.

Social and economic implications: Initial experiences in extending the use of cisterns have been reported by Hodgson (1990: pp 30–34, 40, 45). The philosophy is to prioritise those encampments over 20 km from the deep wells as they would be under particular stress in terms of this distance women and calves have to walk to get water in dry seasons. By 1990 less than 10 water tanks and a couple dozen water holes had been built or were on order (D. L. Coppock, ILCA, personal observation).

The first people interested in water tanks were wealthier Borana entrepreneurs and they were implemented as community demonstrations. Female heads of poorer households were able to have water holes built (D. L. Coppock, ILCA, personal observation). Initial problems revolved around subsequent attempts to privatise the water. Some of the new owners of water tanks and holes tried to sell water, a violation of Borana tradition that elicited complaints. This has subsequently been solved to a large degree by promoting community ownership of water tanks. The poor contribute labour in the construction while the wealthy donate cattle to be sold to finance costs (Coppock, 1990a). Everyone who participates thus gains access. The large size of the tanks and increased likelihood of communal use makes these the priority intervention (C. Fütterknecht, CARE-Ethiopia, personal communication).

Rather than donate cattle to build water tanks on a charitable basis to help ease the workloads of women in hauling water, it appears as though the motives of wealthy men in these projects are more to acquire status associated with the construction of a large semi-permanent structure that may be named after them (C. Fütterknecht, CARE-Ethiopia, personal communication). This fits with traditions of well and pond building (see Section 2.4.7.1: *Water resources*) and with the fact that encampments are also named after the influential *aba olla* (encampment "fathers"). Water tanks may thus give an outlet for those men of high or intermediate wealth for whom there are not enough status-giving community projects to contribute to.

The concern that the people would be unable or unwilling to pay for the water tanks was dispelled by findings of an external review team. The apparent willingness of the wealthy to translate animals into this novel form of prestige and influence is important in promoting increased livestock marketing and monetisation in the society. This apparent willingness to translate cattle assets into a physical structure may be related to the increased management risks associated with the high-density phase of the cattle population during 1989–90 (see Section 7.4: *Component interventions and system dynamics*). With an average of seven head sold per water tank, there are significant local implications for destocking. The major constraints in meeting the high demand for cisterns are the difficulties in procuring construction supplies and perfecting construction techniques to minimise cracking (Fütterknecht, 1990).

The main questions that remain in this regard are whether or not cisterns will be incorporated into the broader reciprocal patterns of resource use among *madda*, how user rights are transferred over time among different individuals, or what implications this has for increased sedentarisation of the population. In a survey of 67 encampments throughout the central plateau, Menwyelet Atsedu (TLDP/ILCA postgraduate researcher, unpublished data) noted that the Boran felt they were more sedentary compared to the past and that this was largely due to the attractions of roads and markets. It is unclear if increased sedentarisation of households is undesirable in normal rainfall years. The regular attempts of *madda* residents to try to regulate grazing pressure (D. L. Coppock, ILCA, unpublished data) indicate that sedentarisation is manageable as long as labour and land are sufficient to allow *forra* herds to move out of the area when necessary (see Section 5.3.1: *General aspects of cattle management*). Indeed, water tanks could be very beneficial because they could allow more families to reside in sites of lower grazing pressure further from the deep wells (Hodgson, 1990: p 30).

Implications for labour, water use and herd productivity: Coppock (1992a) reported a study of the effects of water tanks on women's time allocation, water procurement efficiency and household water use based on an analysis of 64 households during the warm dry season of 1990. Data included: (1) direct observation of 32 married women who had access to cisterns and 32 who did not on a 24-hour basis for one week (distributed over two months); and (2) nightly household interviews to quantify daily water budgets based on recall. Water tanks were located within 1-km distance from households while wells were within 7 km. Time for collecting water included walking and drawing water. Collecting water was undertaken for household use and calves. Women carry water in 20-litre jerry cans on their backs. One hypothesis was that access to a water tank would have dramatic effects in reducing the time women spend collecting water and a major result would be that women, freed of excessive water-collecting duties, would use their newly acquired time in other productive activities (see Section 4.3.3: *The labour of married women*). Another hypothesis was that water use by households and calves with access to water tanks would increase over those with no access to water tanks. Data were analysed using a factorial ANOVA (time budgets) or *t*-tests (water budgets); results are briefly highlighted here.

It was surprising to find that water tanks had only a nominal effect ($P<0.05$) on time women spent collecting water each week. An average of 3.6 h/woman/week was spent collecting water if they did not have access to a water tank, while those with access spent 3.2 h/woman/week. This suggests that the time women spent collecting water in dry seasons was greatly over estimated, even though this was based on many pre-trial interviews of women (Mulugeta Assefa, 1990).

The paradox of insignificant time savings accruing to women with water tanks was due to the fact that they collected water twice as often. Women with water tanks also appeared to draw water in a more leisurely fashion. Overall time budgets of women in the two treatments did not appreciably differ. Women were active some 16 h/day dominated by leisure (33%), general household management (31%), water collection (12%), milking cows (7%), child care (6%), other livestock management (5%) and firewood collection (4%). Women with water tanks, however, drew water twice as efficiently as those without access (42 vs 20 litres/hour worked). Water budgets are depicted in Tables 7.1 and 7.2. Families with cisterns collected about 72% more water than those without and the increment largely went to calves, not people. This may have increased calf water intake from 8 to 26 litres/calf/week, and could have been significant in terms of promoting higher intakes of forage also.

Table 7.1. *Volumes of water (litre/household/week) procured by members of 64 Borana households during the warm dry season (January and February) of 1990.*[1]

Water source	Treatment group			
	Traditional		Traditional plus access to cistern	
	Mean[2]	SE	Mean[2]	SE
Deep well	39*x*	9.4	2*y*	1.1
Spring	12	3.4	–	–
Pond	14*x*	5.8	4*x*	2.5
Runoff	6*x*	2.3	8*x*	3.9
Neighbour	7*x*	2.1	<1*y*	0.2
Cement cistern	–	–	120	7.4
Total	78*x*	8.9	134*y*	7.6

1 Data include water transported to the hut and used at the source as reported in nightly group interviews. Water procured at the source may have been estimated less accurately. All means may be divided by 3.9 to obtain litre/person/week.

2 Means within a row accompanied by the same letter *(x, y)* were not significantly different ($P>0.05$) in t-test comparisons ($N=32$). Entries in which zero liters were recorded could not be included in statistical tests.

Source: Coppock (1992a).

Table 7.2. *Volumes of water (litre/household/week) used by members of 64 Borana households during the warm dry season (January and February) of 1990.*[1]

Water use	Treatment group			
	Traditional		Access to cistern	
	Mean[2]	SE	Mean[2]	SE
Drinking	5*x*	0.7	7*x*	0.8
Washing body	5*x*	0.6	6*x*	0.8
Washing clothes	6*x*	1.7	7*x*	1.3
Washing utensils	4*x*	0.8	4*x*	0.9
Cooking[3]	25*x*	3.5	26*x*	2.8
Donating[4]	10*x*	2.0	9*x*	1.4
For calves	23*x*	4.9	75*y*	5.9
Total	78*x*	8.9	134*y*	7.6

1 Data include water used at the hut and the source as reported in nightly group interviews. Water used at the source may have been estimated less accurately. All means may be divided by 3.9 to obtain litres/person/week.

2 Means within a row accompanied by the same letter *(x, y)* were not significantly different ($P>0.05$) in *t*-test comparisons ($N = 32$).

3 Includes making maize porridge, tea and coffee.

4 Water given away to friends and relatives. This was similar to volumes procured from friends and relatives in Table 7.2.

Source: Coppock (1992a).

This could be significant in mitigating calf mortality (Coppock, 1992a: see Section 7.3.3.5: *Calf mortality mitigation*).

The high interest of the Boran in the water tanks belies some of the research results. The Boran believe that water tanks reduce time needed for collecting water and this is an important reason for their strong interest in this intervention. The effects of water tanks on women's work efficiency and organising their daily work load, however, may be more important cues than time savings *per se*. Water tanks would probably also confer a great benefit by reducing women's time for having water if households are located further than 7 km from the deep wells. Results also suggested that the impact of water tanks may be greater on calves than people through increased water intake. People were very conservative with water from the tanks because they knew that it was a finite supply, and they did not know how long the dry season would be.

Other economic implications: Mulugeta Assefa (1990: pp 46–105) studied the water-tank intervention in the context of improved calf management for households over a 10-year production cycle using a herd-modeling approach. It was assumed in the analysis that improved water intake would occur for calves that had access to water tanks and that this was a key component in the mitigation of calf mortality (Coppock, 1989b). The cost/benefit analysis suggested that use of water tanks should be highly profitable in the long term given the above assumptions. This analysis is described further in Section 7.3.3.5: *Calf mortality mitigation.*

Other aspects of water development

CARE-Ethiopia and SORDU have engaged in other minor forms of water development on the Borana Plateau. These experiences are reviewed in Hodgson (1990).

In sum, large and small-scale water development has involved many projects and has generally been successful. This success is due in large measure to the perception of the Boran that reliable water resources are crucial to their survival. To what extent, however, the pond programme is sustainable and to what degree ponds have contributed to stabilisation or destabilisation of the system during the past 15 years remains unclear. The cost-sharing philosophy for ponds, wells and cisterns will help identify projects most important to the Boran and encourage livestock offtake and monetisation in support of improvements in human welfare.

One remaining question on the use of cisterns involves how they could contribute to sedentarisation and local environmental degradation. This can only be addressed through research. For the pond and well programmes the most effective approach is to orient them towards use of heavy machinery and discount the notion that animal traction will ever be a crucial input. The only exception to this would be if animal traction could be marketed as a consumer service; not as something that requires herd owners to sacrifice their own animals for. Cement, shovels and similar technologies are the most important for uptake by the Boran. Access to these is most constrained by the external economy while access to foreign exchange is the ultimate constraint against using heavy machinery. External factors thus may exceed internal factors as root causes of underdevelopment on the Borana Plateau (see Chapter 8: *Synthesis and conclusions*).

7.3.1.2 Grazing management

The large-scale water interventions are essentially extensive improvements. The availability of new land for water development, however, has rapidly declined (Solomon Desta, TLDP economist, personal communication). Lack of space may now provide some incentives to the Boran to engage in more intensive activities for range management including aspects of controlled grazing. Some of these perspectives are treated in this section.

The traditional system

As reviewed in Section 2.4.1.7: *Water resources*, the wells are the critical resource on the Borana Plateau to which access is largely gained through the descent system. Although traditionally no herd owner may be verbally denied access to a given grazing area or *madda*, rules governing the use of wells can provide some *de facto* control over access to grazing, especially in times of stress (Bassi, 1990: p 263; Hogg, 1990a; D. L. Coppock, ILCA, personal observation). Even if a herd owner gains access to a new well during time of stress, his herd may be relegated to being last in the watering queue, and rather than water his animals late in the day or at night, he may be forced to go elsewhere (Bassi, 1990: p 272). Wealthy and influential men with large herds can also be denied well access if doing so would compromise other but more indigenous users (M. Bassi, Institute of Ethiopian Studies, personal communication). Traditionally, cattle are crudely inventoried in terms of 200-head groups, considered to be the maximum size for herding control (D. L. Coppock, ILCA, personal observation). If a herd owner has two of these groups or less, the community will provide labour for watering. If the herd owner has more animals than this, he must provide his own labour to water the increment above 400 (D. L. Coppock, ILCA, personal observation).

The Borana social system shows a high degree of egalitarianism and this has a great bearing on resource sharing (Asmarom Legesse, 1973; Bassi, 1990; Hogg, 1990a). The pattern of *de facto* boundary enforcement of *madda* as mediated by water access, however, appears to be in contrast to some observations to the effect that territorial boundaries seem to disintegrate in a "free for all" when other aspects of the pastoral system are under stress (Helland, 1980a). While the Borana system may superficially appear to be managed as a "grazing commons", this may be more the case within certain *madda* than among all *madda* in general. Even within *madda* there are other subtle means of allocating grazing resources (below). Considerable internal stress can occur when *madda* are perceived by residents to be overstocked.

The problem today, however, is that there are fewer fallback options outside of the home *madda* because of a general increase in the population (D. L. Coppock, ILCA, unpublished data). The "tragedy of the commons" model, with inevitable misuse of resources by pastoralists, appears too general for practical application here as elsewhere (see Feeny et al, 1990). Here it is more a case of human overpopulation leading to a breakdown of the traditional regulatory processes that constitutes the main threat to sustainable resource use, not that traditional regulations were never in place (see Chapter 8: *Synthesis and conclusions*).

Hogg (1990a) described the traditional territorial organisation of the Boran which still exists today. *Madda* are regional grazing areas associated with well group(s); there are some 35 *madda* on the central Borana Plateau (see Section 2.4.1.7: *Water resources*). *Madda* can be composed of sub-units called *deda* which are grazing areas customarily used by clusters of neighbouring encampments (*olla*). Non-residents of these *olla*, however, may also use the *deda* on occasion. Council meetings are held to discuss aspects of *deda* management, including demarcation of wet and dry-season grazing areas. *Deda* residents must obey rules set down by the council. *Deda*, not *madda*, are thus the fundamental grazing management units (Hogg, 1990a). Hence *Deda* are the appropriate unit to consider when it comes to traditional grazing management practices and whether interventions are feasible.

Recent crisis and innovation in the traditional system

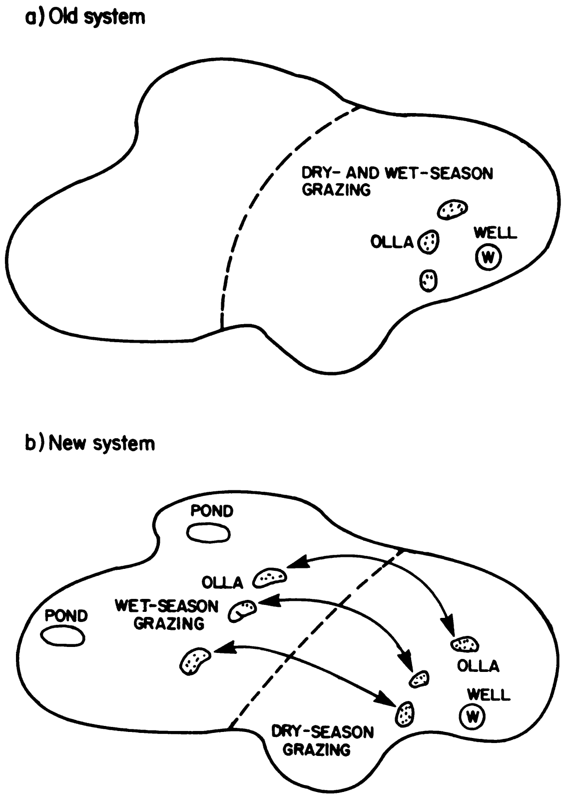
Deda and *forra* management

Increased populations of people and cattle have served to first undermine the *forra* (satellite) grazing system for cattle (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). Traditionally, *forra* herds would be moved out of their home *madda* soon after the long rainy season to exploit underutilised areas elsewhere. Out of some 35 *madda*, roughly seven have been traditionally used by others as fallback *forra* regions in addition to their role as home *madd* a for their residents. These *madda* typically have reliable deep wells that function during droughts, and include Burbur (or Borbor), Das, Dubluk, Gayo, Goray, Medecho and Web (see Figure 2.10). The availability of these sites for *forra* in the late 1980s had been reduced by the growth of the resident population because of immigration of new residents from nearby *madda* that were overcrowded (D. L. Coppock, ILCA, unpublished data). As one response to this crisis, the leadership of the Dubluk *madda* decided to prohibit entry of nonresident (*forra)* herds in 1989 . Emboldened by this a similar action was taken by six other *forra madda* shortly thereafter. An uproar ensued and the *Gumi Gayu* council, the supreme decision-making body (see Section 2.4.2.2: *Some cultural and organisational features*), declared that closure of traditional *forra madda* was unlawful and insisted they be re-opened. The leaders of the *forra madda* had to comply with this ruling and re-open them (D. L. Coppock, ILCA, unpublished data). It is noteworthy that the crisis of 1989 ensued during the high-density phase of cattle population (see Section 7.2.3: *Anticipated short-term cycles*). No such crisis was perceived during the drought-recovery phase of 1985–88. Land tenure crises are thus hypothesised to be more of a cyclic, rather than permanent, feature of Boran society (see Section 7.4: *Component interventions and system dynamics*). The frequency of such crises, however, may now increase because of growth in the human population.

Another response to increasing pressure has been to accomodate both *warra* (home-based) and *forra* cattle herds within *madda* for a longer period each year. Traditionally, *madda* reserved certain restricted local sites for year-round *forra* grazing, but these were rarely used. They were often symbolic in nature (D. L. Coppock, ILCA, unpublished data). Some *madda* residents have responded to increased population pressure by devising innovations in land use and these provide illustrations of how creative thinking can help alleviate grazing problems.

The residents of Gobso *madda* (Figure 2.10) received recognition from the local government administration in the late 1980s for their new grazing system. The former and current systems are depicted in Figure 7.4 (a,b). The former system was based on *warra* grazing throughout the year in the vicinity of the deep wells with *forra* animals being sent outside. This resulted in year-long heavy use of vegetation within the grazing orbit of the wells.

Figure 7.4. *Schematic depiction of changes in grazing resource allocation for Gobso* madda *in the southern rangelands during the mid- and the late 1980s.*



The need in recent years to accomodate more people and animals has led the residents of Gobso to dig new ponds away from their existing deep wells so as to gain access to underutilised grazing; these ponds augmented one original pond constructed by SORDU (Figure 7.4b).

The high utility of these new ponds has led to increased mobility in the *madda*. Residents now live in the region with ponds during the wet seasons and retreat to the region near the wells in the dry season; with this the vegetation has benefited from a wet season with no grazing. The families maintain encampments in both regions and these are thus vacated for part of the year. Furthermore, the two wet and dry-season regions have been subdivided into *warra* and *forra* zones to accomodate *forra* cattle throughout the year; the *madda* as a whole is thus divided into four large blocks (Figure 7.4b). This last aspect of the system reduces major uncertainties of forage supply that may otherwise be caused by continuous grazing. Some rest for the vegetation is provided, but the four blocks are not rotated according to seasonal use because of the fundamental problem of uniform water access in the dry season.

The residents of Gobso *madda* have shown ingenuity in improving their grazing system at the *deda* level of resolution. Further detail improvements such as rotation grazing may have a scope for implementation in the future but this would probably be influenced in a dynamic fashion by the proposed interdrought cycle (see Section 7.2.3: *Anticipated short-term cycles*). During the herd-recovery phase no further grazing management is likely required because cattle density is lower. During the high-density phase, however, some aspects of rotation grazing may be implemented when the system is heavily stocked.

In drier pastoral systems, *de facto* rotation grazing may be practised simply because of the variable distribution of rainfall; for example herds tracking patches of green-flush may not hit the same patch in successive years. In the Borana system, high population densities and the relatively reliable rainfall give a higher probability that sites are grazed on an annual basis. Thus, while the Gobso example provides an impetus for improved grazing management, it may still ultimately be limited by the spectre of range degradation from heavy grazing of wet-season areas. Again, this would be most likely in the high-density phase of cattle population and particularly if rainfall is slightly below average (see Section 7.2.3.1: *Range ecology*).

Plants may be most suceptible to heavy use by livestock during wet seasons (Pratt and Gwynne, 1977: p 112). In contrast, heavy grazing during dry seasons may have little permanent effect on vegetation that is largely dormant. Thus, without implementation of rotations, it is necessary that the wet-season grazing area be relatively large in relation to the number of animals and the size of the dry-season grazing area (Pratt and Gwynne, 1977: p 114). In a review of temperate-zone recommendations, Pratt and Gwynne (1977: p 95) noted that removal of standing biomass should not exceed 50%. It is likely that grazing pressure in Borana commonly exceeds this, especially in the high-density phase of the cattle population (D. L. Coppock, ILCA, personal observation).

The ultimate grazing management problem then becomes how to implement grazing rotations under conditions of high population density and the lack of an even distribution of a permanent water supply. Pratt and Gwynne (1977: pp 112–120) give a number of examples of rotational schemes based on two to five blocks, with the general objective to rest at least one of the blocks on successive years. Such approaches are appropriate to ranches, but would have to be significantly modified to accomodate constraints in a pastoral system. The target area may have to be restricted to wet-season areas only and the proportion of land rested each year would have to be small because enlarging them would endanger human welfare over the short term. Herlocker (1986: p 29) reported that for development of Somali grazing areas (*degaans*), the land area to be rested each year was on the order of 10%, but this was also considered flexible given the variable conditions in different *degaans*. Despite initial resistance, this plan was reportedly accepted and provided another benefit in terms of a dry-season forage reserve (Herlocker, 1986: p 29).

At another level of resolution, the degree of rest for vegetation during the wet season can be altered from rest-rotation (complete protection) to deferred-rotation, in which use is delayed until seed-set is assured (Heady, 1975). It is speculated that some form of deferred-rotation grazing, with land area on the order of 15% or less, may be applicable for extension to some situations on the Borana Plateau, especially during the high-density phase of the cattle population. Implementation would need to be highly flexible in recognition of the differing resources of *madda* (see Section 3.3.1: *Ecological map and land use*), and the residents' having to feel some acute pressure on resources in order for them to be interested. In contrast, the drought-recovery phase of the cattle population presents a natural period for resting vegetation and the effect of the rest would depend on the chance that rainfall during this time is above or below average (see Section 7.2.3.1: *Range ecology*). Middle-level grazing management such as this on the Borana Plateau has received insufficient attention from research or development. It may be that some forms of a rotational system are already in use during the high-density phase and these should be examined. More case studies of grazing management in *madda* are required and this should be a high priority.

Kalo and their management

Hogg (1990a) reported that the *deda* grazing units are further subdivided into *ardha* (localities), populated by *olla* (encampments). It is at the encampment level that *kalo* reserves have been recently carved out of the traditional system and reserved for use by livestock owned by *olla* residents. *Kalo* are the ultimate form of land annexation in the Borana system.

Kalo were studied by Menwyelet Atsedu (1990: pp 10–53). Two surveys were conducted in 1988 that included 67 encampments in six *madda*. Information was collected on the incidence, history, physical features and management of *kalo*. Other studies were undertaken to assess the effects of *kalo* on vegetation, results are reported in Section 3.3.3: *Short-term vegetation change*.

Survey results were interpreted to indicate that the idea for *kalo* originated from the agropastoral Gujji to the north of the study area. *Kalo* have been used on the Borana Plateau during the past 20–30 years, and in part this was stimulated by local government administrators. Virtually all surveyed encampments had *kalo* (Menwyelet Atsedu, 1990). The average age (6.4 years) of *kalo* was similar to that for the encampments they served. Some (26%) were older then 6.4 years and passed from one nearby encampment to the next over time. *Kalo* averaged 12 ha in size, with a range of 1-80 ha. If they were less than 5 ha, they were commonly bush-fenced; larger ones were more typically delineated by natural features and protected by decree. *Kalo* size was determined by the number of young or sick calves anticipated in the coming year for a given encampment as well as by the local forage conditions. If conditions for a given year are expected to be poor, *kalo* are expanded in size. Most *kalo* were located on flat land or gentle slopes. These sites commonly had deeper soils and more productive vegetation.

Olla residents all participate in *kalo* site selection, although the leader (*aba olla*) has a particularly important role in the final decision. When and how to use *kalo* is also decided in a similar fashion. Calves may graze *kalo* in wet seasons when they are at least two months old. In the dry season, however, such young animals are hand-reared in the home (see Section 5.3.1: *General aspects of cattle management*) but cut-and-carry forage for them is often collected in the *kalo*. The main period of use for *kalo* is the warm dry season and, besides calves, older or sickly milk cows and small ruminants may be allowed access. The most important grasses in calf diets during the dry season obtained in *kalo* were ranked by Borana respondents as *Pennisetum* spp, *Chysopogon* sp, *Cenchrus ciliaris* and *Cynodon* sp. Shrubs such as *Pappea capensis* and *Grewia* spp were also regarded as important (Menwyelet Atsedu, 1990; see Table B9, Annex B).

Menwyelet Atsedu (1990: pp 43, 45–46) studied implications of *kalo* for the diet quality of grazing calves in the dry season of 1989. Grazing trials were conducted on and off five *kalo*. The feeding behaviour of four Boran calves was observed in each site for 1.5 h. Bites of all forage were recorded as to plant species and plant part as in Coppock et al (1986b) and forage samples were analysed for nitrogen, *in vitro* digestible dry matter (IVDDM), fibre fractions, and ash according to procedures of Van Soest and Robertson (1980). Diet composition was calculated based on bite frequency and bite size (dry-matter basis). The nutritive value of diets was estimated by multiplying forage-specific chemical values times the amount of the respective forages in the diet profile to obtain weighted averages (Coppock et al, 1986b). Data were analysed using an ANOVA; and the hypothesis was that diets in *kalo* would be nutritionally superior to those outside because of a greater diversity of higher quality forages inside *kalo*, due to protection from continuous grazing.

Results indicated that while calf diets did not differ (*P*>0.05) between on and off-*kalo* sites in terms of total bites, bites per minute, or per cent of stem, they did differ (*P*<0.05) in terms of per cent of leaf in diets, which was greater on *kalo* than off. This, however, did not translate into a significant difference in diet quality (*P*>0.05). It was concluded that the major effect of *kalo* was to provide a higher standing crop of forage for the dry season. In terms other than biomass they did not have any substantial nutritional advantages for calves.

In terms of social control of *kalo*, Menwyelet Atsedu (1990: p 20) reported that Borana regulation requires a fine of EB 50 to 300 for unauthorised use, but this rarely needed to be enforced. Warnings were more common. In one instance, however, a serious altercation among herd owners over unauthorised use of a *kalo* was reported in the Dubluk *madda* in 1989 (D. L. Coppock, ILCA, personal observation).

The emergence of *kalo* on the Borana Plateau is consistent with recent patterns of protected pastoral lands in Syria (Draz, 1978), Kenya (Oba, 1987; Grandin, 1987), Somalia (MASCOTT, 1986: p 95) and the Sudan (Behnke, 1985). This is considered as a means to protect and conserve local resources under threat from increasing populations. Other interpretations have been made, however, that consider fodder reserves as traditional innovations with implications for improved health management of livestock (G. Perrier, Utah State University, Utah, USA, personal communication). *Kalo* have become most prominent in *madda* such as Dubluk and Gayo under threat of internal population growth as well as from *forra* herds of nonresidents (see previous material in this section).

Menwyelet Atsedu (1990: pp 27–28) concluded that *kalo* may provide an opportunity to implement forage improvements. While there is a chance that some interventions could be appropriate, it is more likely that these would involve low-input activities consistent with labour constraints such as prescribed burning (D. L. Coppock, ILCA, personal observation). It is less likely that introduced herbaceous legumes would be successful (see Section 7.3.1.3: *Forage improvements*). This is principally because of the high competition from indigenous species (e.g. *Pennisetum* spp) on deeper soils, high-management inputs required for establishment and poor performance of exotic pasture legumes in the region to date. It must be remembered that the purpose of *kalo* is to reserve an increased standing crop of forage for the dry season. Cutting or trampling measures needed to establish new forages early in the wet season (see Mohamed-Saleem et al, 1986) could compromise wet-season forage production and thus bring increased risk for the utility of *kalo* later in the year (D. L. Coppock, ILCA, personal observation).

The idea that the *kalo* site could be rotated each year, and thus serve the two purposes of resting wet-season grazing areas (above) and as fodder reserve, is attractive. However, Menwyelet Atsedu (TLDP/ILCA postgraduate researcher; unpublished data) found resistance to this concept because *kalo* are usually located in the most productive and accessible locations. Changing *kalo* location from year to year thus incurs risks; i.e. in the event that a poor site is demarcated as kalo for a year in which there is a drought the people could be worse off. It was thought also that degraded pond catchments could be good candidates for kalo as protection would create a fodder reserve and at the same time reduce erosion into the pond (see Section 7.3.1.1: *Water development activities*). The Boran indicated, however, that this is not feasible: Ponds are used in the wet season when forage is abundant; when the dry season comes the people and calves are taken to the vicinity of deep wells and it is inconvenient to return them to the pond area for grazing (Menwyelet Atsedu, TLDP/ILCA postgraduate researcher, unpublished data).

Destocking

Synopsis of the Borana situation: Range planners are commonly preoccupied with the idea that communal pastoral systems need to be routinely destocked to preserve the environment (Sandford, 1983a). This concept has been mentioned in recent SORDU plans for monitoring range trend. When range trend is observed to be declining from transect surveys in a given *madda*, facilitation of local destocking is offered as one solution (Hacker, 1988a).

Even if destocking were unanimously regarded as a wise strategy for the southern rangelands (it is controversial; see below), how this would be accomplished is another matter. During the 1980s the Boran reportedly preferred to sell cattle to Kenya on the black market because they received a much higher price than in Ethiopia. It is argued elsewhere (Section 4.4.4: *Traditional marketing rationale*) that one reason households sought higher prices in Kenya was to reduce the number of cattle they had to sell over the long term, thus giving them a better chance of building their herds. Cattle prices within Ethiopia were regulated and low until 1990, and buyers were mostly government agents whose difficulties in procuring cattle at low prices were widespread (see Section 1.4.4: *Has national range development been successful?*).

Perhaps the biggest impact of this practice on cattle inventories were registered when the socialist government attempted to periodically fill large demands of cattle in attempts to provide beef for the military, then one of Africa's largest with over 250 000 soldiers. Each Pastoral Association (see Section 1.4.3: *The SERP and the Pilot Project* for a review of PAs) had a quota to fill from among its members, by selling cattle for the low prices offered. This resulted in particularly poor public relations with the Boran (Hodgson, 1990: p 54).

In sum, there have not been large incentives for the Boran to destock even if they had an inclination to do so. The prospects are, however, that cattle offtake will increase as the Boran are forced to buy more grain in the future (see Figure 7.2). In addition, there have been no attempts by the government in the 1980s to destock the southern rangelands in the name of conserving the environment. It is doubtful that there has ever been such an attempt.

While ecological research suggests that the central Borana Plateau has been degraded in terms of bush encroachment and soil erosion (see Section 3.4.2: *Environmental change*), it is speculated that much of the change due to bush encroachment is reversible with a wise plan of prescribed burning and if grazing is regulated at the *deda* level of resolution (Section 7.3.1.4: *Site reclamation*). A more serious environmental problem, however, may involve opportunistic cultivation, which is a response to too few cattle on a per capita basis (see Section 4.4.1.1: *Pastoralism and cultivation*). Even if stocking rates could be linked to degradation of range productivity, the cyclic pattern of impact resulting from flactuations in the livestock population would make this trend hard to detect (see Section 7.2.3.1: *Range ecology*). In other words, while a long-term negative trend in range productivity may exist, it would be obscured by post-drought periods of low cattle numbers and improving range trend, followed by high-density phases of declining range trend. This is hypothesised to be the reason Pratt (1987a) judged SORDU to be in "reasonable" range condition in 1987 (unknown to him this was the drought-recovery phase) while Hacker (1990) concluded SORDU range was in poor condition in 1989 (being in the high-density phase). And yet both are experienced professionals who surveyed sites in the same regions. The guiding philosophy on range trend should be to what extent post-drought recovery of vegetation cancels out deleterious trends that result from the previous high-density phase (see discussion of Walker et al (1987) below). To a large extent this depends on rainfall in the drought-recovery phase, and thus is a probabilistic phenomenon; i. e. sometimes drought-recovery will reverse earlier trends and other times it will not (see Chapter 8: *Synthesis and conclusions*).

Destocking is universally and fiercely resisted by pastoralists. That is because in reality there are always fewer and fewer "surplus" animals per capita to supply milk or wealth creating capability so that destocking means increasing poverty and risks for survival. In other words, there are everywhere too many people living in an already marginal situation and land scarcity does not allow increases in herd inventory. Borana leaders acknowledge that the central plateau is overstocked during high-density phases and they associate this with bush encroachment, lower cattle productivity and a declining welfare of the society (see Section 3.3.5.2: *Household use of plants and pastoral perceptions of range trend* and Section 6.3.3: *Drought effects in 1990–91*).

The problem is that for the vast majority of the population there is no alternative but to suffer perturbations and hope that a string of favourable rainfall years will minimise their difficulties. Most are unable to leave the system. *Madda* residents may argue among themselves in the high-density phase about possible actions to take to conserve resources (see below) but the declining availability of fallback areas limits their options (D. L. Coppock, ILCA, unpublished data). The Boran say that either such problems need to be solved by the next generation of leaders, or they be provided with government assistance to help them regulate aspects of resource use that the Boran culture is unable to impose upon itself. Imposition of some aspects of resource regulation has been reported as one favourable attribute of the former PAs implemented by the socialist government until 1990 (Solomon Dessalegn, TLDP/ILCA postgraduate researcher, unpublished data).

An increasingly acute "boom and bust" cycle of the cattle population could now be anticipated about every five to ten years in which milk production is chronically compromised and animal assets are needlessly lost (Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). This could be partially remedied by an alternative investment scheme for the middle class and wealthy whereby livestock assets are translated into status-giving community projects and/or banked in the form of simple savings accounts (see Section 7.3.3.6: *Cattle marketing*). Only in this context could destocking be pursued as a positive intervention because it still permits economic growth and attainment of social status for individuals despite increased population pressure.

It has been hypothesised that social attitudes regarding enforcement of resource-use regulations among the Boran will exhibit cyclic patterns depending on cattle density (see Section 7.2.3.4: *Marketing of livestock products* and Section 7.2.3.5: *Land tenure*). Research surveys and development experiences have indeed revealed important cyclic change in the attitudes of the Boran towards destocking (D. L. Coppock, ILCA, unpublished data). For example, during the drought-recovery phase it is anticipated that attitudes toward selling cattle will be very conservative and consistent with herd-building objectives. Some animals that have to be sold are done so to satisfy immediate cash needs. All will try to sell milk or small ruminants instead of cattle if possible, but the poor will be forced into selling more cattle because of a lack of any other option (Coppock, 1992b). In the high-density phase the picture is probably different. Poorer households will still behave as before, but wealthier herd owners may be far more inclined to dispose of some cattle. This is not related to any need to purchase food or clothing, however, but rather as implicit recognition that density-dependent factors are causing a decline in cattle productivity and increasing risks of possible losses in their inventories. In addition, the high-density phase is a time of increased social pressure on the wealthy to destock excess animals so that the milk cows of poorer households can find adequate forage (D. L. Coppock, ILCA, personal observation).

Selling livestock merely for the sake of cash is inconsistent with Borana culture and the practical desires of herd owners to maximise their size. Although it is getting increasingly difficult to maintain a large herd Borana men still aspire for large holdings that in turn increase their wealth, status and political influence (Coppock, 1992b). During the high-density phase it appears that wealthier herd owners are more inclined to destock if they can transfer this form of animal wealth status to one of patronage to a popular community project (D. L. Coppock, ILCA, unpublished data). They thus can sell an animal, ingratiate themselves with their peers for destocking and retain some of the money. Of course, the real benefits that accure to a benefactor of an important project are both social prestige and future access to resources. Certainly these returns in sum are by far greater than losing the animal to density-dependent factors or sudden drought.

Examples of this behaviour in the high-density phase of 1989–90 are numerous on the Borana Plateau. Roughly EB 20 000 was collected from herd owners in the Did Hara *madda* to desilt a large pond, and this was obtained from cattle sales. Bassi (1990: p 275–276) reported that EB 3265 was collected to repair a well at Dubluk *madda* and other contributions of money for projects have replaced traditional donation of animals to be slaughtered for food at work sites.

Showing the risks of cattle keeping by wealthier herd owners in the high-density phase may convince them of alternate and more secure forms of investment safeguard against risk. The recent interest towards opening bank accounts in Yabelo by some wealthy herd owners is a critical finding in this respect and will be reported in detail in Section 7.3.3.6: *Cattle marketing*.

Other views on destocking: It is important to note that investigators commonly question whether destocking is worthwhile to pastoral systems. Sandford (1983a: pp 38–43) distinguished between conservative and opportunistic strategies of pastoral livestock production. The conservative approach is to keep a constant number of livestock that could not damage the range during years of lowest rainfall while providing net primary production. The opportunistic approach is to adjust the number of stock up or down in response to variation in forage resources; this may involve timely (efficient) or tardy (inefficent) adjustments. While the conservative strategy has advantages during low-rainfall years (i.e. animal losses would be few and the environment would not be damaged), during times of higher rainfall surplus forage would go unutilised. An assessment of the higher probability of average and above-average rainfall years may indicate that there are great costs for a conservative strategy in terms of livestock production foregone. Sandford (1983a: p 40) illustrated this by a hypothetical example in which a conservative herd owner would produce from 17 to 42% less than an opportunistic herd owner under varied degrees of conservatism in relation to climate. Although the opportunistic strategy may show more livestock production overall, it more consistently threatens to degrade the environment, particularly if adjustments in animal numbers in relation to resources are inefficient.

This last point is critical in evaluating the relative balance of advantages of either strategy. If numbers can be adjusted at the right moment, and if there are no negative carry-over effects of intensive grazing to the future, the opportunistic strategy is probably superior overall. However, Sandford (1983a: p 41) noted that the range management argument is that under an opportunistic strategy livestock numbers are not adjusted properly and that negative carry-over effects on the environment do occur.

In conclusion, Sandford (1983a: pp 40–42) noted that: (1) pastoralists are neither entirely opportunistic nor conservative, but the tendency appears to be more towards the former; (2) the greater the variation in rainfall the greater the opportunity cost of conservatism; and (3) effects of the environment, livestock species, local economy and culture would all be expected to influence the balance of benefits and costs accruing to either strategy.

Abel (1990) and Abel and Blaikie (1990) have explored the consequences of destocking policies for southern Africa. Abel conducted a preliminary analysis of the costs and benefits of opportunistic pastoralism versus conservative ranching in central Botswana by parameterising a simulation model with livestock and soil data for an 11-year run. It was noted that overall rates of energy output and the gross margin/livestock unit were higher in the ranching system but that energy output and gross margin/hectare were higher in the pastoral system (see Section 4.4.2: *Economic comparisons among pastoral systems*). The soil erosion resulting from opportunistic pastoral stocking was three times higher than that from ranches, which appeared to support the idea that environmental damage was a cost of opportunism. However, Abel cited Biot (1988) who had concluded that similar rates of soil loss for granitic landscape would not be expected to reduce herbaceous production for 400 years. Abel remarked in a preliminary conclusion that given this information, efforts to destock communal rangelands in Botswana would not be worth the social costs.

Walker et al (1987) studied wildlife population dynamics in response to drought in four conservation areas in southern Africa. The key issue was whether it was necessary to cull wildlife populations under the assumption that overuse of vegetation leads to a progressive deterioration in the habitat, or alternatively, were the habitats resilient enough to recover from overutilisation during periods of decline in wildlife populations due to drought? Conservation areas differed in ecological heterogeneity and management varied from heavy culling to no culling during periods of average rainfall. The dynamics were described for each in a comparative analysis. Drought intensity was similar for all areas. Walker et al concluded that pre-drought culling to preserve habitats was unnecessary if the herbivores had access to sufficient areas of reserved forage, but in instances where forage reserves had been eliminated by water development, pre-drought culling could prevent environmental degradation as well as catastrophic losses of animals during drought.

Relating these views to experience on the Borana Plateau, it must first be stated that the Boran in general appear to be opportunistic producers for social as well as biological reasons (Coppock, 1992b). Differences in behaviour, however, may occur especially among the wealthy in the drought-recovery phase (opportunistic) versus the high-density phase (conservative). Facilitation of incremental destocking among the middle-class and wealthy in the high-density phase is speculated (above) to be an important means to achieve efficient opportunism of production, reduce risk of permanent environmental degradation and reduce potentially wasteful losses of livestock capital. This strategy appears to capture the best elements of opportunism as outlined by Sandford (1983a). While the preliminary conclusion of Abel (1990) regarding the relatively minor costs of erosion is important, evidence from the Borana Plateau suggests that heavy grazing encourages bush encroachment, which likely occurs long before effects of erosion become evident. Even though some degree of bush encroachment is reversible, over the short to medium term it can reduce the utility of land (see Section 3.4.2: *Environmental change*).

Under these circumstances attention to destocking is warranted but better risk management for human beings is still the main benefit of creative destocking strategies. Experience among the Boran fully supports the perspectives of Walker et al (1987): the pre-drought occupation of *forra* areas by pastoralists fundamentally undermines the capacity of the system to adjust to future drought impacts (see Section 6.4.5: *Equilibrial versus non-equilibrial popuation dynamics*). Furthermore,if a high-density phase is long enough and rainfall is slightly below average, environmental degradation will be more likely to have a carry-over effect and undermine prospects for efficient recovery. Attempts to destock even incrementally during the high-density phase could provide safeguards against intense competition and density-dependent effects on cattle productivity and catastrophic herd losses in drought. Another useful, but socially difficult, strategy is to prohibit occupation of *forra* areas except in years of below average rainfall (Section 7.3.3.7: *Mitigation of drought impact*).

In summary, there is no reason to assume that the Boran have a vested interest in system sustainability beyond their immediate needs for asset accumulation and survival (see Swift, 1990). Destocking in the context of alternative investment is best justified in terms of system stabilisation to improve the immediate welfare of human beings. It is less justified in terms of promoting sustainability of the environment, which would be difficult to measure and is not as important a problem today as immediate human welfare (see Chapter 8: *Synthesis and conclusions*).

7.3.1.3 Forage improvements

The next stage in the range management hierarchy is introduction of new forages. It is important to note that forage interventions may be very difficult to implement in semi-arid environments under communal grazing tenure. Strategies to introduce new forages tend to receive more emphasis than better grazing management in African national programmes. This is because grazing management appears more complex and falls within the realm of social change. Apparently simple technical solutions like planting forages are easier to conceptualise and appear to fall more in the domain of research and development programmes. This does not confirm, however, that forage introductions should be the priority over better grazing management. As noted by Pratt (1987a: p 30) if overgrazing is the problem, it will not be solved by planting something new. New forages will also be eventually exhausted. The high inputs to sustain forage introductions are thus best justified, and will yield more sustainable benefits, if they are within a framework of grazing control. Other constraints related to problems of labour and cultural values regarding improvement of forage resources on the Borana Plateau will also be highlighted in this section.

Compared to higher-potential zones, drier regions of sub-Saharan Africa present fewer options for intervention with exotic leguminous forages, either for herbaceous or woody perennials (Tothill, 1986). Pratt and Gwynne (1977: p 122) noted that most attempts to introduce legumes into East African rangelands have been unsuccessful (apparently including efforts by private ranchers). They mentioned that more trials on legumes were needed but in the meantime all that could be safely recommended is promotion of the best indigenous grasses. In the semi-arid zone the debate about whether to promote indigenous or exotic forages must be tempered by consideration of adaptation to local conditions, including competitive ability against local vegetation tolerance to pests, diseases and a high degree of environmental variability. Plant performance must thus ultimately be judged in terms of persistence, not merely dry-matter yield over the short term.

In their analysis of the ability of African savannah ecosystems to recover from environmental disturbances, Walker and Noy-Meir (1982: pp 584–585) highlighted some attributes of plant species that contribute to system resilience. These included higher reproduction rates under stress, increased net primary production at low levels of above ground biomass, large root reserves and complex seed-dormancy mechanisms. This illustrates the large role of evolution in shaping persistence mechanisms in successful species of indigenous vegetation and suggests that the chance that an exotic would persist in such an environment is likely to be poor. Even in developed range systems with a successful history of legume establishment, persistence of legumes can be threatened by biological and economic changes.

In their review of Australian experiences, Gramshaw et al (1989) variously implicated the reduced use of phosphorus fertilisers, overgrazing, land degradation, new diseases and expansion of cultivation in the decline of introduced pasture legumes; some of these trends were related to general changes in management practices as a result of the falling profitability of ranching since 1970. One other factor calling for a critical review is the presumed role of legumes in fixing large quantities of nitrogen in rangelands. Nitrogen fixation demands considerable energy and it is less likely that plants under stressful rangeland conditions would have much energy to spare. Farnsworth et al (1978) reported that the evidence for nitrogen fixation by legumes in drier ecosystems is often equivocal. They also mentioned, however, that possibilities exist for nonsymbiotic nitrogen fixation in the rhizosphere of non-leguminous, native range species.

Exotic herbaceous legumes

Screening and establishment in native rangeland vegetation: The experience to date for the screening and establishing forage legumes in rangeland vegetation in southern Ethiopia is largely based on a series of trials carried out by ILCA (Migongo-Bake, 1986), CARE-Ethiopia (Hodgson, 1990: pp 60–65) and Yohannes Alemseged (1989: pp 136–150). For the most part only summary points will be highlighted here. This is largely because no species or cultivar was viewed as offering outstanding possibilities (Hodgson, 1990: p 62), despite the average or above-average rainfall during the study period from 1985–89. More rigorous evaluation may also be required for firm conclusions to be warranted. In addition, whether because of modest performance or other reasons, the pastoralists have shown little interest in the introduction of species that only serve as livestock forage.

In a review of 10 screening and establishment trials, Hodgson concluded that the most promising lines (with growth form in brackets and in descending order of performance) were: *Stylosanthes hamata* cv Verano (prone); *S. hamata* #167 (prone); *S. scabra* cv Seca (erect); *Cassia rotundifolia* cv Wynn (prone); *Centrosema pascuorum* cv Bundy (prone); *C. schottii* (climber); *Desmanthus* *virgatus* (prone); *Macrotyloma axillare* (climber) and *Desmodium discolor* (erect).

Stylosanthes spp

Comments are warranted regarding *S. hamata* cv Verano which was consistently ranked among the best of some 20 forage species initially screened by Migongo-Bake (1986). These results, in conjunction with the availability of seed in Ethiopia, led to its evaluation in most establishment trials. *Stylosanthes hamata* is regarded elsewhere as an outstanding plant well adapted to drier production conditions (Williams and Burt, 1983). It has, for example, made an important contribution to the beef industry in Australia (Gramshaw et al, 1989: pp 15–16).

Methods of legume establishment reported in Hodgson (1990: p 61) followed the approach of Mohamed-Saleem et al (1986). Sixteen 0.25-ha sites dominated by native vegetation were bush-fenced near encampments at Did Hara, Medecho, Melbana and Web *madda*. The sites were subjected to grazing and trampling by confined cattle after the starting of the long rains in March 1986. This disturbance was intended to reduce potential competition. To judge soil chemical constraints, triple superphosphate was applied to half of each site (Migongo-Bake, 1986: see Haque et al (1986) for a review of the role of phosphate deficiency in limiting performance of legumes). Seed was scarified, innoculated and broadcast at a rate of 10 kg/ha within a week of site preparation.

Germination rates were evaluated in May and were typically less than 10% at each site; this also was not influenced by the phosphate application (D. L. Coppock, ILCA, unpublished data). Seedling survival monitored through July was generally poor (i.e. <1%). A few instances of spreading were observed during the next two years but growth rates were uniformly low; plants usually never exceeded 7 cm in height. Abiotic constraints were likely important in the failure of *S. hamata* to perform adequately (see below). It is also speculated that another constraint for establishment could be competition from indigenous grasses (Robertson, 1988; Hodgson, 1990: p 63–64). Establishment was usually attempted on deeper soils (≥1 m deep) that would have higher water-storage capacity. These sites, however, were commonly dominated by deep-rooted aggressive *Pennisetum* bunch grasses. These plants were also relatively unpalatable to cattle in rainy periods and this undermined using grazing as an implementation technique.

Better performance of *S. hamata* cv Verano was observed in cultivated plots (1 x 1 m in size) at Did Hara prepared in 1985 as a yield trial (Migongo-Bake, 1986). Pure swards of *S. hamata* persisted for the next six years but plants never exceeded 20 cm in height (D. L. Coppock, ILCA, personal observation; Hodgson, 1990: p 64). Robertson (1988) visited Did Hara in 1989 and was encouraged by the seeding and spread of *S. hamata* cv Verano, *S. scabra* cv Seca, *C. rotundifolia* cv Wynn, *D. virgatus*, *C. pascuorum* and *Macroptilium atropurpureum*. Did Hara was the best site of the ILCA/CARE forage-screening programme (Hodgson, 1990: p 62). This was probably because Did Hara receives slightly more annual rainfall (600 mm; see Section 2.4.1.4: *Climate, primary production and carrying capacity*).

In another approach SORDU broadcast *S. hamata* cv Verano from a moving vehicle along roadsides throughout the subproject area in 1989. Follow-up surveys indicated very poor establishment (Gossaye Fida, SORDU, personal communication) even though roadside broad- casting had been successful in the Ethiopian highlands with higher rainfall (A. Robertson, FLDP consultant, personal communication).

Yohannes Alemseged (1989: pp 136–150) conducted an experiment to examine effects of ground preparation and manuring on germination and establishment of *S. hamata* cv Verano on a deep red soil site dominated by *Pennisetum mezianum*. The experimental design was a randomised split plot with three replicates per treatment. Plots consisted of one of two levels of manuring (0 and 2 kg/m^2) and the sub-plots consisted of three types of soil preparation (no preparation, hoeing to 20-cm depth and scratching to 3-cm depth). Seed was scarified, innoculated and broadcast at a rate of 6.6 kg/ha over all plots which were 3 x 3 m in size. Seedlings were counted at 15 and 105 days after sowing.

Results indicated the main positive effects of manuring ($P<0.01$) and soil preparation ($P<0.001$) on both germination (within 15 days) and establishment (within 15 to 105 days). Manuring increased germination and establishment by 100 and 49%, respectively. Differences between scratching and hoeing were minor, but relative to no soil preparation both increased germination and establishment by an average of 700 and 83%, respectively. Despite these results, Yohannes Alemseged (1989: p 149) concluded that performance of *S. hamata* cv Verano was unsatisfactory, which was also based on its very poor performance in another yield trial (see below). Poor performance was attributed to low rates of germination, perhaps due to seed quality.

In sum, even for a relatively superior exotic herbaceous legume, such as *S. hamata* cv Verano result are at best equivocal and at worst poor in the southern rangelands. Besides problems of management implementation, it is likely that the environment limited performance. Humphreys (1980: p 91) gives 600 mm of annual rainfall as the lower limit for *S. hamata* and this may explain its better performance at Did Hara. In addition, growth may be limited by the relatively cool temperatures (22 and 15°C on average for the mean and minimum, respectively, for seven sites throughout the year; see Section 2.4.1.4: *Climate, primary production and carrying capacity*). This was deduced from short internodes and the low growth habit of the mature plants (J. C. Tothill, ILCA, personal communication). Burt et al (1983: p 149) and Gramshaw et al (1989: p 15) listed *S. hamata* as a semi-arid species best adapted to warmer temperatures without specifying an optimum range. Williams and Gardener (1984: p 184) stated that dry-matter production and stem elongation of *S. hamata* cv Verano was limited by mean nighttime temperatures below 22°C and mean daily temperatures below 25°C. Temperature is thus probably a significant constraint in the southern rangelands.

In reference to the establishment methods of Mohamed-Saleem et al (1986), Robertson (1988) remarked that it was unfortunate that it had not been attempted on sites subjected to high levels of naturally heavy grazing, consistent with the success of the Ministry of Agriculture in the Ethiopian highlands. Researchers agree that in the event a truly superior legume is identified, the approach of Robertson (1988) could be more viable, and this is for social as well as biological reasons. Experiences on the Borana Plateau have indicated that labour is a common constraint (see Section 4.4.8: *Labour and the encampment*). Under such conditions it is unrealistic to expect pastoralists to put much effort into legume establishment.

Taking advantage of natural grazing pressure reduces this constraint. Areas near the deep wells may seem viable sites because of the high grazing pressure but this is so only during dry seasons. Wet season production of native grasses near wells is high and this would mean severe competition for introduced legumes (D. L. Coppock, ILCA, personal observation). In contrast, establishing legumes near encampments offers these benefits: (1) year-round grazing gradient to reduce competition; (2) a fertility gradient from manure probably containing enhanced levels of phosphorus; and (3) a local forage resource for young calves which are restricted to graze far from the encampments (see Section 5.3.1: *General aspects of cattle management*). This approach could be attempted in the future. Hodgson (1990: p 197) listed appropriate establishment sites for 21 leguminous species based on his experiences. This is shown in Table G2, Annex G.

Yield trials of forage and dual-purpose legumes by Yohannes Alemseged

Yohannes Alemseged (1989: pp 106–135) conducted a trial to assess biomass yield and nutrititve value of 10 promising annual and perennial legumes targeted for forage or dual-purpose use (seed for people and forage for livestock). These were selected on the basis of seed availability and screening trials conducted by Migongo-Bake (1986), Hodgson (1990: pp 60–65) and the Norwegian Church Aid (NCA) in Yabelo (Yohannes Alemseged, 1989: p 107–108). The trial employed a complete randomised block design with four replicates per legume and a plot size of 2 x 3 m. Native vegetation was cleared from a fenced area ploughed by oxen. The site was leveled and plots were demarcated with wooden pegs. Six 2-m long rows, 50 cm apart, were sown in each plot on 24 March 1987, at the beginning of the long rains. All seeds were scarified and innoculated using standard methods (Yohannes Alemseged, 1989: p 110). Plots were harvested 116 days later on 18 July. Annual species were harvested at 6 cm aboveground level from the middle 45% of the plot to minimise edge effects. Perennials were harvested at the same height using a variant of a split-plot procedure. Plots were divided length wise and one was randomly selected and harvested on 18 July with the outer two rows discarded to eliminate edge effects. This plot was harvested again for regrowth at the end of the cool dry season (September), after the short rains (November) and in the long dry season (December). Out of the remaining four rows in the other half of the plots, one was randomly selected for harvest in September, November or December to sequentially contrast performance over time. Crude-protein (CP) content of leaves and stems were determined for five species from per cent kjeldahl nitrogen x 6.25 as in AOAC (1980) while estimation of per cent *in vitro* dry-matter digestibility (IVDDM) followed procedures of Goering and Van Soest (1970). The same analytical procedures were used for determination of whole-plant chemical characteristics of *C. rotundifolia* and *C. schottii*, due to their morphology.

Total dry-matter fodder yields of legumes from July to December are presented in Table 7.3 and indicated *C. rotundifolia* cv Wynn, cowpea (*Vigna unguiculata* cv White Wonder Trailing) and *Lablab purpureus* to be the most productive. Effects of harvest date on yields of the five perennials are shown in Table 7.4 and indicated that *Macroptilium lathyroides* and *Cajanus cajan* had the highest average productivity. In contrast, there were no differences (P>0.05) among perennials in terms of regrowth. Regrowth typically decreased with sub-

Table 7.3. *Dry-matter yields (kg/ha) of forage for eight legumes under cultivation conditions at two sample dates in 1987 at Dembel Wachu ranch in the southern rangelands.*[1]

Species/Cultivar	Harvest date[2]	
	July	December
Vigna unguiculata cv White Wonder Trailing	9708	9708
Lablab purpureus	7949	7949
Macroptilium lathyroides	5746	6483
Vigna unguiculata cv IT-82	6458	6458
Cajanus cajan	2481	3565
Desmodium discolor	2048	2641
Cassia rotundifolia cv Wynn	1168	1600
Centrosema schottii	619	931

1 Tabular entries that vary by: (1) ≥ 807 for the July harvest date; or (2) ≥ 1267 for the December harvest date, were significantly different (P ≤ 0.05) according to an LSD (least significant difference) test.

2 Planting took place on 23 March or 11 April. Perennials were harvested more than once. See text for details.

Source: Yohannes Alemseged (1989).

Table 7.4. *Dry-matter yield (kg/ha) of five perennial forage legumes at different harvesting dates in 1987 planted during March and April at Dembel Wachu ranch in the southern rangelands.*

Species	Harvest date[1]				
	July	September	November	December	Mean[2]
Cajanus cajan	2481	2385	3165	3075	2717
Desmodium discolor	2048	1085	1185	2125	1698
Cassia rotundifolia cv Wynn	1168	1535	1070	1145	1217
Centrosema schottii	671	715	430	395	555
Macroptilium lathyroides	5746	2080	1865	3235	3734

1 Entries in monthly columns that varied by ≥ 671 were different (P≤ 0.05) according to an LSD (least significant difference) test.

2 Entries in this column of means that varied by ≥ 590 were different (P ≤ 0.05) according to an LSD test.

Source: Yohannes Alemseged (1989).

sequent cuttings except for *C. cajan* and *M. lathyroides* (Table 7.4).

Crude-protein content of plant parts is shown in Table G3, Annex G. Values for leaves were commonly two to three times higher than that for stems. Crude protein content of stems and leaves was affected (P<0.05) by legume at the July harvest date; various interactions also were observed (P<0.05) for legume x harvest date for *C. cajan* and *D. discolor*. Whole-plant values for *C. rotundifolia* and *C. schottii* typically declined (P<0.05) from July to December.

Digestibility values are shown in Table G4, Annex G. Leaf IVDDM averaged 17 percentage points higher than that for stems over all legumes and sample dates. Stem and leaf IVDDM was affected (P<0.05) by legume and by the July harvest date. Whole-plant values indicated interactions (P<0.05) among legume x harvest dates between *C. rotundifolia* and *C. schottii*.

Yohannes Alemseged (1989: pp 128–134) concluded that the annual legumes typically produced more biomass than the perennials, but there was no evidence that annuals and perennials differed in terms of per cent CP or IVDDM. The difference in nutritive value among plant parts, the decline in nutritive value over time and the higher value of regrowth was consistent with previous research literature (Minson, 1977). The nutritive value of all forages was considered outstanding for livestock but the search for dual-purpose crops to feed people as well as livestock was noted as being most appropriate. This need in conjunction with trial performance, suggested that the annual *V. unguiculata* and *L. purpureus* as well as perennial *C. cajan* be prioritised for extension into appropriate intercropping systems in the southern rangelands. Results for an intercropping trial will be reported later.

Exotic woody plants

Screening and establishment trials: Hodgson (1990: pp 69–72) reviewed efforts to establish exotic trees by ILCA (Migongo-Bake, 1986), CARE-Ethiopia and SORDU. Seeds were usually scarified and inoculated and seedlings were reared under nursery conditions and transplanted to the field. Although most sample sizes were small and conclusions therefore limited, a number of species had done well and may merit further research (Hodgson, 1990: pp 69–71). On well-drained, red upland soils largely at Did Hara and Melbana *madda*, the most reliable performances have been observed for *A. albida* (a native elsewhere in Ethiopia), *Cassia artemesioides*, *Prosopis chilensis* and *P. juliflora*. *Enterolobium cyclocarpum, Gliricidia sepium, Leuceana diversifolia, L. shannoni, Parkinsonia acculeata, Samanea saman* and *Sesbania sesban* have also established. In depressions and other favourable sites where soil moisture was higher, *L. leucocephala* (cv unstated) has performed adequately.

In general, most trees appeared to grow faster at wetter sites in Did Hara (Hodgson, 1990: pp 69–70). For lowland soils (Vertisols) that are seasonally waterlogged, notable performances of *S. sesban* and *L. leucocephala* cv Cunningham and cv Peruvian have occurred. Hodgson (1990: p 70) mentioned growth rates of 3 m in six months for *S. sesban*. These observations for *L. leucocephala* in particular are somewhat surprising given environmental guidelines for this species. The minimum temperature limit of 15.5°C (ILCA Plant Sciences Division, unpublished data) suggests that *L. leucocephala* would perform best below 1400 m elevation on the Borana Plateau, and yet Did Hara is at 1500 m. Skerman (1977) noted a minimum annual rainfall requirement of 750 mm for this species but Did Hara showed less rainfall than this during most of the 1980s. This paradox may be due to landscape effects and *L. leucocephala* may have a very limited range outside of water-collecting depressions.

In contrast, *S. sesban* can thrive at 500 mm annual precipitation under cooler temperatures (A. Russell-Smith, ILCA, nd) and appears better adapted for the Borana Plateau. *Sesbania sesban* may be vulnerable to drought, however. A stand of trees established at Dembel Wachu Ranch in 1986 appeared to be weakened by lack of moisture during the 1987–88 warm dry season and were subsequently killed by termites (D. L. Coppock, ILCA, personal observation).

In summary, Hodgson (1990: p 71) mentioned that *S. sesban* could be directly planted as seeds in moist sites such as pond catchments. *Glyricidia sepium* and *L. leucocephala* could be planted as seeds or seedlings in moist depressions (see Table G2, Annex G). Although based on limited experiences, it is apparent that exotic trees have been easier to establish than exotic herbaceous plants, but both may be vulnerable to drought and pests. As with exotic herbaceous legumes, Hodgson (1990: p 71) again expressed reservations regarding the Boran interest in exotic trees. An example from Kenya was cited in Hodgson (1990) that indicated efforts to get the Turkana pastoralists interested in several tree-planting projects had failed.

Promising native forages and management innovations

Native grasses: As noted earlier, experience in East African rangelands supports promotion of promising indigenous species because these are best adapted to local conditions (Pratt and Gwynne, 1977: p 122). While grasses may not be associated with nitrogen fixation (Farnsworth et al, 1978), it cannot be assumed that introduced legumes will always be capable of nitrogen fixation either. The necessity to innoculate seeds of introduced species with specific rhizobia may also undermine the sustainability of intervention if the rhizobia are unable to persist in a new environment.

Common grasses on the Borana Plateau include *Cenchrus ciliaris*, *Cynodon plectostachyus*, *Chloris roxburghiana* and *Themeda triandra* (see Section 2.4.1.5: *Native vegetation*). These represent genera that are regarded as superior forages (Pratt and Gwynne, 1977: pp 122–123, 240–246). Their relative advantage may be best realised in terms of improved grazing management, range burning (especially for *T. triandra*; Pratt and Gywnne, 1977: p 246), site rehabilitation (see below) and feed storage such as hay-making (Hodgson, 1990: pp 57–58).

Hay-making: After three years of often frustrating trials, CARE-Ethiopia achieved success with hay-making from local grasses (Plate 7.2). The Boran have had no tradition of feed preparation and storage. This intervention, targeted towards improved feeding management of calves by women (Hodgson, 1990: pp 57–58), has implications for reducing women's labour in dry seasons because women may invest up to 16% of their time collecting standing grass for calves reared in the home (see Section 4.3.3: *Labour of married women*). Having a hay stack on hand that was prepared in the previous wet season could substantially reduce this time commitment in dry seasons when women's work loads are higher. Hay-making also could improve calf nutrition because it conserves forage nutrients. Standing grass collected in dry seasons is expected

Plate 7.2. *A Borana woman and her haystack.*

Photograph: Shewangizaw Bekele

to be poor in protein content and digestibility (Coppock, 1990a) and improved calf management has been viewed as the major intervention pathway in this system (see Section 7.3.3.5: *Calf mortality mitigation*).

Effects of hay-making on dry-season labour for women were examined in conjunction with the study on the effects of water tanks on women's time and household water budgets (see Section 7.3.1.1: *Water-development activities*). Access or lack of access to a hay stack was included with access or lack of access to water tanks in the factorial design in which 64 women were continuously observed for one week, with 16 per treatment (Coppock, 1992a). Research methods for recording time budgets for collection of standing grass or using hay were the same as previously reported for water collection.

Households with hay stacks had put up 50 to 300 kg of hay after the long rains as part of an extension activity. Hay stacks were located adjacent to family huts. During the warm dry season of 1990 the women in the control group (N=32) on average spent 2.7 h/woman/week collecting standing grass for calves in the traditional fashion. This was 2.4% of total active time per week, which was considerably lower than the 16% anticipated from interviews (Mulugeta Assefa, 1990). Women who had hay stacks (N=32) on average spent less than 30 min/woman/week preparing hay for calf feeding. This time saving was significant (P<0.05) but it was less than expected given the overestimated time that women were supposed to spend collecting standing grass. As with the water tanks, the time savings of having hay stacks were small. This belied the enthusiasm for making hay that existed among women in the community, who believed time savings to be the major advantage of hay-making (Brandstetter et al, 1991; Hodgson, 1990). The women also believed that the hay was more nuitritious than standing grass and allowed calves to be fed more regularly (Coppock, 1992a).

In a related study (Coppock, 1991), the opportunity cost of hay-making was evaluated for 62 households during five weeks in May and June after the long rains in 1990. The work was conducted to see if any major labour constraints existed that would prevent women from making hay in a timely fashion. Records were kept for all households in terms of time spent building support platforms, locating, cutting and drying suitable grasses for hay making, transporting and stacking hay. All household labour was inventoried daily as it was expected that women, children and older youths would participate. For any given worker on any given day, the opportunity cost of a hay-making activity was evaluated through interviews that ranked what perceived activities were foregone as a result of time invested in hay-making. Results of the study are briefly highlighted hereunder.

Total hay prepared averaged 121 kg per household (range: 20 to 300 kg). Hay-making statistics are shown in Tables G5 and G6, Annex G. Households made 121 kg of hay in 18 hours over 16 days on average. Rate of hay production was thus 6.2 kg/h. Married women contributed over 80% of the labour but all family members participated. Time taken away from other activities included an average of three hours each for child care and household chores and two hours of leisure. Women could delegate most activities to other family members, however. Women felt that the work demands of hay-making could be easily incorporated into existing schedules. Seventy-three per cent of 85 families that made hay in 1990 said they planned to do so again in 1991 (Coppock, 1991).

It has long been known that hay-making with grasses has advantages for animal feeding (Pratt and Gwynne, 1977: p 128). Mulugeta Assefa (1990: pp 52–55) analysed samples of grass hay put up by Borana women and compared this to samples of standing grass collected from inside and outside nearby *kalo* enclosures in the long dry season of 1989. Chemical procedures were the same as reported for work of Yohannes Alemseged (1989). Results are shown in Table 7.5 and demonstrate that hay-making improved both forage crude protein (CP) and digestibility (IVDDM) by over 70%. Different grass species may also provide hay of varying quality. Coppock et al (1990: p 8) reported CP values for hay made by the Boran from seven species of local grasses in 1989 and these are shown in Table 7.6. These data reflect species differences as well as variation among households in their ability to make nutritious hay, but results suggest that species such as *C. ciliaris* and *P. stramineum* may be superior for hay-making.

A 90-day feeding trial was also undertaken with yearling calves to assess benefits of hay-making in terms of calf growth and body condition (Coppock, 1993a). Sixteen calves per treatment were fed under confinement and given water once every three days as is done normally (see Section 5.3.4: *Water restriction and cattle productivity*). Treatments included: (1) poor quality standing grass (with 4% CP and 30% digestibility on a dry-matter basis) collected in the dry season offered *ad libitum*; (2) grass hay prepared after the long rains (with 7.5% CP and 44% digestibility on a dry-matter basis) offered *ad libitum*; and (3) grass hay plus 500 g/head/day of local *Acacia tortilis* fruits (with 13% CP and 58% digestibility on a dry-matter basis) as a protein supplement. (Using acacia fruits as protein supplements is reviewed later in this section).

Calves were weighed weekly and given a condition score at the beginning and end of the trial using the method of Nicholson and Butterworth (1985). Selected results are shown in Table G8, Annex G. The data indicated that while calves on hay plus acacia fruit diet gained weight, those on hay only maintained their weight and those on traditional standing grass lost weight. Only the

Table 7.5. *Nutritional characteristics (per cent on a dry-matter basis) for native grasses under different management[1] in the dry season of 1988–89 in the southern rangelands.[2]*

Factors	Management					
	Hay		Off-*kalo*		*kalo*	
	Mean	SD	Mean	SD	Mean	SD
Nitrogen	1.14*x*	0.21	0.72*y*	0.15	0.59*y*	0.05
In vitro digestible dry matter	51.6*x*	6.20	30.4*y*	7.53	30.2*y*	5.7

1 Where management includes: (1) hay made from grass at the end of the previous wet season; (2) standing grass collected from continuously grazed sites (i.e. off-*kalo*); or (3) standing grass collected from inside *kalo*, which are local exclosures to promote deferred use of vegetation (Menwyelet Atsedu, 1990).

2 Entries within the same row accompanied by the same letters (*x, y*) were not significantly different (P≤ 0.01) according to a one-way ANOVA (*N* = 8 random samples per forage category).

Source: Mulugeta Assefa (1990).

Table 7.6. *Crude-protein concentrations (per cent on a dry-matter basis) for native grass hay produced by pastoralists under pilot trials in the southern rangelands supervised by CARE-Ethiopia staff in 1989.*

Species	Crude protein[1]
Cenchrus ciliaris[2]	7.2*w*
Pennisetum stramineum[3]	6.4*wx*
Cynodon plectostachyus[2]	6.1*x*
Pennisetum mezianum[3]	5.0*y*
Chloris roxburghiana[2]	4.2*yz*
Chrysopogon plumulosus[2]	4.0*yz*
Themeda triandra[4]	3.5*z*

1 Per cent *kjeldahl* N x 6.25; *N* = 4 per species. Entries accompanied by the same letter (*w, x, y, z*) were not significantly different (P<0.05) in a one-way ANOVA using an LSD (least significant difference) test. As a guideline, it may be considered that a 6% crude-protein content and above is more suitable as forage for young calves.

2 Genera and species regarded as good indigenous forages (Pratt and Gwynne, 1977).

3 New growth can be palatable but mature growth generally is not (Pratt and Gwynne, 1977).

4 Sometimes this species is not so nutritious when mature, but it is often consumed by livestock (Pratt and Gwynne, 1977).

Source: Coppock et al (1990).

animals receiving acacia fruits showed no change in condition score during the trial; animals in the other two treatments showed similar decline in condition score (Coppock, 1993a). There were no differences among treatments in terms of intake of dry matter or organic matter, but both hay diets were superior to the standing-grass diet in terms of nitrogen intake. Calves on the hay diets consumed 27% more water than those on the standing-grass diet. These results suggested that simple hay-making could offer substantial benefits to calf performance over traditional practices, especially when subsistent feeding is a major objective.

In an economic cost/benefit analysis of improved calf management systems, Mulugeta Assefa (1990) included hay-making as one component which he found to be profitable under the assumption that feeding hay would result in reduced calf mortality. This study is reported in Section 7.3.3.5: *Calf mortality mitigation*.

In summary, advantages of hay-making in terms of women's labour savings in the warm dry season were assessed by research to be minor, but Borana women apparently have time to make hay after the long rains and hay offers improved nutrition for calves. It is likely that hay-making will be rapidly taken up by the Boran (Brandstetter et al, 1991) and while it may be judged as a modest achievement, hay-making does illustrate the principles of successful intervention based on a bottom-up focus on felt needs in the community (Hodgson, 1990; Coppock, 1991). Hay-making is also new to some smallholders in the Ethiopian highlands (T. Varvikko, ILCA, personal communication) and thus it should not be overlooked in favour of introduced technology especially since it is also easily transferred. From experience women already know how much hay they will need for coming years based on the numbers of young calves expected. Key problems involve proper stacking to minimise moisture penetration and spoilage so that some technical oversight from SORDU extension is important. Hay-making represents only a minor alteration of an aspect of animal management here that traditionally is intensive (see Section 5.3.1: *General aspects of cattle management*). It also transforms a communal forage resource into a private one. However, hay-making would only be taken up by households that do not have to move seasonally in response to shortages of water or grazing (Hodgson, 1990) as households would be unable to take hay stacks with them if they move. Hay-making is exclusively for calves in this situation, which is appropriate given seasonal scarcity of resources. Others have proposed feeding hay to milk cows in semi-arid systems (Sullivan et al, 1980) but this would not be viable here. Considering the model of system dynamics given above, hay-making would be most advantageous in the high-density phase of the cattle population (Section 7.4: *Component interventions and system dynamics*).

One final question is why hay-making is treated as an innovation here, given that the Boran are clever producers and have exploited this environment for centuries. The simplest answer, of course, is that no Boran ever thought of it before even though it was always necessary and appropriate. An alternative and more interesting explanation is that the need for hay-making is relatively recent. It is probable that hay-making was less necessary or more difficult to implement in the past because of a lower density and higher mobility of the population. Today, under the presumed conditions of a higher livestock density, competition among women who need to collect forage is probably more pronounced. One stimulus for the recent innovation of *kalo* is probably to improve efficiency of forage collection by women (see Section 7.3.1.2: *Grazing management*).

Native trees: Results in Section 3.3.5.1: *Livestock food habits* and Section 3.3.5.2: *Household use of plants and pastoral perceptions of range trend* illustrate the diversity of native woody plants used as forage, fibre, human food, medicines, fuel and construction materials. This section will focus on the uses of tree as fodder for nutritional supplementation of calves in cut-and-carry feeding systems. A critical resource in this respect are the dry, dehiscent fruits of acacias. These fruits include a spiral-shaped casing (pod) containing seeds. Although indigenous trees usually grow more slowly than exotics, they have advantages in terms of adaptating persistence and forage stability to African pastoral systems (Coughenour et al, 1985). Products from native trees such as dry fruits also have an advantage over leaf fodder from exotic trees in that the fruits are produced in dry seasons when they are most needed. Even though exotics such as *Sesbania* and *Leuceana* spp may be established in some situations on the Borana Plateau, they commonly drop their leaves during dry seasons and thus offer no utility at these times (D. L. Coppock, ILCA, personal observation).

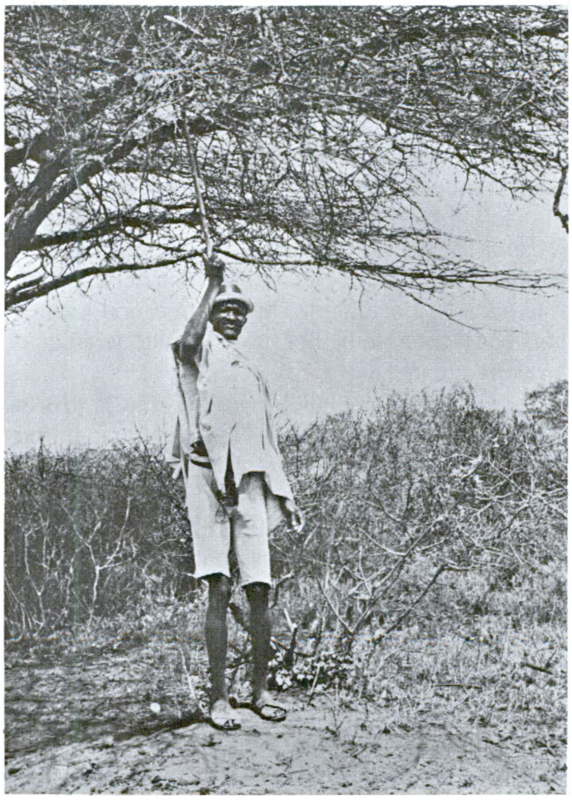
Screening trials: In addition to reporting on screening of exotic trees (above), Hodgson (1990: pp 69–72) noted performances of species indigenous to Ethiopia that were uncommon or absent on the Borana Plateau. Good establishment and growth was observed on well-drained red soils for *Acacia albida*, *Moringa stenopetela*, *Pappea capensis* and *Tamarindus indica*. All should be considered for further research. *Acacia albida* is well known in Africa as a producer of nutritious dry fruits for livestock (Pratt and Gwynne, 1977: p 257;

Tanner et al, 1990). *Moringa stenopetela* also produces fruits that can be consumed by people and *P. capensis* is regarded well among the Boran as a dry-season forage for calves in *kalo* (Menwyelet Atsedu, 1990: p 23). Hodgson (1990: p 71–72) reserved his greatest enthusiasm, however, for *A. tortilis*. *Acacia tortilis* is well-known elsewhere for its persistence and production of fruits consumed by livestock and people (Pratt and Gwynne, 1977: p 258; Coughenour et al, 1985; Galvin, 1985; Coppock et al, 1986a; 1986b; Gates and Brown, 1988; Sperling, 1989).

Use of key species: Menwyelet Atsedu (1990: pp 10–28) studied several aspects of the ecology and utility of *A. tortilis* and *A. nilotica* fruits on the Borana Plateau. These species were selected because they were ranked as the most important among fruit-producing species by the Boran in a survey (Plate 7.3 a, b). In another survey of 67 encampments, residents of 54 reported that they used acacia fruits as supplements for cattle in dry periods. Fruits are allowed to dry prior to feeding, but are otherwise untreated. Calves most commonly graze fruits off the ground, but some people collect them for calf feeding inside the family hut if the fruits are locally abundant. The contribution of *A. tortilis* fruits to livestock in dry seasons was universally appreciated. Use of fruits from *A. nilotica*, however, was restricted to times of drought when other forages are less available. This is because of their inferior palatability and feeding value due to high levels of tannins that have been found elsewhere to have negative effects on livestock nutrition (see below).

Feeding trials: Use of small quantities of high-protein forage from indigenous legumes like acacia trees could improve utilisation of roughage in traditional calf diets on the Borana Plateau. Native legumes, however, may also contain high levels of tannins which may impair protein utilisation. Coppock and Reed (1992) examined these questions using feeding trials with sheep and calves. Animal performance based on supplementation with *Acacia tortilis* fruits or *A. brevispica* leaves was compared to that based on supplementation with non-tanniniferous legumes, namely cowpea hay (*Vigna unguiculata*) and lucerne hay (*Medicago sativa*). *Acacia brevispica* leaves were chosen as one treatment because they had been found important in diets of browsing stock (see Section 3.3.5.1: *Livestock food habits*), and means to better utilise this species are important

Plate 7.3 (a, b). Acacia tortilis *is a valuable native tree; (a) Borana man using a stick to shake fruits from a mature tree, and (b) a close-up of the fruits.*



Photograph: Shewangizaw Bekele

because it is an encroacher at higher elevations (see Section 3.4.2.4: *Population ecology of woody species*). Leaves of *A. brevispica* are also commonly available in dry seasons (Woodward, 1988). Cowpea hay could be important in agropastoral situations on the Borana Plateau (Section 7.3.2: *Land-use policy and agronomic interventions*). Lucerne is not a viable forage for the southern rangelands but its hay was included as a "positive control".

Thirty male sheep (average age seven months; average live weight 17.6 kg) were stratified by weight and allocated into five groups of six animals each for feeding under confinement at Debre Zeit in the highlands. All groups recieved *ad libitum* access to poor quality grass hay (6.25% CP on a dry-matter basis) as the basal diet. Supplements were offered on an iso-nitrogenous basis to provide nitrogen for 50 g of live-weight gain/head/day (ARC, 1980). Animals had *ad libitum* access to water and salt lick. Treatments included: (1) control diet of grass hay or the grass hay plus; (2) lucerne hay (13.1% CP); (3) cowpea hay (11.3% CP); (4) *A. brevispica* leaves (18.8% CP); or (5) *A. tortilis* fruits (14.4% CP). The first experiment was an 84-day growth trial with forage intake and live weight measured daily and weekly, respectively. Average daily gain (ADG) was calculated as the slope from linear regressions. The growth trial was followed by a 10-day metabolism trial with collections of urine and faeces to assess protein utilisation. Preparation and analysis of feed samples followed AOAC (1980) and Van Soest and Robertson (1980). Tannins were divided into two components: tannins and other phenolics soluble in aqueous acetone (soluble phenolics) were quantified as in Reed et al (1985) while proanthocyanidin polymers associated with fibre (insoluble proanthocyanidins) were measured as in Reed (1986). Urinary and faecal nitrogen was determined by kjeldahl analysis (AOAC, 1980) and faecal nitrogen was partitioned into soluble and insoluble forms (Mason, 1969). Retained nitrogen was calculated as the difference between intake and excretion. A one-way ANOVA analysed treatment effects on ADG, forage and nutrient intake, diet conversion efficiency, diet digestibility, and nitrogen retention and losses.

In a second trial 125 Boran calves (average age 3.5 months; average live weight 37.4 kg) were stratified by weight and allocated into five groups of 25 animals each for feeding under simulated pastoral management at Dembel Wachu ranch. The experiment consisted of a 94-day growth trial with forage intake and live weights measured daily or weekly, respectively. Milk intake was measured biweekly using a weigh-suckle-weigh method, and water intake was measured biweekly as consumption from buckets. Treatments included: (1) control of restricted suckling that allowed intake of 50% of milk production, grazing for 8 h/day (with a diet quality of 6.3% CP (Coppock and Reed, 1992)) and a once-daily access to water and local salt lick; or the control condition plus: (2) lucerne hay (21.3% CP); (3) cowpea hay (13.1% CP); (4) *A. brevispica* leaves (16.9% CP); and (5) *A. tortilis* fruits (15% CP). Supplements were offered to provide nitrogen for 250 g of live-weight gain/head/day (ARC, 1980). Average daily gain was estimated and chemical analyses were performed as in the sheep trial. A one-way ANOVA-analysed treatment effects on ADG intake of supplements and water.

Only highlights of results from growth trials are presented here. Other details are in Coppock and Reed (1992). Compared to supplements, basal hay or grazing diets were consistently lower in nitrogen content and digestibility and higher in per cent fibre and fibre-bound nitrogen. Compared to cowpea or lucerne hay, the acacia materials had a lower percentage of fibre and were higher in tannin content. *Acacia brevispica* leaves had higher levels of lignin and insoluble proanthocyanidins than *A. tortilis* fruits, but the fruits were higher in soluble phenolics. In the sheep growth trial animals consumed from 78 to 91% of supplements on offer. All supplements increased ($P<0.05$) nitrogen intake by an average of 71% compared to the control. Acacia materials contributed to higher nitrogen intakes than the cowpea hay or lucerne hay ($P\leq0.01$). Compared to the control growth rates were increased ($P\leq0.01$) by supplementation by an average of 74% (Table G9, Annex G). Results from the sheep metabolism trial indicated that while all supplemented sheep had similar levels of nitrogen retention, this was accomplished in different ways. The acacia diets contributed to higher losses of nitrogen in the faeces because of the binding effects of tannins in the rumen. The cowpea and lucerne diets contributed to higher levels of nitrogen loss in the urine.

In the calf trial animals consumed from 71 to 86% of the supplements on offer. Nitrogen intakes from supplements ranged from 8.1 g/head/day *(A. brevispica)* to 14.9 g/head/day (lucerne). Supplementation increased ($P\leq0.01$) calf growth rates by 44 to 95% compared to the controls, with lucerne eliciting higher growth rates than other supplements ($P\leq0.01$; see Table G9, Annex G). Supplementation increased ($P\leq0.01$) water intake by 15% overall compared to the controls. Calculations of theoretical nitrogen requirements for observed calf performance in relation to actual nitrogen intake from supplements and milk indicated that the supplements probably replaced 40 to 80% of the grazing diet. Use of legumes was thus more on the order of diet substitution rather than supplementation (Coppock and Reed, 1992).

Coppock and Reed (1992) concluded that despite containing tannins, the acacia materials were suitable protein supplements for dry-season diets. They were readily consumed and often produced growth rates similar to those based on lucerne or cowpea hay. The net effect of tannins was thus minor. Such perspectives have been reported elsewhere (Nastis and Malechek, 1981; Tanner, 1988; Woodward, 1988; Nunez-Hernandez et al, 1989).

Variation in concentration and type of tannins in other acacia species have elicited a diversity of feeding responses (Reed et al, 1990; Tanner, 1988; Woodward, 1988; Tanner et al, 1990). Other research indicates that like the acacia materials tested here, leaves of *A. seyal* or fruits of *A. albida* can be suitable protein supplements. But fruits of *A. nilotica* or *A. sieberiana* are more marginal in value because they elicit excretion rates of faecal nitrogen that can be markedly higher than what is lost as urinary nitrogen from feeding non-tanniniferous forages. For example, phyllodes (modified leaves) of *A. cyanophylla* can yield pronounced negative imbalances of nitrogen in sheep because of excessive losses of faecal nitrogen (Woodward, 1988).

Productivity of acacias: Nutritive value is only one measure of the utility of a forage. Another critical aspect is productivity and ecological distribution. Despite the high nutritive value of acacia fruits and leaves, the main obstacle to enhancing their use is low productivity.

Mulugeta Assefa (1990: p 57) harvested leaves from 18 *A. brevispica* shrubs after the short rainy season that ranged in size from 1 to 6 m or more in height. He found an average of 0.7 kg air-dried weight of leaves per shrub. Only shrubs taller than 6 m had leaf biomass that exceeded 4 kg air-dried weight. This problem of low yield per shrub is somewhat offset, however, by the high density of *A. brevispica* shrubs at higher elevations on the Borana Plateau. Control measures are needed to reduce these thickets.

Menwyelet Atsedu (1990: pp 54–76) studied fruit production of *A. tortilis* and *A. nilotica* during an average rainfall year. He selected 50 mature trees of each species at five sites. Understories were cleared and bush-fenced to facilitate collection of fallen fruits three times per week for seven months from early September 1988 to mid-March 1989. Trees were measured for diameter-at-breast height (DBH) and crown area in an attempt to correlate fruit production with tree size using linear regression. Analysis of variance was used to gauge effects of species, site and season on total fruit production. Results indicated that 87 of 100 trees produced fruits, but that production was low and variable over time. Total fruit production on an air-dried basis ranged from 0.1 to 43.9 kg/ tree for *A. tortilis* (=6.7 kg) and 0.03 to 44.5 kg/tree for *A. nilotica* (=5.0 kg). About 75% of *A. tortilis* trees and 85% of *A. nilotica* trees produced less than 10 kg of fruits during the seven months.

There were no significant correlations of DBH or crown area with fruit production despite large-size differences among trees. It was concluded that such low and variable levels of productivity were not conducive to a sustained use of fruits for livestock feeding at these sites. In a review of the literature, Menwyelet Atsedu (1990: p 72) noted that fruit production in this trial appeared lower than that recorded for other pastoral areas in Africa. Landscape may be an important factor. Large *A. tortilis* trees along drainages with concentrated moisture have been shown to be quite productive in Kenya (Coughenour et al, 1985). Menwyelet Atsedu (1990: p 73) noted that the most productive trees in his study were found in large bowl-shaped sites that probably collect more moisture. Other than these infrequent bowls, the Borana landscape consists of relatively uniform undulations without drainages (see Section 2.4.1.2: *Landscape*) which may be unfavourable for maximum fruit production from *A. tortilis.* The Boran pointed to (Menwyelet Atsedu, 1990: p 19) low and variable fruit production as the major constraints to improved use of these trees for calf-feeding interventions. They said that production varies sharply from year to year. It was thus concluded that one seven-month period is insufficient to assess fruit production. Monitoring for several consecutive years would yield more meaningful results. The variable production of acacias may also be genetically influenced; this masting behaviour is well known among many species of trees. Unpredictability in seed output may be a means of discouraging high levels of seed loss to parasites such as bruchid beetle larvae (Harper, 1977; Southgate, 1983; Pellew and Southgate, 1984).

Other perspectives: In summary, strategic use of local leguminous forages may be important in this system. The low production of *A. tortilis* fruits and difficulties in harvesting *A. brevispica* leaves dictate against their use as sole components of improved feeding for calves, however. This is because labour demands may be too high to be practical (Coppock, 1990a). One solution could be to use such supplements with grass hay to replace grazing or the traditional cut-and-carry use of standing grass. Results reported earlier in Table G8, Annex G, illustrate these beneficial and additive effects. What is more the higher the hay quality, the less legume would be needed to "top it up" (Coppock, 1990a). This illustrates that efforts to make better-quality hay could result in less dry-season labour needed for legume collection. In addition, increased water intake for calves as a result of water-tank implementation (Section 7.3.1.1: *Water-development activities*) may also have positive interactive effects (Coppock, 1989b; see Section 7.3.3.5: *Calf mortality mitigation*). All this shows the interdependency among calf feeding innovations (Coppock, 1990a).

Forage evaluation reported here as well as other cited work suggests that *A. tortilis* fruits, *A. brevispica* leaves, *A. seyal* leaves and *A. albida* pods could be combined with grass hay in a diverse regional approach that takes advantage of different distributions of woody plants in the environment (see Section 2.4.1.5: *Native vegetation*). This could be carried out with selective bush control strategies in mind and the pastoralists may be able to recommend other browses that could be utilised in this fashion. In this regard CARE-Ethiopia has had some success encouraging the Boran to collect and store *A. tortilis* fruits for the dry season (Hodgson, 1990: pp 56–57, 173–175). In some cases only helping the people get burlap sacks was all that was needed (Hodgson, 1990: p 56). As with hay-making, it may be that increased competition among people for resources is a key factor in the relative ease that CARE-Ethiopia has had in apparently changing some aspects of resource use among the Boran. The Boran have been reported to actively collect acacia fruits during drought when they are desperate for calf forages (D. L. Coppock, ILCA, personal observation). Hence they may do likewise in normal rainfall years under a higher density of consumers.

Development agents should consider planting valuable indigenous trees in suitable sites such as *kalo* enclosures (see Section 7.3.1.2: *Grazing management*). Forage stabilisation in times of drought, as well as calf feeding in normal years, could benefit from it (Coughenour et al, 1985; Coppock, 1990a). However, Hodgson (1990: p 71) did express concern about whether the Boran would be interested in planting indigenous trees. The reason being individuals are unlikelly to personally benefit from tree planting because while the costs are endured today, the benefits would not be realised until years later. Menwyelet Atsedu (1990: p 26) reported that the Boran think that *A. tortilis*, like other trees in general, is increasing. This may be due to the absence of bush fires (see Section 3.3.2: *Long-term vegetation change*). This is not to say that the people have not collectively expressed concern over the future of *A. tortilis*. In fact the Borana *Gumi Gayu* council declared in 1988 that *A. tortilis* should be a protected tree in 1988 (see Section 2.4.2.2: *Some cultural and organisational features*).

Finally, if a household has hay of a suitable quality, the added labour needed to collect supplements may not be necessary. Supplementation of hay may only be worth the extra cost if the hay is poor quality or calves are in need of a drastically improved feeding. Households with a pronounced pressure to sell milk, such as the poor who reside near towns (Holden et al, 1991), may be most in need of improved feeding packages for calves. The appropriate goal is to supply feeding to improve the chance of survival and not so much for faster growth of calves *per se*. This is because the apparent advantage of weight gains is easily lost as the animal matures; feeding above survival needs is thus likely to be wasted (Coppock, 1989b).

7.3.1.4 Site reclamation

As the last stage in the range management hierarchy, reclamation of degraded sites is the most intensive and expensive management activity per unit area (Pratt and Gwynne, 1977: p 122). Because of this, site reclamation may initially appear as an unsuitable activity for communal pastoral systems. Recent experience on the Borana Plateau suggests, however, that when a confined pastoral society is under increasing pressure to secure adequate grazing resources, it may be easier to achieve a concensus on actions to rehabilitate land compared to those intended to slow degradation of land; the latter appears, at least superficially, to be inadequate. From surveys it is apparent that the Boran are interested in participating with SORDU to reclaim sites, but feel that there has been insufficient dialogue to date (Solomon Dessalegn, TLDP/ILCA postgraduate researcher, unpublished data). It is anticipated that effective participation within the community by development agents could achieve a satisfactory level of site-specific control as long as the local community agrees that action is warranted. While some strong leaders in Borana society may help implement local programmes to change several aspects of resource use (Hodgson, 1990), many others require the assistance of outside authorities (Solomon Dessalegn, TLDP/ILCA postgraduate researcher, unpublished data).

Herbaceous layer

Pratt and Gwynne (1977: pp 121–126) reviewed aspects of reseeding degraded land, and only some species useful for reclamation will be noted here. It must be emphasised that given a nucleus of good perennial grasses, it is easiest to achieve reclamation by bush-fencing or declaring areas off limit by the Boran to permit natural recovery. Some form of protection must be implemented in any case, and if this cannot be done, no amount of seeding will make a difference. According to the proposed model of cattle population dynamics in relation to drought (see Section 7.2.3: *Anticipated short-term cycles*), it is most likely that successful site rehabilitation will occur during the drought-recovery phase when cattle densities and demand on forage are lower. Pratt and Gwynne recommend East African perennial grasses for reseeding sites and these include some prominent local species such as *C. ciliaris*, *C. roxburghiana*, C. dactylon and *Enteropogon macrostachyus*. Tables A6 to A10, Annex A, give environmental guidelines for some of these species. If in doubt, inspection of similar sites can provide additional information. A discussion of reseeding procedures is provided in Pratt and Gwynne (1977: pp 123–126).

It is envisioned that priority sites for reclamation of the herbaceous layer include those in the upper semi-arid and subhumid zones that are rapidly degrading due to pressure from increasingly sedentary pastoralists (Section 3.4.2: *Environmental change*). These sites have higher rainfall and cooler temperatures than the rest of the plateau, and thus offer better possibilities for success although not for exotics like *S. hamata* cv Verano because of the cooler temperatures (Section 7.3.1.3: *Forage improvements*). One disadvantage, however, is that these regions to the north (not served by wells) occur outside of the traditional *madda* system and have been in the domain of PA organisational structures. This may require a different approach in terms of getting support from the local people. In addition, the trekking routes through this area that are used to move cattle up-country (Assefa Eshete et al, 1987) present other social challenges for implementation.

Bush control: Field methods and policies

Bush encroachment has occurred on the Borana Plateau over many years and may be exacerbated by the grazing impacts of cattle (Section 3.4.2: *Environmental change*). If this hypothesis is correct, increases in cattle density should aggravate bush encroachment under suitable rainfall conditions. Bush establishment thus may be most likely to occur as an episodic phenomenon during prolongued periods in the high-density phase of cattle population. Although bush encroachment can limit using land for cattle grazing, it may serve a useful purpose in site protection and rehabilitation (Section 3.3.2: *Long-term vegetation change*). Bush control programmes must thus be tempered by this consideration.

Prescribed burning: Woody plants may be variously controlled using manual labour, chemicals, prescribed burning, machinery and browsing livestock. Pratt and Gwynne (1977: pp 128–138) provided a review of experiences from East Africa. Although it is acknowledged that fire has variable effects on controlling woody vegetation and more research is needed, it is still the most cost-effective means for bush control in East Africa (Pratt and Gwynne, 1977: p 132).

Solomon Dessalegn (nd) used prescribed burning to assess impact on an acacia community at Wollenso Ranch during the warm dry season of 1989 (Table G10, Annex G). These data indicate that overall mortality rates of trees on two sites were about 30%. Younger trees (<2 m tall) suffered mortalities of 35% while larger specimens lost only 11% of their numbers. The finding that younger age classes are more susceptible to fire has been reported elsewhere (Norton-Griffiths, 1979; Pellew, 1983; à Tchie and Gakahu, 1989). The protection afforded older trees may be due to increased trunk thickness (which protects vascular tissues), elevation of buds and foliage and whether accumulation of sufficient herbaceous fuel load in the understory is inhibited by shading and/or root competition. Fire is thus only a partial management solution in that it mostly inhibits recruitment of young trees but it still can gradually shift the advantage to grasses. Older trees survive fires to produce seed for the future, however. It is important to note that fire has variable effects related to site and species. For example, it may stimulate germination in some woody species that are adapted to respond positively to burning (e.g. *A. brevispica*). Adult trees less than 2 m tall may be destroyed by one fire. A large stand of *Commiphora* sp was completely killed by a wild fire at Dembel Wachu Ranch in 1987 (D. L. Coppock, ILCA, personal observation). Effects of site and species on the susceptibility of trees to fire are reviewed in Pratt and Gwynne (1977: pp 128–138).

Solomon Dessalegn (nd) interviewed leaders of five Pastoral Associations (PAs) in 1989 and found that the Boran used to burn sites once every three years to kill bush, control ticks and improve the nutritional quality and accessibility of grasses. These benefits from burning are well known elsewhere (Hobbs and Spowart, 1984; Coppock and Detling, 1986; Mbui and Stuth, 1986). In the view of the Boran, cattle grazing and absence of fires were mostly responsible for bush encroachment. Government policy restricting range fires was considered by these leaders as a major management constraint. Reserving sites for burning, however, was reportedly more difficult than in the past because of forage demand from a large cattle population (Section 3.2.5.2: *Household use of plants and pastoral perceptions of range trend*).

A sound range-management programme based on prescribed burning requires years of detailed site-specific research (Pratt and Gwynne, 1977: pp 128–138). This may be a luxury, however, that few national programmes like SORDU can afford. It is noteworthy that the policy prohibiting burning on the Borana Plateau was lifted in 1990 (Tafesse Mesfin, TLDP General Manager, personal communication) because of the perception by local administrators that bush encroachment was a significant threat to the production system. It is expected that the Boran will now be able to recommend sites for burning and SORDU will provide regulation through site evaluation, approval of methods and by helping organise the work (Kidane Wolde Yohannes, TLDP range ecologist, personal communication). The Boran have indicated that they would work with SORDU on bush control (Coppock et al, 1990: pp 21–22). Pratt (1987a: p 22) recommended that with the ban lifted, controlled burning should be allowed in the semi-arid and arid zones where appropriate, but not allowed in upper semi-arid and subhumid zones that are more in need of rehabilitation of the herbaceous layer (see Section 3.4.2: *Environmental change*).

Without regulation, the danger is that sites may be burned too frequently under today's conditions of higher human and livestock populations. The tendency may be to burn more for short-term gains such as stimulating green flush. Effects of burning on improving forage quality are only short-lived (McGinty et al, 1983; Mbui and Stuth, 1986) and more frequent burning can damage microbes in the topsoil (Biederbeck et al, 1980), expose soil to erosion (Ali et al, 1986) and kill important forages such as *Chloris roxburghiana* (Pratt et al, 1966). In contrast, appropriate burning may stimulate increases in *Themeda triandra* (Pratt and Gwynne, 1977: p 246). This species is an important forage in the north-central part of the Plateau and it has been noted to be in decline possibly as a result, in part, of the absence of fire (Menwyelet Atsedu, 1990: p 83).

Optimal burning frequencies are thus anticipated. Pratt and Gwynne (1977: p 133) noted that a burning interval of three to six years checks most bush encroachment in relatively open areas. Burning experiments with thick bush based on an initial series of annual and biannual fires are also proposed in Pratt (1987a: p 23). If careful records are maintained and site monitoring is carried out, it may be wise to use sites nominated by the Boran as part of a comprehensive research and management programme. One other danger of loosely regulated burning is the threat it may pose to juveniles of useful tree species. For example, Pellew (1983) and á Tchie and Gakahu (1989) noted that younger age classes of *A. tortilis* are vulnerable to fire.

The likelihood that higher populations of livestock may reduce the capability to implement burning programmes is a significant constraint, but this will vary among *madda*. Consideration of the cattle population cycle in response to drought (see Section 7.2.3: *Anticipated short-term cycles*) may be useful in evaluating opportunities for burning. Early in the drought-recovery phase cattle populations would be lower and forage (fuel load) more abundant. A lighter grazing pressure could also encourage more grass growth that could further keep tree seedlings from emerging after fire. It is stipulated that if burning can be focused to occur in this time frame implementation could be more successful. It may also be expected, however, that the pastoralists will be most interested in burning during the high-density phase, largely for short-term goals of improving cattle nutrition or controlling ticks.

Mechanical and chemical methods: Focusing on *Acacia drepanolobium*, Solomon Dessalegn (nd) conducted an experiment that included various treatments of manual cutting (stumping), ring-barking and application of used motor oil or TORDON 101 arboricide to stumps. Subsequent mortality rates are shown in Table G11, Annex G. It is apparent that without the use of arboricide, other forms of control were largely ineffective. In addition, *A. drepanolobium* resprouted easily from stumps not treated with the arboricide, which results in a bushier growth form that is more likely to be obstructive to livestock (Plate 7.4). The ability to regenerate after simple cutting is common among East African trees (Pratt and Gwynne, 1977: pp 133–134). Although the use of an imported chemical may be regarded as inappropriate, it certainly was the most cost-effective means of ensuring kills in this trial. It has been calculated (Coppock et al, 1990: p 24) that with only 1 ml of arboricide/stump, the cost to kill 600 trees/hectare is less than EB 10 which is a small addition to the cost of labour that is otherwise much less effective. One other drawback with chemicals, however, is that their safe use requires careful supervision. Attempts to control bush purely through human labour are thus thought to be expensive, time consuming and largely ineffective. Not surprisingly, the Boran do not express much interest in engaging in such activities unless they are paid or receive Food-for-Work (D. L. Coppock, ILCA, personal observation). The lack of interest in labour-intensive methods for bush clearing among the Boran may reflect time constraints as well as the labile land tenure; i.e. if a location becomes unusable because of bush encroachment, the people can probably still move

Plate 7.4. *A specimen of* Acacia drepanolobium *a few months after an attempt to kill it by stumping using manual labour.*

Photograph: Shewangizaw Bekele

elsewhere. Options to move are probably declining, however, and this may stimulate interest in bush control among the Boran.

Wood collection: Billé and Assefa Eshete (1983b) noted that while the general effect of pastoralists on trees through wood collection may be locally significant around individual encampments, this is not important for bush control in a regional context. This agrees with the interviews of pastoral leaders by Solomon Dessalegn (nd) in which they indicated that routine harvest of wood for cooking and construction has little effect on tree populations overall (Coppock et al, 1990: p 21).

Charcoal production: Charcoal production from undesirable woody plants is a cost-effective means of bush clearing (Pratt and Gwynne, 1977: p 129; Cossins and Upton, 1988b). Solomon Dessalegn (nd) conducted initial trials using local methods to assess whether some of the encroaching species could be turned into suitable charcoal. There was concern that abundant and apparently useless species such as *A. drepanolobium* may not make suitable charcoal because of their slender trunks, commonly less than 20 cm in circumference. It was found that the dry-matter yield of charcoal from a standard fresh weight of 350 kg ranged from 16 to 25% for five species (Table 7.7). A good predictor for efficiency of charcoal conversion was per cent moisture of wood (Coppock et al, 1990: p 24). As per cent moisture increased (x) so did the per cent charcoal yield (y) in a significant correlation ($y=0.715x-38.6$; $r2=0.40$, $P=0.003$, $N=20$). Samples of charcoal were taken to Addis Ababa to see if traders could evaluate the quality (Coppock et al, 1990: p 27). There were no repeatable differences among rankings of samples by five traders; so all were judged as similar. The traders, however, regarded acacia charcoal as superior to the non-acacia charcoal that dominates the Addis Ababa market. The lump size was considered adequate and the dull matte finish suggested a good combustibility and absence of sparking (Coppock et al, 1990: p 27).

A cost-benefit study suggested that 9400 kg of charcoal from 600 *A. drepanolobium* trees/ha could provide a gross return of over EB 7400 if marketed in Addis Ababa (Coppock et al, 1990: p 27). The total cost for 135 man-days of labour, local transport, field supplies and arboricides was estimated as EB 1125/ha. The net profit was on the order of EB 6600/ha. This also assumes that SORDU could transport the charcoal to Addis Ababa at neglible cost when empty cattle trucks go for maintenance. Even if transport costs were included the activity would still be highly profitable (Coppock et al, 1990: p 27).

Table 7.7. *Per cent charcoal yield from 350 kg of fresh wood for five* Acacia *species using local methods during November 1989 in the southern rangelands.*[1]

	Species				
	A. bussei	*A. drepanolobium*	*A. etbaica*	*A. mellifera*	*A. seyal*
Per cent yield	25.0*x*	19.5*y*	17.4*yz*	16.6*yz*	15.8*z*

1 Each entry is the mean of four replications. Entries accompanied by the same letter (*x, y, z*) were not significantly different ($P<0.01$) in a one-way ANOVA with an LSD (least significant difference) test. In addition, there was a significant effect of replication over time ($P = 0.01$) which indicated that after the second or third use of the same charcoal-production pit, better conversion was achieved.

Source: Coppock et al (1990).

It is thus apparent that bush-encroached sites could be reclaimed using a combination of burning (to eliminate young trees), stumping and chemical application to kill larger trees, which could then be converted into charcoal to recoup the costs and provide profits for other local projects such as water tanks or maintenance of wells and ponds (see Section 7.3.1.1: *Water-development activities*). Chemicals are still needed because the stemmy regrowth of stumped trees is probably not useful for further conversion into charcoal (D. L. Coppock, ILCA, personal observation). This approach may be most successful during drought-recovery phases when grazing pressure is lower and cattle are less available for donation for community projects. Organised charcoal-making alone could also provide jobs for pastoralists during drought (see Section 7.3.3.7: *Mitigation of drought impact*). It is envisioned that this activity could be coordinated and regulated by SORDU. Alternatively, the Boran could attempt to control it themselves as part of bush clearing projects at the *deda* or *madda* level of resolution. Other pastoral groups near Awash Park have reportedly taken keen interest in conserving trees that are under pressure from neighbouring urban dwellers. The fact that the pastoralists are armed and the urban dwellers are not allows the pastoralists to regulate collection of fuel wood by the former (C. Schloeder, Ethiopian Wildlife Conservation Organisation, personal communication).

Despite the economic attractiveness of charcoal production, the main concern of SORDU is whether it could be controlled once knowledge of charcoal-making is more widely disseminated (Coppock, 1990b). Experiences elsewhere in Africa support this view (Moris, 1988). Charcoal-making is illegal on the Borana Plateau but small quantities are still produced (D. L. Coppock, ILCA, personal observation). It is likely that in addition to existing regulations, problems of labour, local transport and a low local demand would discourage wider production of charcoal (Coppock, 1990b). Conservatism is warranted as the continued rapid growth of local towns and a declining prosperity of many pastoralists may encourage faster rates of charcoal-making (and/or wood collection) in the future. In addition, there are no assurances that unregulated charcoal production could always be confined to less useful species of trees. To conclude, the major constraint against charcoal production is the ability of SORDU or the Boran themselves to regulate such activities.

Site selection for bush control: At this point it is important to again address the issue of the possible role of bush encroachment in protecting overgrazed sites and contributing to rehabilitation of the top soil through leaf litter (see Section 3.4.2: *Environmental change*). There are no easy rules for site selection for bush control but a conservative approach would be to avoid bush control in those locations where a very reduced grass cover and heightened soil erosion is apparent. These would be difficult to burn, regardless. In contrast, those sites where the grass cover has recovered, but is only limited in terms of its accessibility, may be considered as priority sites for bush clearing. This would also provide management that is consistent with the hypotheses of the useful role of bush encroachment. Site selection must be undertaken in collaboration with the local people. As with other aspects of range improvements and site rehabilitation, the *deda* is probably the most appropriate level of social organisation with which to undertake bush control (Section 7.3.1.2: *Grazing management*).

Role of browsing stock: Pratt and Gwynne (1977: p 138) give examples where goats can be effective in controlling woody plants. They cite an example in Kenya (probably a well-managed ranch) where running goats at a rate of four goats per steer reduced the need for burning to once every six to eight years versus once every three to four years when cattle were managed alone. The Borana pastoralists, however, have stated that browsing stock cannot control bush encroachment (Coppock et al, 1990: p 21). This response is probably due to several factors: (1) the relatively low population density of browsers; (2) the high level of herding coordination probably required to assemble enough browsers to impact trees in a given site; and (3) once woody plants have reached a certain size, browsers can probably inflict only minor damage. In some local instances, however, browsing by small ruminants has probably contributed a degree of regulation. The closely pruned stands of stunted *Commiphora* spp at Did Hara may be one example (D. L. Coppock, ILCA, personal observation). Goats probably are most useful for controlling bush at the seedling stage and some detailed food-habits trials would be required to test this hypothesis. However, goats could also eat seedlings of valuable tree species and compete with calves for forages such as *A. tortilis* fruits (Coppock et al, 1986a; see below). Because of their large size and need to consume foods from large abundant trees, camels are relatively useless for bush control compared to small ruminants (Coppock et al, 1986a). In addition, with the exception of *A. brevispica*, camels do not appear to consume species that are regarded as encroachers (see Section 3.3.5.1:*Livestock food habits*). With the understanding that too many small ruminants may also be ecologically undesireable, the most effective policy to encourage more targeted impacts by small ruminants could be to provide better veterinary services (see Section

5.4.6: *Small ruminants*), by prioritising such interventions on a site-specific basis to *madda* or *deda* with emerging populations of seedlings of undesireable bush species.

7.3.2 Land-use policy and agronomic interventions

Dealing with the anticipated spread of cultivation on the Borana Plateau represents a major challenge. Central to this is the problem of the conflict between the short-term survival goals of the pastoralists and the longer-term interests of the nation in promoting sustainable use of rangeland resources. In many cases the literature notes the negative effects of opportunistic cultivation on soil fertility and structure as key factors in the degradation of rangelands (Moris, 1988). It is also evident, however, that mixed cropping and livestock systems offer economic advantages to populations by providing a buffering capacity in variable environments (Campbell, 1984). The ideal situation would be to accomodate cultivation only where it is environmentally appropriate, but this places significant burdens on regulatory agencies.

The spread of cultivation in more mesic valleys in the north and south-central portions of the study area (see Section 3.3.1: *Ecological map and land use*) is speculated to become a permanent fixture in the system (see Section 7.2.2: *Anticipated long-term trends*). Black soils in valley bottoms are more fertile than red upland soils and far less likely to be degraded (I. Haque, ILCA, personal communication; see Section 2.4.1.3: *Soils*). Valley landscapes will also be the best sites for reliable accumulation of soil moisture and plant growth each year will be less dependent on annual rainfall compared to that on red upland soils. Thus, cultivation in valley bottoms is expected to be less risky and probably could be practised every year. The main danger of cultivating valley bottoms is the threat to the *Pennisetum* spp community that characterises these sites. Hodgson (1990: p 66) cited speculation by R. Hacker (TLDP consultant) that the *Pennisetum* community is of little value to the livestock production system. However, work reported by Menwyelet Atsedu (1990) indicates that *Pennisetum* spp have value as dry-season forage for calves and other domestic use as roofing material for Borana huts. The stemmy brown appearance of *Pennisetum* spp in dry seasons gives the impression that it has little feeding value but the Boran report that persistent green tissues are usually available in the tussocks even late in the dry season when no other green herbaceous material is available (D. L. Coppock, ILCA, personal observation).

It is thought that the Boran are aware of local trade-offs between cultivation and maintenance of *Pennisetum* spp communities, and opt to cultivate. This decision is likely dictated by the need for grain, but the Boran are probably also aware that if they produce their own grain, they need to sell less milk that can benefit calves (Section 5.3.2: *Calf growth and milk offtake*). In addition, they probably recognise that crop residues can substitute to some degree for the forage lost in the form of *Pennisetum* spp. Even in a dry year some crop residues will be produced (Cossins and Upton, 1988b) so the land is unlikely to be lost to the production system even during times of stress. It is also important to note that all surveyed encampments in cropping areas such as Did Hara *madda* have *kalo* enclosures of *Pennisetum* spp for calves (Menwyelet Atsedu, 1990). Thus, actions have apparently been taken to accomodate both calf needs as well as cultivation.

In contrast to valley bottoms, cultivation will be more opportunistic and risky on red upland soils. The frequency of cultivation on these sites will be more episodic in nature and most common in the drought-recovery phase of the cattle population because of a shortage of milk for human consumption (Section 7.2.3: *Anticipated short-term cycles*).

Cultivation has been variously encouraged and discouraged among the Boran by local officials. Some administrators, PAs and nongovernmental organisations have been implicated in encouraging the spread of cultivation while SORDU and other development agents seek to ban cultivation from the rangelands. The lack of a coordinated policy is a hindrance.

The pronounced need for grain among the pastoralists will increase in the future because of population growth, and cultivation is one response to avoid having to sell milk or animals to buy grain (Section 7.2.2: *Anticipated long-term trends*). Banning cultivation entirely would particularly jeopardise the poor and it would be highly resisted and difficult to enforce. The most appropriate course of action would be to permit cultivation in suitable valley sites but not allow opportunistic farming on red upland soils. Food production and environmental sustainability could thus both be accommodated. Regulatory agents should act through existing pastoral organisations to communicate such strategies and facilitate implementation of regulatory norms where traditional means are not available (see Chapter 8: *Synthesis and conclusions*). The Boran commonly contend that they recognise the dangers of cultivation for the land and can regulate cultivation themselves; but it is unclear how well they have thought through the issues (Hodgson, 1990: p 85).

A total ban on cultivation has disadvantages to the pastoralists that could also result in costs to the nation in terms of more of the poor moving into local towns. A ban, however, does offer the advantages in forcing increased marketing of livestock and in simplifying the work of regulatory agents that are often incapable of enforcing a piece-meal supervisory approach. The critical issue is thus regulation. It is assumed here that valley bottoms are appropriate for sustained cultivation. Some results from agronomy trials thus warrant mention.

Agronomy trials: Yohannes Alemseged (1989: pp 57–105) investigated legume intercropping strategies for maize. The objective was to assess the complementary or competitive nature of legumes with yields of maize grain. The experiment employed a complete randomised block design with four replicates per treatment. Treatments included: (1) four planting densities of maize (0 (controls for the legumes), 20 000, 30 000 and 55 000 plants/ha); (2) two planting times for legumes (i.e. at the same time as the maize or 20 days later); and (3) four species of annual legumes. Maize was also planted alone in four replicates of each planting density. The legumes included two dual-purpose species (*L. purpureus* (lablab) and *V. unguiculata* cv White Wonder Trailing (cowpea)) and two forage species (*C. rotundifolia* cv Wynn and *C. schottii*). All legumes were deemed as superior performers from previous screening trials.

Maize seeds were obtained locally while legume seeds were obtained from ILCA. Plots (2 x 3 m) and seeds were prepared as in the forage yield trial reported earlier (see Section 7.3.1.3: *Forage improvements*). The site was located in a small valley of red soil at Dembel Wachu Ranch. Rows of maize were evenly spaced by 75 cm, and variation in plant density was achieved by altering the distance between seeds within rows. Maize was planted before the main rains on 23 March 1987. Legumes were planted in the middle of the interrow spaces of maize. Seeds of cowpea and lablab were spaced 20 cm within rows while seeds of *C. rotundifolia* and *C. schottii* were planted at rates of 10 and 15 kg/ha, respectively. Legume planting dates were either on 23 March or 11 April in an attempt to gauge temporal effects of competition; the 20-day interval was chosen given the short duration of the long rainy season.

Rainfall was initially delayed but subsequently heavy during the next six weeks. Maize was harvested when ripe 109 days later on 9 July, air-dried for 10 days and separated into grain and residue components. Cowpea was harvested from 30 June to 14 July because of uneven ripening. Lablab was harvested on 14 August when ripe. Biomass of both legumes was air-dried. Grain was removed from pods and weighed and residue was separated out. Forage legumes were harvested when the maize was harvested. *Cassia rotundifolia* was setting seed and *C. schottii* was beginning to flower at this time. This biomass was also air-dried. Sub-samples of all components for maize and legumes were oven-dried at 60°C for 24 h for determination of dry matter. Data were analysed on a dry-matter basis using ANOVAs with LSD tests to separate means.

Only highlights of results will be presented here. Details are available in Yohannes Alemseged (1989: pp 66–92). The main effects of legumes on yields of maize grain over both planting dates of legume are shown in Table G12, Annex G. Overall, the dual-purpose legumes had a much greater effect on reducing maize yields compared to the forage legumes. This was related to the higher productivity of the dual-purpose species. Over both planting dates and three densities of maize (excluding zero), the highest total dry-matter yields were reported for cowpea (4791 kg/ha; 39% grain), lablab (4051 kg/ha; 26% grain), *C. rotundifolia* (267 kg/ha) and *C. schottii* (144 kg/ha). Grain yields overall for cowpea (1991 kg/ha) and lablab (869 kg/ha) were significantly different ($P<0.001$). Maize, in turn, depressed grain yields of both cowpea and lablab by 46% compared to respective controls ($P<0.05$), with negligible variation due to maize density and planting date.

Delaying planting time of legumes by 20 days reduced competition and maize yields increased ($P<0.05$) from 8 to 17% at densities of 20 000 and 55 000 plants per hectare, respectively. The later planting time for dual-purpose legumes, however, reduced ($P<0.05$) their grain yields by 57% overall.

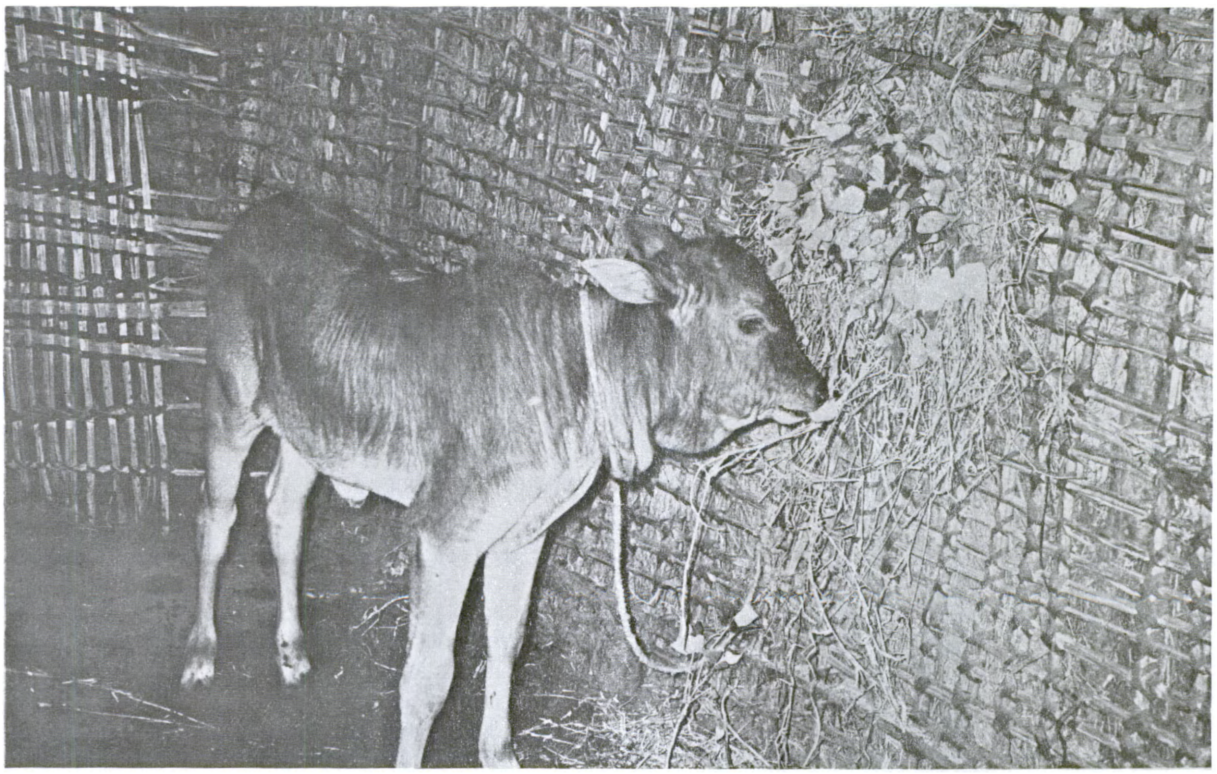
Total grain yield (maize plus legume) was only marginally affected by legume planting date, but the proportion comprised of maize tended to increase when legumes were planted later. Over both planting dates and three maize densities (excluding zero), the average total grain yield was highest for cowpea plus maize (4280 kg/ha), followed by maize only (3824 kg/ha), maize plus the forage legumes (=3579 kg/ha) and lablab plus maize (3359 kg/ha). Total yield of residue followed similar patterns. Considered across both planting dates and for three densities of maize (excluding zero), the highest average residue yields were for cowpea plus maize (5241 kg/ha), lablab plus maize (4140 kg/ha), maize only (3777 kg/ha) and maize plus the forage legumes (=3382 kg/ha).

In sum, it is apparent that despite competitive effects, planting cowpea plus maize yielded greater benefits compared to maize alone in terms of total yield of grain and residue. The lower yields of legume grain at the later planting date, the relatively moderate effect of later planting on yields of maize grain at the lower planting densities of maize, labour considerations and the uncertainties of good rainfall all indicate that planting maize and cowpea at the same time is the best strategy.

Although not observed in this trial, the Boran perceive that cowpea requires less time to mature under a given amount of rainfall than local maize. This is reflected in the observations that cowpea is commonly planted during the short rains (October–November) when prospects for a successful maize harvest are poor (D. L. Coppock, ILCA, personal observation). The true value of intercropping here is thus the mixture of a lower-risk crop (cowpea) with a higher risk crop (maize) under conditions of uncertain precipitation. Production of grain, not forage, is thus more likely, and grain is what the people are most interested in (Hodgson, 1990: p 80). Legume grain may also have a valuable role in diversifying the nutritional base of human diets which focus on milk and maize (Holden et al, 1991). Crop residues for livestock are definitely secondary. This indicates that promotion of dual-purpose legumes, with the priority towards production of human food, would be far more successful than promotion of those intended only as forage.

Management perspectives: The inclusion of a dual-purpose legume such as cowpea also offers possibilities to enhance crop/livestock interactions, particularly through improved calf feeding (also see Table G9, Annex G). The mixture of cowpea and maize not only yielded more crop residues but also of higher nutritional value for animals because of the contribution of cowpea (12.2% CP on a dry-matter basis) (Coppock and Reed, 1992). Dried maize leaves typically only have a CP content of 2.6% on a DM basis (Urio and Kategile, 1987) and thus mixing the two in feeding packages would allow improved utilisation of low-quality maize residues (Tanner et al, 1990). A ratio of cowpea residue to maize leaves on the order of 1:1 would achieve a diet quality of 7.4% CP for young calves, slightly above a minimum requirement of 7% for sustenance. Cowpea hay could also be incorporated into feeding packages based on grass hay (see Section 7.3.1.3: *Forage improvements*; Plate 7.5). Just in terms of readily accessible biomass, cowpea offers advantages over *A. tortilis* fruits or *A. brevispica* leaves in considering constraints of time and labour (Mulugeta Assefa, 1990: p 62–71). Field observations (D. L. Coppock, ILCA, personal observation; Tesfaye Wogayehu, CARE-Ethiopia, personal observation) also indicated that management of

Plate 7.5. *Calf feeding on a mixture of cowpea hay residue and grass hay in a slight modification of the traditional system.*



Photograph: Shewangizaw Bekele

cowpea residue is a problem. Higher-quality leaves are deciduous and fall from the plants at harvest and thus are likely to be lost. Besides promoting calf-feeding packages, extension agents need to inform and encourage the people regarding efficient collection and storage of crop residues. The Boran already build corn cribs and put up grass hay (Coppock, 1991) so these concepts are no longer foreign. Harvest comes at a time when seasonal labour burdens are somewhat reduced (see Section 4.3.3: *The labour of married women).*

Cowpea is already present in the Borana system but more widespread use could be encouraged in appropriate sites. A major problem is the availability of seed. Nongovernmental organisations like the Norwegian Church Aid (NCA) have long been involved in promoting improved cultivation practices among farmers who live on the periphery of the pastoral system. Cultivation of cowpea has been a cornerstone of some of these programmes (D. L. Coppock, ILCA, personal observation). The most sustainable means to improve the availability of cowpea seed among the Boran is for development agents to promote more economic interactions between farmers and pastoralists.

The contribution of cowpea or other dual-purpose legumes to the sustainable use of cultivated areas is unclear. Working in Mali, Hulet and Gosseye (1986) noted that compared to sites planted only with millet, sites where millet was intercropped with cowpea showed a higher soil fertility. Although this is also reportedly known by the Boran in some cases (R. J. Hodgson, CARE-Ethiopia, personal communication), there is no evidence that cowpea fixes nitrogen in this environment. What legumes contribute to the maintaining of soil structure is another issue. Highly productive annuals such as cowpea or lablab would probably be much more desired by the Boran than less productive dual-purpose perennials such as *C. cajan* which performed adequately under multiple harvest treatments. Although as a perennial *C. cajan* may promote more stability of soil structure as an intercrop, it produces less human food over the short term.

The Boran will not be concerned about the ecological sustainability of cropping sites as long as the suitable cropping area can expand. Indeed, they often do not express a concern about declining soil fertility. This may be because they think it has not happened yet to a significant degree (Hodgson, 1990: p 68) and because they recognise the resilient nature of valley landscapes which are cultivated most often. When people in Did Hara *madda* were asked why they refrained from adding manure from encampments to their fields in the valley below, they remarked that they did not have to; rainfall washes it down there for them (D. L. Coppock, ILCA, personal observation).

The main point is that intensification of cropping, whether by promotion of soil ridging, intercropping or manure application will fail until such time as the Boran regard it as necessary. When that time comes such activities may still not be implemented because of a shortage of labour. Manure application is a case in point. Encampments are characterised by enormous mounds of manure that has been cleaned from corrals over the years (Donaldson, 1986: p 61), but it is unutilised. Improved use of manure must alleviate the labour problems of transporting it to fields up to 1 km away.

CARE-Ethiopia has attempted to extend two-wheeled carts that can be drawn by oxen or donkeys that cost on the order of EB 325 (Hodgson, 1990: p 36). The Boran are interested in the carts but the problem to date has been the supply as well as the maintenance of these carts. Alternatively, the people may be interested to rent SORDU vehicles to transport manure and this should also be investigated. Hodgson (1990: p 68) reported a distinct lack of interest by the Boran in the intensification of farming although this may change in the future. The Boran at present appear unmotivated to even intercrop legumes. They state that cowpea broadcasted among maize yields suitable results. (D. L. Coppock, ILCA, unpublished data).

If cultivation in valleys is considered to be a viable proposition in terms of local policy and regulation, it must be recognised that increased use of draft power will be required. Draft technology would facilitate expansion of cultivation in all suitable sites and forego the need to rely on human labour alone. Despite the fact that men and women share tasks of cultivation today (Section 4.3.6: *Cultivation*), it is anticipated that more of the responsibilities of cultivation will fall to women in the future in view of the postulated increase in the emigration rates for men (Section 7.2.2.3: *Labour availability*). Initial transfer of oxen draft technology has been stimulated by the Boran observing local farmers as well as other pastoralists using animals for farming that were originally trained for pulling scoops to desilt ponds (Section 7.3.1.1: *Water-development activities*).

7.3.3 Animal production strategies

This section explores the potential for sustainable improvements in livestock production with their ramifications as regards the cost of implementation and the risks involved in realising their benefits. Interventions that superficially appear to offer the greatest economic returns over the long term may in reality be too risky or difficult to implement. The most appropriate interventions may be those that bring only an incremental improvement. It was demonstrated in Chapter 5 *(Livestock husbandry and production)* that the Boran are skilled livestock producers and so the scope for sustained improvement may be limited. Risks and costs of intervention are largely dictated by the environment, labour pool and stocking rate. Earlier in this chapter (Section 7.2: *A theory of local system dynamics*) it was hypothesised that these three factors interact to periodically constrain cattle production. This concept helps illustrate the utility of a systems approach for implementing development interventions.

7.3.3.1 Mature cattle

Milk production: Cows and resource management

The most important production feature of adult cattle to the Boran is milk production, and low offtake of milk in dry periods is the most critical factor affecting human welfare over the short term. As mentioned in Section 7.2.1: *Empirical modeling*, calving rate and milk production are supposed to be influenced by annual rainfall as mediated by stocking rate. Milk production should thus be dramatically affected by the interdrought cycle (Section 7.2.3: *Anticipated short-term cycles*). To illustrate, assuming average rainfall throughout an interdrought period, during the first several years of drought-recovery, milk production per cow should be the highest because of low forage competition (i.e. the stocking rate would be <15 head/km^2). As the stocking rate increases each year thereafter, milk production per cow should gradually decline. Although dry seasons would cause spot deficits of protein for cow nutrition, the decline would primarily be in response to decreasing availability of forage energy (i.e. forage quantity).

Although scientists commonly think that productivity per head is very important, survival of a subsistence society like the Boran is more influenced by production per unit area, which incorporates stocking rate and productivity per head. This is not to say, however, that households perceive changes in production per unit area, responding only to changes in milk supply for family members. It is to say that as an ecological factor, milk production per unit area is a decisive variable at the population level of resolution. Compared to milk production per cow, milk production per unit area probably shows far more interesting patterns in the interdrought cycle. For example, milk offtake per hectare would be low but increasing in the drought-recovery phase because of a low stocking rate of cows that survived the drought. Milk offtake per hectare would then peak some five years after the end of the drought when the cow component of the regional herd had recovered its numbers through a combination of recruitment and trade. In the following high-density phase, milk offtake per hectare should gradually decline because of competition for forage among cows and a gradual decline in output per cow. These dynamics are shown in Figure 7.3 and reflect patterns reported in research from Jones and Sandland (1974) and Hart et al (1988). If these patterns are correct, over the short term the Boran would probably perceive milk offtake at the household level as slowly rising, peaking and then falling, as long as annual rainfall is near average throughout. Over the long term, however, they might perceive milk yield per person as declining because of rapid human population growth (D. L. Coppock, ILCA, unpublished data).

Appreciation of these milk production patterns is important because they illustrate that: (1) even if widespread supplementation was feasible, nutritional constraints for milk production would change depending on the kind of year; and (2) it would be difficult to assure sustainable increases in milk production without expanding the grazing area or decreasing the male component of the regional herd. For an example of the first scenario, lack of minerals could limit milk productivity during wet seasons of years early in the drought-recovery phase when forage supply is high. Once the herd grew, seasonal protein deficits could become the next main limiting factor. In the high-density phase energy shortage would be the main constraint. For the second scenario, land expansion is difficult because neighbouring areas are likely occupied by other people. While cutting down on male cattle compromises asset accumulation and the ability to recover from drought (see below). Intensification is difficult and risky because internal resources are already scarce due to low rainfall and high densities of consumers. The people have developed attitudes of aversion to taking risk shaped by generations of extensive management.

Besides drought, the other times of greatest per capita shortages in milk production would be in a warm dry season of a below-average rainfall year in either the drought-recovery or the high-density phase of the cattle population. During both phases the quickest and least risky means for a household to increase milk supply is to trade bulls for more cows. Such activity is reportedly on the increase. It is viewed by TLDP as a move that undermines the integrity of the Boran genotype when pastoralists trade for inferior cows from the southern highlands (see Section 5.4.5: *Cattle growth and implications for breed persistence*). Even if the Boran had the means to intensify cow management in the high-density phase, the high stocking rates in conjunction with chance deficits in annual rainfall makes this very risky. In sum, pervasive constraints of access to forage and water supplies dictate that little can be done directly to improve milk production through enhanced feeding management of cows.

There could be more ways, however, of indirectly enhancing people's access to milk such as improved calf feeding using grass hay, crop residues and acacia supplements and providing supplemental water from cisterns (see Section 7.3.1.1: *Water-development activities* and Section 7.3.1.3: *Forage improvements*). These materials could substitute for calf milk intake to some degree and allow people a higher consumption of milk. If calf mortality is mitigated through improved feeding their dams may also remain lactating longer (Donaldson, 1986). Another indirect means to increase fodder for cows is to reduce competition from male cattle. The *forra* system (Section 5.3.1: *General aspects of cattle management*) mediates competition between cows and bulls for forage, but *madda* are under increasing pressure to accommodate *forra* cattle within (Section 7.3.1.2: *Grazing management*). Milk production of cows would benefit from enlargement of *deda* grazing areas through local water development, bush and tick control (see below) and improving forage quality through prescribed burning. Enlargement of *forra* fall-back areas through carefully planned large-scale water development could ease the pressure. Finally, tactics that encourage selling of males to bank the money or finance community projects would also relieve pressure. Most of these interventions would have their greatest effects on milk production, and be the easiest to implement, during the high-density phase of the cattle population when the people are forced to consider innovations (see Section 7.4: *Component interventions and system dynamics*). All of these interventions have been previously discussed except banking which is reviewed in Section 7.3.3.6: *Cattle marketing*.

Health

Perhaps the most straightforward means to increase milk production is through mitigation of tick damage to cow udders. Milk production may be reduced by about 15% simply because of tick challenge which closes off teats (see Section 5.4.3: *Cattle mortality and health*). In the upper semi-arid and subhumid zones it has been reported that large tracts of grazing land have been abandoned in response to heavy tick infestation (I. DeLange, Holy Ghost Mission, personal communication). Lack of acaricides and prohibition of range burning have reportedly contributed the most to this problem (Coppock, 1990b).

Acaricides have been generally unavailable in Ethiopia during the past 10 to 15 years (Sileshi Zewdie, SORDU veterinarian, personal communication). Lack of foreign exchange for rural development has been the ultimate constraint since acaricides have to be imported. Bureaucratic procurement problems in Addis Ababa have also been reported to limit use of acaricides (Sileshi Zewdie, SORDU veterinarian, personal communication). Acaricides and dipping facilities were available on the Borana Plateau during the Second Livestock Development Project from 1973–1981 when livestock development projects could control procurement of their own imports (Girma Bisrat, PADEP Coordinator, personal communication). Cost in local currency seems to be a minor issue as the Boran are willing to pay for acaricides (Coppock, 1990b). It is remarkable that the use of acaricides is not institutionalised given that they were developed over 50 years ago (Jahnke, 1982: p 164).

One argument against acaricides is speculation that frequent use undermines attainment of a natural resistance to tick-borne diseases. Having introduced their widespread use procurement of acaricides becomes subsequently irregular, it is thought cattle may thus be rendered more vulnerable (G. Smith, former FLDP consultant, personal communication). It is unclear if this assumption is correct. It would be useful to know to what degree immunity to tick-borne diseases is inducible over a cow's lifetime, and whether or not animals can attain lifetime immunity as calves. Even if acaricide use in the form of dipping is deemed inappropriate, implementation of acaricides or other repellents in the form of a salve for udders could be a valuable contribution.

Prescribed burning has been reported as being effective in tick control (Barnett, 1961; Rodgers and Homewood, 1986). This can be another benefit of implementing comprehensive burning programme (Section 7.3.1.4: *Site reclamation*). It remains unclear, however, which seasons and site types are best for using fire to control tick and whether these approaches would be compatible with those needed for other objectives such as bush control or management of grass swards. It is likely, because of environmental conditions, that most burning would occur at the end of either of the two dry seasons in September and/or March. The population and reproductive status of tick species at these times are presently unknown in the southern rangelands and this requires research.

Live-weight gains: Mineral nutrition

There are two approaches for improving endurance of mature cattle during dry seasons of average rainfall years: (1) dry season supplementation; or (2) promoting an improved body condition of animals before they enter the dry season. As just indicated, resource scarcity during dry seasons makes attempts to supplement diets of large stock with energy or protein impractical. Facilitating weight gain during wet seasons, however, by providing small amounts of mineral supplements could be more feasible in meeting the second objective. This is a time when energy and protein requirements are more reliably met. The Boran traditionally supplement livestock with salt obtained from local volcanic craters. The composition of this salt was found to be 41% NaCl with minor quantities of macro and trace minerals (Kabaija and Little, 1987).

Kabaija and Little (1991) hypothesised that supplementing the diet of growing male cattle with phosphorus (P) and copper (Cu) would show benefits in terms of improved weight gains. The study was conducted for animals kept on Dembel Wachu Ranch from June 1987 to May 1988, a year of average rainfall. Sixty-four male Boran cattle (averaging two years old with a mean live weight of 200 kg) were vaccinated against common diseases, stratified by weight and randomly distributed among four treatments: (1) supplemented with both P and Cu; (2) supplemented with P only; (3) supplemented with Cu only; and (4) the control (no supplement). Phosporus was offered as bone meal mixed with local salt at a ratio of 2:1 in troughs inside corrals where animals passed the night. Copper was administered in the form of calcium copper acetate given subcutaneously at a rate of one 100-mg dose per animal every six months. Local salt was also offered to treatments 3 and 4 in troughs. Animals were weighed initially and every 45 days thereafter. At each weighing except the last, blood was collected from the jugular vein of all animals and analysed for serum concentrations of Cu, Zn, Ca and Mg using atomic absorption spectrophotometry. Every 45 days samples of grass species and parts commonly eaten by the cattle were hand plucked, separated into species and analysed for concentrations of K, Na, Ca, P, Mg, Fe, Mn, Zn and Cu using atomic absorption spectrophotometry after a wet digestion. A representative sample of soil collected from a depth of up to 15 cm at 90 day intervals was composited from dominant substrate that was well drained and derived from a gneiss/quartz parent material. Soil was analysed for pH and concentrations of the same minerals by atomic absorption spectrophotometry. Data on average daily gain (ADG) and blood–mineral content were analysed using a general linear model procedure.

Only a brief summary of results of this study is presented here. Details are in Kabaija and Little (1991). Averaged across the year, the 16 dominant forage species varied markedly in mineral content and in relation to the minimum mineral concentrations required for ruminants (McDowell, 1985). All species were sufficient in terms of K and Fe; 9, 13 and 14 out of 16 were sufficient in terms of Ca, Zn and Mn, respectively. In contrast, 0, 1, 2 and 2 out of 16 were sufficient in terms of Na, Cu, Mg and P, respectively. The soil had a pH of 6.65 and was below critical levels for concentrations of available P and Cu. Treatment effects considered throughout the year were not significant (P>0.05) for either ADG (195 to 225 g/head/day) or blood serum values. Inspection of seasonal weight dynamics for the treatments (see Figure 1 in Kabaija and Little, 1991) did not indicate any meaningful variation in wet-season gains or dry-season losses. (Also previously noted by AGROTEC/CRG/SEDES Associates (1974h).

Despite indications that forage mineral concentrations were deficient in P and Cu the animals were not affected by supplementation and all showed similar serum values for these elements (Kabaija and Little, 1989: pp 4–5). This seeming paradox may be explained by: (1) the unsuitability of general mineral-nutrition guidelines (McDowell, 1985) for local African conditions; (2) the ability of cattle to obtain their mineral requirements by foraging on a greater variety of grasses and sites than measured in this trial; and/or (3) water as a source of minerals. The animals in the trial watered at the Dubluk well area, some 14 km from the ranch. Nicholson (1984) reported mineral concentrations for water samples from several wells on the plateau and noted significant concentrations of P and Cu. This shows that drinking water could provide important supplemental minerals and vegetation analysis alone may not be an adequate assessment. In conclusion, while some aspects of mineral nutrition may constrain livestock performance on the plateau, this remains to be proven. In addition, in the attempt to isolate key constraining minerals, development agents must also consider the most appropriate means to rectify the situation. More research may be required on this topic within the framework of improving wet-season performance by cattle early in the drought-recovery phase.

7.3.3.2 Camels, donkeys and small ruminants

Studies reviewed in Section 5.4.6: *Small ruminants* and Section 5.4.7: *Camels and donkeys* indicated that: (1) disease control is the priority production intervention for camels and small ruminants; and (2) basic research is required to assess what constrains growth in donkeys. Small ruminants have their greatest value in diversifying food production and cash income options for households (Coppock, 1992b). Camels and donkeys have their greatest value as beasts of burden alleviating the demand on women. Camels also have value for milk production during drought and, through their capacity for long-distance transport, in contributing to calf management (hauling water), food security (hauling grain) and rural development (hauling various construction materials).

Work reported elsewhere supports the philosophy of herd diversification by pastoralists. Keeping camels and small ruminants with cattle can lead to more efficient use of grazing and browse resources (Coppock et al, 1986a). The most beneficial mix of species for households may vary with their wealth. Optimal mixes reportedly confer higher chances of household economic viability in response to drought (Mace and Houston, 1989; Mace, 1990).

Until disease among small ruminants on the Borana Plateau can be better controlled, their production will be perceived by the Boran as a more risky activity than keeping cattle and will thus remain ancillary (Coppock, 1992b). Small ruminant production could, however, serve a valuable role in generating income among the peri-urban poor who must sell their meagre amounts of cow's milk in order to purchase a survival ration of grain (Holden et al, 1991). Despite large efforts by authorities to stimulate cattle commercialisation among the Boran, cattle offtake has been generally disappointing (Section 1.4.4: *Has national range development been successful?*). And it is ironic that such efforts may have worked much better for small ruminants. This is because cattle have been traditionally viewed by the Boran as a means of generating and storing household wealth; by contrast, small ruminants are valued relatively more for meat and income generation. In addition, when small ruminants are to be sold the seller is not subjected to the social restrictions that may prevent a cattle sale (Coppock, 1992b; see Section 4.3.4.7: *Marketing attitudes*). Even export markets may be more favourable for sheep compared to cattle and Middle East markets for sheep tend to be less volatile (Solomon Desta, TLDP economist, personal communication).

Survey of 70 encampments in the semi-arid and upper subhumid zones confirmed that most Boran are interested in acquiring more camels both for transport and milk production (Coppock and Mulugeta Mamo, 1985; Coppock, 1988). For 24 Borana households at Beke Pond, holdings of food-producing stock (excluding equines) were assessed to be an average of 70% cattle, 24% goats, 5% sheep and 1% camels on numerical value basis (Coppock, 1988). The households were asked to express their desired herd composition and they responded in favour of diversification, the average desired composition was 42% cattle, 14% goats, 13% sheep and 31% camels. They were then asked what their biggest problems were in acquiring more camels. Wealthier households cited lack of management knowledge for camels as their major constraint while the intermediate and poor classes stated that camels were too expensive to acquire (camels cost roughly twice as much as cattle; see Section 4.3.4.6: *Prices*). Strategies by wealthier families to procure camels involved attempts to trade cattle for camels. Population stress may be a contributing factor to a shift in attitudes. So that forward-looking leaders of a few *madda* groups are actively promoting camel procurement as part of a general strategy for diversification (D. L. Coppock, ILCA, personal observation).

The low availability and poor quality of camels for sale in markets accessible to the Boran have been identified as a major drawback for herd diversification (Hodgson, 1990: pp 122–124; Fütterknecht, 1990: p 16). Camel-keeping Gabra living among the Boran reportedly strive to retain camels within their clan networks and rarely offer prime animals for sale to non-Gabra (Coppock, 1988). The other major camel sources are markets to the south and east of the study area and the Boran feel they must travel through hostile regions to get to these markets.

To tackle this problem, CARE-Ethiopia began to assemble buyers and transport them to camel markets. Purchases were made and animals were herded back to Borana *madda*. It is hoped that once more of the Boran get used to the idea they would learn to take public transport to markets and help others procure camels (Hodgson, 1990: p 125). If larger numbers are interested, SORDU could coordinate marketing trips on a routine basis and the new owners would require extension help on camel management. For example, in contrast to cattle, camels are inducible ovulators and would require a different approach for breeding management (Section 5.4.7: *Camels and donkeys*).

Expanding the development role of camels on the Borana Plateau has been constrained because local administrators have believed that: (1) camels cause bush encroachment; and (2) camels are "primitive", useless for export and thus not worthy of development attention (D. L. Coppock, ILCA, personal observation). This is consistent with prevailing official attitudes elsewhere (Wilson, 1984: p 173). Contrary to these views, evidence suggests that grazing cattle, not camels, are the major factor in bush encroachment (see Section 3.4.2: *Environmental change*) and that they are highly desired by the pastoral community. That camels can contribute to economic development was amply shown by Wilson (1984: pp 27, 173) who emphasised their triple-purpose value (i.e. for milk, meat and draft) while pointing out the critical contributions of camel power to the development of railways, telegraph and wool-export capacities in rural Australia in the late 1800 and early 1900s. Although not an export animal for Ethiopia, camel development on the Borana Plateau is viewed as a concession to local needs and values and facilitates opportunism in Borana society.

7.3.3.3 Dairy processing and marketing

Milk processing

Section 4.3.5.1: *Milk processing procedures* described traditional methods of milk processing. Data were collected from 31 instances of butter-making by 20 Borana women to assess whether technical improvements were possible (Coppock et al, in press). Data collection included: (1) milk temperature before and after churning; (2) per cent of lactic acid in whole milk before churning using 10 N sodium hydroxide for titration; (3) churning time; and (4) fat content of whole milk and buttermilk using the Gerber method. Chemical procedures followed O'Mahony (1988). Per cent milk-fat recovery was calculated by subtracting the fat in buttermilk from that of whole milk, dividing this difference by the fat yield of the whole milk and then multiplying by 100. Calculations included specific gravity of 1.032 and 1.036 for whole milk and buttermilk, respectively (O'Mahony, 1988). Butter yields were recorded but were not an adequate assessment of fat recovery because moisture content of the butter was not measured.

Only highlights of results are presented here. Details are in Coppock et al (in press). Measurements of butter-making involved women using a traditional *gorfa* churn having an average volume of 1.7 litres (see Figure 4.3 for a depiction of a *gorfa*). *Gorfa* were filled to 60% capacity with milk that had been soured for an average of two days (range: one to five days). Processing statistics are shown in Table G13, Annex G. The average rate of milk-fat recovery was 84%. Butter yields averaged 67±5.6 g, including moisture. Churning time averaged 40 minutes.

The results suggest that technical improvements in butter-making would be difficult. Efforts have been made here and elsewhere in Ethiopia to introduce a larger milk churn with interior agitators (wooden paddles) to improve butter-making efficiency and reduce the amount of time women spend churning (O'Mahony and Ephraim Bekele, 1985). The strategy is probably inappropriate for Borana, however, for several reasons (Coppock et al, in press). First, the Boran appear to be very efficient at milk processing despite their crude methods, as they appreciate the subtle factors involved. For example, women churn milk early in the morning when temperatures are cooler, and this facilitates milk-fat recovery (O'Mahony, 1988). The 84% milk-fat recovery rate observed among the Boran compares favourably with the 76% recovery rate for Ethiopian highlanders (also using traditional methods) reported in O'Mahony and Ephraim Bekele (1985). Second, since buttermilk is consumed, milk fat is never "lost" by Borana households making higher levels of efficiency unwarranted. Third, there is no evidence that Borana women consider milk processing tedious. On the contrary, it seems to be regarded as an "enjoyable" social activity (D. L. Coppock, ILCA, personal observation). Fourth, one important long-term trend in the system is postulated to be a declining per capita surplus of milk (see Section 7.2.2.7: *Miscellaneous household activities*). This suggests that all forms of milk processing involving surpluses will become less common in the future. Fifth and finally, the volume of the improved milk churn in O'Mahony and Ephraim Bekele (1985) is over 10 times that of the Borana *gorfa*. The size of the *gorfa* is more appropriate for the small scale of milk processing here.

For an improved milk churn to be successful among the Boran, it must thus improve the efficiency of butter-making for larger-than-average quantities of milk and in that case labour would be an obvious constraint. The only group to which the suggested improvements apply would be a small number of very wealthy households (i.e. those with many cows and few workers) that reside near towns and market butter. Seasonal dynamics of butter production also suggest that improved churns would only be used during the long rains (April through May; see Section 4.3.5: *Dairy processing and marketing*). The irony is that improved milk churns might have been more widely applicable in this society 30 years ago when per capita milk surpluses were more common; but now this technological window is probably closing (see Section 7.4: *Component interventions and system dynamics*).

Milk processing will be highly variable from year to year on the Borana Plateau in light of the interdrought cycle proposed in Section 7.2.3: *Anticipated short-term cycles*. It would be most widespread at the end of the drought-recovery phase of the cattle population because this is the time when per capita surpluses are the greatest. There will be less chance of a surplus: (1) early during the drought-recovery phase because of a shortage of cows or (2) during the high-density phase because of declining production per cow as a result of density-dependent interactions. Gradual increase in the human population will also dictate that the potential peak milk surplus of each interdrought period will become sequentially smaller over time.

In summary, these perspectives are in marked contrast to other situations where improved milk processing and/or dairy development are viewed as viable options for pastoralists (Kerven, 1987a) or agropastoralists (Waters-Bayer, 1988). The differences are probably because these other groups have a lower demand on milk as the dietary mainstay compared to the Boran, either because of less population pressure or because of significant alteration of human diets to include more non-pastoral foods. In addition, while cheese-making has been proposed as a diversification goal in dairy development proposals for pastoralists (Kerven, 1987a), this is unlikely in the southern rangelands because of the small quantity of milk surpluses and lack of technology that prohibits manufacture of hard cheese. Even if hard cheese could be produced, it is unlikely that there is any appreciable local demand for it . By contrast, local demand for soft cheeses is probably higher due to use of cottage cheese in Ethiopian *injera* and *wot* cuisine. Making cottage cheese by heating buttermilk, however, is mostly the domain of urban producers or traders who buy milk in the market place. This is because cottage cheese has a very short shelf-life and would spoil during a typical trip to market undertaken by Borana women (Coppock et al, in press).

Dairy marketing

Section 4.3.5: *Dairy processing and marketing* reviews the increasing importance of dairy marketing to Borana households in the peri-urban subsystem. Dairy income is important for women and may enhance household security by delaying sales of capital livestock. The opportunity to sell dairy products may be particularly important for poorer households. Poorer women would preferbly reside nearer to markets so they may sell small quantities of fresh milk on a daily basis in order to buy a survival ration of grain. While this helps meet short-term survival needs, the cost could be in terms of increased risks to malnourished calves and children who consume grain deficient in protein. Today and in the near future, interventions that facilitate dairy marketing, but which also mitigate its risks, are far more important to the welfare of the Boran than milk-processing technology.

A gradual increase in dairy marketing may be expected over the long term from a growing population of peri-urban poor (see Section 7.2.2.5: *Livestock and dairy marketing and herd diversification*). This should have important patterns induced by the interdrought cycle. For example, marketing of fresh milk should be the highest early in the drought-recovery phase when the Boran will be selling from a milk-deficit situation to buy grain and have insufficient animals to sell because of the drought-induced mortalities. Dairy marketing should be the lowest a few years later when cow herds have recovered their numbers, but this would only be for a short time before density-dependent factors begin to reduce milk production per unit area during the high-density phase. Milk and butter marketing should increase during the high-density phase. Marketed milk would increase from poorer households selling from a milk-deficit situation while marketed butter would increase from wealthier households further from town. Butter is better marketed from outlying areas because it does not spoil as rapidly as fresh milk while fetching a higher price per given unit (see Section 4.3.5.3: *Effects of distance to market, wealth and season on pastoral dairy marketing*). Wealthier households are the ones that would have the quantities of milk necessary to make butter after their cows had recovered their numbers. Interviews of Borana women and dairy traders were very enlightening in clarifying these cyclic patterns (Holden, 1988; D. L. Coppock, ILCA, unpublished data). For example, women interviewed the same year during the drought-recovery phase commonly stated that selling milk at that time was more important than consuming it directly (Holden, 1988). Butter traders interviewed in 1987 lamented that butter supplies were in a general downward trend, but that periodic increases in butter supply could be expected in markets after "a few more years" (i.e. after recovery of cow numbers following the 1983–84 drought).

In the past dairy income was reportedly used more to purchase nonessential items such as coffee beans or shoes (D. L. Coppock, ILCA, unpublished data). Nowadays it is used more to buy food for subsistence. Thus, it is understood that the need for food energy is the primary reason behind dairy marketing. Assuming similar population pressures for the different regions, where the Boran are able to grow their own grain (such as Did Hara), dairy marketing flows tend to vary inversely with rainfall and crop production so that in years of high maize production dairy marketing would decrease. In drier regions (but near markets) where cultivation is unreliable (such as Medecho), it is more likely that gradual increases in dairy marketing would be observed over the long term. Because per capita surpluses of milk will become increasingly rare over the long term, fresh milk will gradually make up a larger proportion of total dairy sales. Butter will become less common and traditional products based on surpluses such as long-term fermented *ititu* and ghee will gradually become more scarce. Dairy marketing may have become more complex because of urban growth in the study area and it is reported that prices for dairy products have also increased (see Section 4.4.10.2: *Dairy marketing in a wider perspective*). The crucial role of small towns in providing opportunities for selling dairy products cannot be overemphasised.

Given these conditions maintaining an unhindered flow of grain from the farming highlands to the rangelands is crucial in reducing insecurities of food supply and maintaining favourable terms of trade of dairy products for grain (Holden and Coppock, 1992). Likewise, policies and procedures that facilitate the movement of butter from the rangelands to markets in the southern highlands could also be useful because this would increase both demand and prices. Traders have traditionally collected butter from markets in the rangelands and taken it using the public transport to sell in market in the southern highlands (Holden, 1988). This was viable because butter was only periodically regulated at road check points (D. L. Coppock, ILCA, personal observation).

Policy issues related to freeing up grain movements are also related to freeing up livestock marketing channels. These are discussed in Section 7.3.3.6: *Cattle marketing*. Policies and procedures that improve access by Borana women to local markets by improving infrastructure and transport are also very important. There is scope for reducing the acute need of very poor women in peri-urban settings to sell their little amount of milk for a survival ration of grain, or at least better protect their households from the consequences of this activity. Most of the interventions in this connection have been discussed earlier in this chapter. For example, use of hay-making and water tanks to improve the feeding of calves, deprived of milk because it is sold, would lessen the risk of these calves dying. Improved agronomic practices such as growing dual-purpose legumes (*Vigna* spp) on suitable sites could help diversify human diets. Ancillary sources of income are needed and could include sales of small ruminants (this requires better veterinary support), poultry production, handicraft production and employment in regulated charcoal manufacturing, site reclamation or infrastructural maintenance projects. The one advantage of targeting peri-urban women for these activities is their enhanced accessibility by urban-based extension agents from SORDU or the Ministry of Agriculture that often do not have sufficient resources to work far from towns anyway.

As a scenario put forth earlier in this chapter indicated life may become more difficult for Borana women in the future. One aspect of this is experience from elsewhere that has shown women gradually losing control of dairying activities and dairy income to men as pastoral societies come under increasing pressure (Salih, 1985; Waters-Bayer, 1988). Even at present, it is occasionally reported that Borana men take their wives' milk money and spend it for themselves; such behaviour is said to be in violation of traditional laws of Borana society (D. L. Coppock, ILCA, personal observation; see Section 2.4.2.2: *Some cultural and organisational features*). The only feasible means to control such violations in the future is to transcribe tenets of traditional law and incorporate their enforcement within new regulatory bodies that may gradually replace the traditional order. This relates also relates to regulation of resource use and is discussed further in Section 7.4: *Component interventions and system dynamics*.

7.3.3.4 The calf: Prospects for growth acceleration

Initial modeling

As summarised in Chapter 5: *Livestock husbandry and production*, slow rates of calf growth have been proposed as a major constraint in the Borana production system. The hypotheis that competition between calves and people for milk leads to low weaning weights, slow calf growth, delayed time to puberty and limited life-time performance in terms of total calves produced per cow were initially forwarded by Nicholson (1983a) and Cossins and Upton (1988b). Competition between calves and people for milk has been cited as an important constraint for livestock production in other pastoral and agropastoral systems (Dahl and Hjort, 1976: pp 143–146; Pratt and Gwynne, 1977: p 36; Wagenaar et al, 1986: p 51; Waters-Bayer, 1988; Preston, 1989; de Leeuw et al, 1991; R. von Kaufmann and R. Blench, ILCA, unpublished data; R. T. Wilson, ILCA, unpublished data). Competition for milk may even be a factor in farming systems having low-yielding breeds of cattle because milk is consumed or sold by households. For example, Mukasa-Mugerwa et al (1989) reported poor calf performance and milk offtakes of 45% for smallholder herds in the Ethiopian highlands; this level of milk offtake is comparable to that observed in pastoral systems (Section 5.4.1: *Cattle management*). Milk restriction as a reason for poor animal performance is thus probably relevant throughout rural Africa.

Cossins and Upton (1988b: pp 267–272) hypothesised that low weaning weight hinders cattle reproduction. In a review of production data from East Africa, they estimated that, compared to Boran cattle reared under pastoral conditions, Boran heifers raised on commercial ranches have their first calf 14 to 16 months earlier while males from ranches attain mature weights at three years of age rather than five. It was stipulated that the crucial difference in performance occurs during the first 210 days of life when growth rates for pastoral calves average 20% of that for ranch calves (i.e. 140 vs 656 g/head/day). This difference in growth rates was thought to be due to ranch animals having unrestricted access to milk. Cossins and Upton (1988b) stated that milk has a greater economic value than merely to increase weaning weight. They pointed out that, if acceleration of growth prior to weaning could have carry-over effects in terms of a reduced time to puberty, increased mature sale weights, or reduced calf mortality, then the benefits of calf nutritional interventions could substantially increase.

Cossins and Upton (1988b: pp 269–270) used analytical modeling methods to examine the economic effects of halving milk offtake for people from 312 to 156 kg per lactation in the Borana system. This represents a decline in offtake from 37 to 18% of total yield (see Section 5.3.2: *Calf growth and milk offtake*). In the absence of experimental data, an increased milk intake of 156 kg per calf was assumed to allow males and females to reach maturity at 320 kg and 230 kg, respectively. (This is roughly 18% higher than the traditional situation (Cossins and Upton, 1987; 1988b)), and is supposed to allow animals to reach mature weights at three years of age rather than four. It was also assumed that compared to the traditional situation, live weights would be increased by 50% at all other intermediate ages while calf mortalities would be reduced by 5%. Results were derived by using a steady-state herd model (Upton, 1986b) structured under the assumption that herd owners seek to manage a fixed number of cattle; this fixed herd size is maintained by offtake counterbalanced by increases in numbers as a result of production improvements. This approach allowed a more straight forward monetary evaluation of production intervention. The analytical unit was the average eight-cow herd introduced in Section 4.3.1: *General household structure and economy in average rainfall years.*

The benefits of intervention were evaluated in terms of accumulation of food energy from domestic consumption and cash income from sales (Upton, 1986b; Upton, 1989). Results indicated that reducing milk offtake by 50% would not be profitable. When offtake was lowered the output per 250-kg livestock unit was reduced in terms of cash (–11%) and food energy (–26%), compared to the traditional situation. The traditional practice was interpreted as being valid because it maximised returns of cash and food energy per livestock unit (Cossins and Upton, 1988b: p 270).

Modeling results led Cossins and Upton (1988b: pp 270–272) to hypothesise that supplementation of nursing calves with good quality forage, and possibly water, could compensate calves for milk deprivation and help achieve higher lifetime performance. They also estimated, however, the alternative of providing such resources to milk cows instead of calves. Using the steady-state herd model they contrasted: (1) a cow-feeding option with an increased milk offtake of 3%; (2) a calf-feeding option "A", where feeding results in a reduction of mortality from 25 to 15% in calves and 13 to 10% in yearlings, weaning weights are doubled from 47 to 94 kg/head, culling rates of immature females increased from 40 to 55% and offtake of immature males is maximised; and (3) a calf-feeding option "B" which is similar to option "A" but milk offtake is also increased by 11%. Results shown in Table G14, Annex G, indicate that substantial gains in terms of self-sufficiency, animal offtake and cash income could accrue from either calf-feeding options as compared to the cow-feeding one. Cossins and Upton (1988b: p 274) concluded that supplementation of calves through improved forage feeding could result in increased calf growth, earlier maturity, increased productivity and improved human welfare. Similar intervention strategies have been proposed by Wagenaar et al (1986: p 51) and de Leeuw et al (1991).

Field tests of calf supplementation hypotheses

Objectives and methods: A six-year experiment was initiated in early 1986 to test model assumptions used by Cossins and Upton (1988b). The work was designed to examine the globally accepted hypothesis that supplementation of traditionally managed nursing calves with forage and/or water could compensate them for milk deprivation and result in sustained improvements in growth, live weight, body frame characteristics and time to puberty. The trial ended in late 1991. Preliminary results briefly summarised here for females have been analysed by Sovani (1990) and provide a sound test of the above hypothesis; other preliminary results are provided in Coppock (1989b) and ILCA (1989: pp 2–5). Comprehensive results will be reported in a future publication (Coppock and Sovani, in preparation).

Each calf born in 1986 (N=21 per treatment) and 1987 (N=17 per treatment) was stratified according to sex and birth date and allocated to one of seven treatments. Six of the treatments were based on a factorial combination of legume hay (three levels offered) and supplemental water (two levels offered) superimposed over a background of traditional pastoral management (for treatment combinations) (Table 7.8). Water was thus considered to be a production constraint. The limited access of Boran calves to water and the role of water restriction in cattle management are reviewed in Section 5.4.1: *Cattle management*.

rather, this selection was based on using a well-recognised forage that would provide the best chance of sustained production improvements. If sustained improvements could not be achieved with lucerne, it would be much less likely that another forage could do so.

Supplementation began at two months of age when the calves began to graze and ceased at the beginning of the subsequent long rains some nine

Table 7.8. *Factorial treatments[1] in a calf growth and development trial used for animals from 2 to 11 months of age and sample size of heifers in each treatment from replicate 1 born in 1986 at Dembel Wachu ranch in the southern rangelands.*

Group	Hay offered (g/d)	Extra water offered (i.e. 5 l/day)	*N*
1 (control)[2]	–	no	9
2	400	no	9
3	650	no	13
4	–	yes	10
5	400	yes	11
6	650	yes	10

1 Treatments were superimposed over a background of traditional management (Coppock, 1989; see text).
2 Traditional management (no supplements of forage or water).

Source: Sovani (1990).

Another objective of this trial was to assess the effects of traditional levels of milk restriction on cattle performance, and this required a seventh treatment (described below). The background of simulated pastoral management was characterised by separation of calves from their mothers except for suckling. This consisted of: (1) restricted access to the dam's milk, implemented by allowing calves to suckle two of four quarters once each morning and evening with the goal that they would get roughly 50% of the milk (the remainder being milked out by hand, measured and consumed by people); (2) housing calves individually at night in mud huts where they received hay supplements in buckets; (3) subsistence on a milk diet for the first two months of life, followed by a diet of milk plus grazing with a calf herd for up to eight hours/day in a *Pennisetum mezianum* community for nine months; and (4) restricted access to water that varied from once every two to three days in wet and dry seasons, respectively. The seventh treatment group received no supplemental hay or water and was managed traditionally in all respects except that animals received access to their mother's milk overnight, which was presumed to be nearly complete access.

The forage supplement consisted of a medium-quality lucerne hay (*Medicago sativa*) with 17% CP as a legume "standard". It was not expected that lucerne would be grown in the rangelands;

months later when all calves were forcibly weaned. Supplementation thus largely occurred during the dry seasons from July through March in 1986–87 and 1987–88. Hay and water refusals were weighed and removed each morning. Milk intake of calves was estimated using a weigh-suckle-weigh method once every other week (Coppock and Reed, 1992). Background water intake for calves was measured once every other week quantifying consumption from buckets. Empty body weights and shoulder heights were measured bi-weekly prior to weaning. The grazing diet quality of nursing calves was estimated once per month as reported in Coppock and Reed (1992). Calves had access to local salt lick before and after grazing. Animals were vaccinated against important local diseases soon after birth.

After weaning the supplementation phase of the trial was over and all animals were run together under traditional management until the females reached puberty. The animals were held at neighbouring encampments where they were corralled at night, grazed during the day and watered once every day in wet and once every four days in dry seasons. They walked long distances to feed and water in dry periods. The wells at Dubluk were the dry-season water source and this was over a 20 km round trip from the encampments. During this time males were weighed and measured monthly for frame features until four years of age. The females were measured in a similar fashion until two years of age which was anticipated to be the earliest possible age when puberty could occur. After two years the females were run with breeding bulls at a ratio of 20:1. Every 10 days females were weighed and blood was collected from their jugular veins for analysis of plasma progesterone. Blood was centrifuged on site and plasma was stored at –20°C for future analysis using the Enzyme Linked Immuno Assay (ELISA) technique (Sovani, 1990).

Onset of puberty was verified using three complementary methods: (1) animals were observed during daylight hours for successful mounts that were recorded as to date and hour; (2) rectal palpations to detect the presence of a corpus luteum at 40 and 60 days post-mating; and (3) analysis of plasma progesterone levels for four samples collected within 10 days before and 30 days after the observed mount. Plasma progesterone levels over 1.3 ng/ml were indicative of a significant rise in hormone concentrations associated with oestrous. If the palpation and progesterone analyses were found to be positive, the date of mating was considered to be the date of puberty. Routine rectal palpations were also conducted on all animals monthly to provide a back-up in case matings were not observed. Nocturnal mounts were found to be rare.

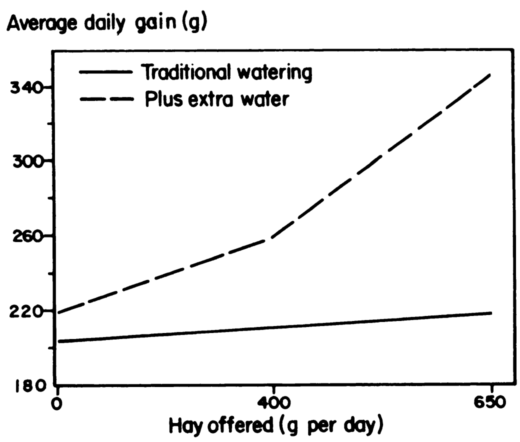
Analyses for females born in 1986 conducted by Sovani (1990) are reported here. These results are representative of those for other females and males in the trial (D. L. Coppock, ILCA research scientist, unpublished data). Seventy-seven per cent of 62 heifers born in 1986 had become pregnant by July 1990. Data for these animals were analysed using a two-way factorial (hay x water) ANOVA for: (1) weight, height and weight:height ratio at weaning and puberty; (2) average daily gain (ADG) and absolute weight gain from birth to weaning, weaning to puberty, birth to puberty; and (3) time to puberty. All ANOVAs used least-squared means (SAS, 1987) and milk intake (ml/kg $LW^{0.75}$) as a covariate. Variation among means was considered significant at $P \leq 0.05$. Background information on treatments is from Coppock (ILCA, unpublished data).

Results: The average birth weight for animals born in 1986 was 18.6 kg and calves were weaned at an average of 333 days. Calves in the six factorial treatments received an average of 1.1 litres/head/day of milk, which represented about 65% of total yield. The average cow produced 511 litres/lactation, which suggested that these cows were poor producers by local standards (see Section 5.3.2: *Calf growth and milk offtake)*. Supplemental water was consumed by calves at a rate of 2.6 litres/head/day. This increased water intake for supplemented animals by 142% (i.e. from a background of 1.9 litres/head/day to 4.5 litres/head/ day). Intakes of hay averaged 227 g/head/day for the medium level and 388 g/head/day for the high level offered. Calves offered supplemental water plus hay ate 27% more hay on average.

There was an interaction for ADG prior to weaning as a function of hay and water supplementation ($P \leq 0.05$) (Figure 7.5); also at weaning there were main effects of hay (all linear; $P<0.05$) and water ($P<0.001$) on absolute weight gain, weight and weight-to-height ratio (Table G15, Annex G). The milk intake covariate was not significant ($P>0.05$) in any case. A hay x water interaction occurred ($P=0.05$) for age at puberty with a maximum spread of 177 days between the average of the control and the group which received the high level of hay plus supplemental water (not illustrated). There were also persistent effects ($P<0.05$) of water supplementation on ADG from birth to puberty and height at puberty, with the milk intake covariate significant for several variables (Table G16, Annex G). A schematic diagram of overall growth relationships is presented in Figure 7.6.

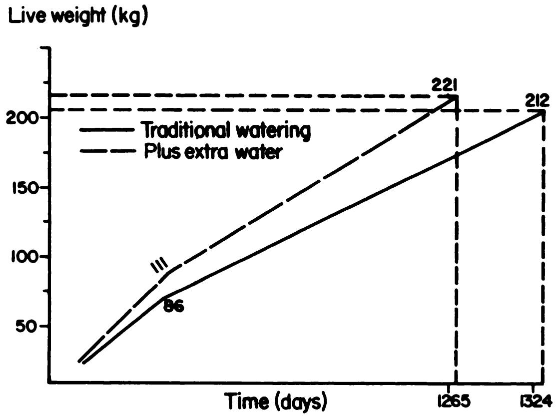
In sum, although supplemental water resulted in almost a 30% increase in weaning weight, this did not persist because animals in the control group gained significantly more weight from weaning to puberty, thus nullifying earlier differences (Table 7.9). Average daily gain from weaning to puberty was not different among groups (126 g/head/day for water-supplemented vs 120 g/head/day for those on traditional watering) because animals under

Figure 7.5. *Average daily gain of female calves in response to supplementation with legume hay (three levels) and/or water (two levels). This interaction is based on 11 calves per treatment for animals born in 1986.*



Source: Sovani (1990).

Figure 7.6. *Schematic diagram of the effect of water supplementation on growth and time to puberty for heifers born in 1986. Average daily gains (i.e. 111 or 86 g/head per day) accompany respective growth curves (N=33 per group).*



Source: Sovani (1990).

traditional watering management took about two months longer to reach puberty, although this was not significant (*P*>0.05; Figure 7.6).

Results for weaning weights confirmed that both water and hay were required for maximum early growth (Donaldson, 1986; Cossins and Upton, 1988b). Work reported by Coppock (1989b) and ILCA (1989: pp 2–5) from analyses of male and female calves showed similar interactions over both 1986 and 1987. In addition, the best treatment of high level of hay plus water resulted in weaning weights that were 96% of those for the seventh treatment, which received traditional management but unrestricted access to milk; it is thus apparent that supplementation with a total of 105 kg of legume hay and 700 litres of water compensated for some 179 litres of milk otherwise lost to each calf. It is notable that supplemental water was required to elicit an improved growth response of calves; hence forage development in the absence of water development may only have a negligible effect on production (Coppock, 1989b).

Improvements of most aspects of production cattle obtained through supplementation did not persist long after weaning (Sovani, 1990). The water x hay interaction was significant for accelerating puberty but this advantage of six months is probably not important for cows that continue to calve after 10 years of age (Mulugeta Assefa, 1990). The six-month advantage may also be heavily influenced by a succission, by chance, of favourable rainfall years and other density-dependent interactions (see below). The ability of control animals to compensate for early nutritional deprivation agrees with other studies (Richardson et al, 1978; Tawonezvi, 1989). All of this research found differences in weaning weight to persist from 1.5 to 11 months past weaning. The significant effects of the milk intake covariate for several parameters at puberty indicates that there is a long-term consequence for milk deprivation and this may be reflected in frame development which could influence mature weight to some degree (Berg and Butterfield, 1976). Under the experimental conditions applied here, however, such long-term costs of milk restriction were small. Results do not support the contention that milk restriction under pastoral conditions constitutes a significant cost to the life-time productivity of cattle, as long as the calf survives (Coppock, 1989b; Sovani, 1990). Another key point is that it is the long period of the post-weaning environment, not the relatively brief pre-weaning conditions, that more likely influences the time to puberty according to the different environments. For example, nearly all of the conceptions studied by Sovani (1990) occurred in the rainy seasons, as previously found by Nicholson (1983a) and Mulugeta Assefa (1990). Had one or two of these rainy periods have failed, there is a high probability that animals would not have come into their first oestrus for many more months, which would give even more time for the

Table 7.9. *Absolute live-weight gain (kg) in water-supplemented and traditionally watered heifers from birth to weaning, weaning to puberty and birth to puberty in the southern Ethiopian rangelands, 1986–1990.*

Treatment[1]	Period		
	Birth to weaning	Weaning to puberty	Birth to puberty
Traditional watering	66.7	126.9	193
Supplemental watering	89.8	112.2	202.4
Difference	23.1	-14.7	9.4
F-test[2]	***	*	NS

1 Where traditionally watered calves gained access to water once every two to four days depending on season during 2–11 months of age and supplemented animals were offered an additional five litres of water/day over the traditional situation.

2 * and *** indicate significance at $P = 0.05$ and $P = 0.001$, respectively.

Source: Sovani (1990).

gradual harmonisation of growth rates and attainment of puberty. This also underscores the big risks of attempting to improve long-term production parameters in variable environments (Coppock, 1989b). It was fortunate that 1986–90 were largely years of average rainfall; there were no very dry or drought years that could have resulted in big weight losses and thus in wasted expensive inputs.

Based on this preliminary analysis, it is thus apparent that advocates of interventions to accelerate cattle growth in variable environments have failed to recognise the considerable risks as well as the effect of compensatory growth and environmental influence in harmonising production dynamics over time. Their intervention strategy has, at least on the Borana Plateau, also ignored the production values of the pastoralists. While it could be argued that supplementing, at least, nursing male calves so that they may achieve a more profitable sale weight at one year of age is a reasonable approach, this is not an objective of producers here (Coppock, 1992b). The Boran do not want to sell an immature male if they can avoid it; this is done by the poor that have fewer other options (see Section 4.3.4.7: *Marketing attitudes*). Producers much prefer to sell animals at least three years old because they bring a greater income.

The idea of speeding up cattle growth, whether to achieve a higher market weight for immatures or to reduce age of first calving, is inimical to values of low-input animal production in risky environments. Low-input production has minimal overheads and thus may not count time as a critical management variable. Despite the apparent advantages of improved watering for calves from experimental work, the Boran have repeatedly stated that they will always be conservative in watering calves, because they believe that restricted watering prepares calves to endure restricted watering as adults (D. L. Coppock, ILCA research scientist, personal observation; R. J. Hodgson, CARE-Ethiopia, personal communication).

In sum, hypotheses regarding calf feeding to accelerate growth in a pastoral setting are relatively easy to falsify. In one respect this is because they are conceived within a uni-disciplinary framework; i.e. they make sense as animal production hypotheses but fail because they do not consider the ecological or socio-economic circumstances within which animal production is imbedded. Even in terms of just animal production some of their underpinning logic is faulty. Attempting to compare cattle production parameters within traditional and modern ranching environments, with the assumption that the production levels of ranches represent some form of an attainable standard for the traditional system, is inadvisable given the experience here. The observation that calves grow faster on ranches, and that this is primarily due to milk intake (Nicholson, 1983b; Cossins and Upton, 1988b), is heavily confounded with other characteristics of ranches such as improved breeds and ample forage resources throughout the year. To illustrate this using data from Cossins and Upton (1988b; Figure 2 on p 268), it is likely that much of the difference in four-year weights of Boran cattle between the best animals reared on Laikipia (Kenya) ranches (575 kg) and on the Borana Plateau (275 kg) is probably strongly influenced by breeding and environment as much (if not more than) by calf management. Both Alberro (1986) and Trail and Gregory (1981) reported large increases in mature weights by improved breeds compared to indigenous animals. S. Sovani (ILCA, personal communication) reported that there is little phenotypic similarity between improved Boran cattle at Ethiopia's Abernossa Ranch and the indigenous stock on the Borana Plateau. The point is that when 210-day weights are calculated as percentages of four-year weights, animals on the Borana Plateau achieved 17% while the others achieved 39%, which is a much lower differential than the 325% increase for ranch animals when 210-day weights are compared directly. By three years of age the improved animals had achieved 87% of their four-year weight and the indigenous animals 76%. This suggests that the relative difference in growth had been made up to a higher degree by the indigenous animals between 210 days and three years of age. This undermines the postulate that milk deprivation has a key role in constraining faster attainment of weights at four years.

Furthermore, influences of milk deprivation on calf growth in the Borana system will be subjected to fluctuations caused by density-dependent interactions (see Section 7.2: *A theory of local system dynamics*). Calf growth may be higher in the recovery phase of the cattle population after drought and lower in the high-density phase. Observations of Nicholson (1983b) on milk production and calf growth (see Section 5.3.2: *Calf growth and milk offtake*) may have been biased toward low because they occurred in the high-density phase preceeding the 1983–84 drought. Similar work conducted in 1985–86 during the early recovery phase could have revealed a different picture, with higher milk production and faster rates of calf growth.

7.3.3.5 Calf mortality mitigation

In contrast to accelerating cattle growth, interventions to mitigate calf mortality are more consistent with traditional pastoral values and the shortfalls of risky low-input systems (Coppock, 1989b). Compared to other interventions, attempts to save the life of a calf are more short term, require a lower quantity of resources and the outcome is more of a direct reflection of the management effort with less influence from uncontrollable environmental conditions. Thus, not surprisingly, calf mortality mitigation appears to be a priority of cultural Boran livestock mangement (D. L. Coppock, ILCA, personal observation). Calf management is consequently their most intensive production activity and includes substantial time invested in hand-rearing (see Section 5.3.1: *General aspects of cattle management*).

In their modeling analyses, Cossins and Upton (1988b) noted that mitigation of calf mortality was unlikely to yield the economic benefits that could accrue from faster calf growth. However, this conclusion is invalid because producer risk was not considered. Another problem is their use of the steady-state herd model (Upton, 1989) with the assumption that herd owners seek to maintain a fixed number of cattle, increases in one age class could detract from benefits derived from others. For example, an increase in calves as a result of mortality mitigation could ultimately have costs in terms of a reduced output from fewer mature cows. In contrast to model assumptions, the Boran seek to expand herd size and calf recruitment is central to this goal (Coppock, 1992b).

Opportunities exist for building upon traditional production values and further intensify calf management using hay-making, small quantities of local legumes and an improved access to water (see Section 7.3.1.1: *Water-development activities* and Section 7.3.1.3: *Forage improvements*). The goals of intensification would be to reduce calf mortality in years of average or slightly below average rainfall and improve labour efficiency for women in the process. There is an impetus among the Boran to intensify calf management because of increasing resource competition arising from population pressure (Menwyelet Atsedu, 1990; see Section 7.2.2: *Anticipated long-term trends*).

It could be argued that sustained reductions in calf mortality, without increased cattle offtake, will ultimately be unsustainable given the conceptual model of density-dependent production (Section 7.2.3: *Anticipated short-term cycles*). Increases in cattle recruitment, however, could contribute to economic growth, improved food security and sustained overall development if herd turnover is stimulated in the context of food supply, contributions to community projects and banking a portion of livestock capital. These topics are covered in Section 7.3.3.6: *Cattle marketing*.

Economic implications of calf mortality mitigation

Background: Mulugeta Assefa (1990) conducted a statistical analysis of the effect of family wealth on calf mortality, as reported in Section 5.3.3: *Cattle production and pastoral wealth*. He (1990: pp 27–45) also quantified (Table 7.10) calf mortality due to disease or nutrition deficiecy from producer interviews. During wetter years relatively more calves were reportedly lost to disease while during drier years more were lost to poor nutrition. Although the highest mortality rates occurred during drought, these probably constitute only a small proportion of total losses for any given decade. This is because of the low drought frequency and the large decline in calving rate induced by drought (Section 6.3.1.2: *Cattle productivity*). For example, considering an average eight-cow household during 1980–89 and calving rates reported in Section 5.3.3: *Cattle*

Table 7.10. *Annual rates (%) of calf mortality as reportedly due to (1) nutrition-related or (2) all sources combined for animals held by various wealth classes of Borana households across different rainfall years in the southern rangelands.*[1]

Wealth category[3]	Year type[2] / Mortality source: Average		Dry		Drought	
	Nutrition	All	Nutrition	All	Nutrition	All
Poor	15	25	21	26	66	69
Middle class	9	21	4	14	36	36
Wealthy	11	19	16	22	60	60

1 From a sample of 90 households (30 per wealth class) reporting life histories of 482 cows and 1410 calves (Mulugeta Assefa, 1990).

2 Where an average year has a 60:40 distribution of 600+ mm of rainfall across long and short wet seasons, respectively; a dry year is an isolated year of lower rainfall (i.e. 450 mm or less); and a drought year is a second consecutive dry year.

3 Where wealth is defined as the ratio of lactating cattle: reference adults as in ILCA (1981) and Holden and Coppock (1992). See text for details.

Source: Coppock et al (1990).

production and pastoral wealth and Section 6.3.1.2, on average 14 of 54 calves would have died in the dry years while the one born during the second drought year of 1984 would have had a high risk of dying. This implies, overall, that about 7% of calf deaths would have occurred as a result of drought compared to 93% at other times.

Objectives and methods: The main objective of the study by Mulugeta Assefa (1990) was to judge the potential profitability of reducing calf mortality using internal resources in average rainfall and dry years and external resources during drought. The tool used for the analysis was a bio-economic herd model by von Kaufmann et al (1990) that simulates herd performance for households over a 10-year period. This model had to be parameterised, however, for biological and economic conditions applicable on the Borana Plateau.

Mulugeta Assefa calculated costs of collecting sufficient forage, providing water and implementing veterinary services that could reduce calf mortality by 75% for households in all wealth classes in average rainfall and dry years. Two-thirds of the impact was hypothesised to result from improved nutrition and the remainder from veterinary intervention. Increasing water supply in conjunction with improved feeding (Coppock, 1989b) was hypothesised to increase calf growth rates by 40%. The specific resources included grass hay (Coppock, 1991), local legumes (Yohannes Alemseged, 1989; Coppock and Reed, 1992), water tanks (Hodgson; 1990) and veterinary extension in the context of Service Cooperatives (SCs).

In addition, Mulugeta Assefa (1990: pp 40–43) considered the hypothetical provision of a 97:03 mixture by weight of molasses and urea to reduce calf mortality during drought by 50%. In contrast to the other resources which are locally available, molasses and urea would have had to be brought from the highlands. Molasses and urea were previously found to be useful feed supplementation of Boran cattle during the 1983–84 drought (Donaldson, 1986).

Implementation costs of interventions were primarily calculated on the basis of the value of women's labour in collecting forage and in terms of community monetary expenses for construction and maintenance of water tanks and veterinary services. Benefits were calculated as the summed cash value of cattle and cattle products generated over time as a result of interventions to reduce calf mortality. Cumulative costs were subtracted from cumulative benefits. The resulting statistic from the model was a measure of the Net Present Value or NPV (Workman, 1986) of cattle herd output as a function of intervention. Intervention scenarios are thus contrasted with traditional management to assess economic impacts. Model inputs were modified to accomodate the special characteristics of the Borana system as described in Mulugeta Assefa (1990).

Feeding packages for average rainfall and dry years were calculated to obtain sustenance requirements of energy during a 120-day dry season (i.e. December through March). Sustenance energy requirements for calves (ARC, 1980) added 20% of the cost of the activity, calculations incorporated energy metabolisability and efficiency of use (Mulugeta Assefa, 1990: pp 74–75). It was stipulated that women would collect 110% of the forage required for half of their calves, with an additional 10% lost through wastage.

Mulugeta Assefa (1990: pp 35–82) conducted numerous field studies to parameterise the model for local conditions. Yabelo and Mega markets were surveyed to obtain price data for milk, meat, offal, hides and grain for different seasons and rainfall years, a statistical analysis of these data is provided elsewhere (Mulugeta Assefa, 1990: p 50). Nutritional assessments were made of grass hay, *A. tortilis* fruits and *A. brevispica* leaves for nitrogen content (AOAC, 1980) and *in vitro* dry-matter digestibility IVDDM; (Goering and Van Soest, 1970) for determining calf rations. Standing crops of leaves of *A. brevispica* shrubs in the dry season were assessed by a total harvest of 23 shrubs of varied size classes. Production of fruits from *A. tortilis* trees was obtained from Menwyelet Atsedu (1990). Use of forage from these woody plants was expected to occur only where they were abundant so that costs of searching for fruits or leaves were discounted in the analysis. Yields and nutritive values of cowpea hay and pidgeon pea (*C. cajan*) forage were obtained from Yohannes Alemseged (1989) for consideration of calf feeding in a cropping situation.

Labour required to implement forage activities was assessed in Did Hara and Dubluk *madda* for 60 families (Mulugeta Assefa, 1990: pp 57–73) using interviews of Borana women. Twenty-two of 60 families reported significant seasonal constraints for forage collection while 34 reported shortage of preferred grass as the biggest problem for hay-making. For the majority of households, women's labour was most commonly reported as the main option for improving efforts for forage collection. Calculations were based on forage yields, walking and collecting time, and appropriate backloads/woman/trip to estimate the effort required to collect enough material on a dry-matter basis. Using sickles to cut grasses to make hay, for example, was determined to yield about 40 kg of fresh weight from a 200-m^2 area at the end of the long rainy season. Three 10-kg loads of fresh grass could be cut and carried back to encampments in six hours. Further drying and stacking costs of hay-making were determined to be negligible. Consideration of the incremental time (man-days) used in land preparation for forages intercropped with maize was included in the budgets for cowpea and pidgeon pea, along with an opportunity cost penalty for loss of maize grain yield. Grain yield of legumes was considered as additional revenue (Yohannes Alemseged, 1989).

Projected activities reduced or foregone as a result of increased labour allocation for forage collection or cultivation were specified either for the wet season when cultivation and preparation of grass hay would occur, or for the dry season when harvest of cultivated legumes or collection of *A. tortilis* fruits or *A. brevispica* leaves would occur. Respondents largely indicated (58 of 60) that more wet-season activities could be incorporated into their existing schedules, but only 40 of 60 reported the same for the dry season (Mulugeta Assefa, 1990).

Monetary costs for collection of each forage were derived from estimating total quantity required per year for half of the calves of each modal family in each wealth class. Seasonal market values for grain used as payment in food-for-work projects were employed to value hourly labour. Rates for food-for-work ranged from 3 to 5 kg of grain per person per six-hour work day in dry and wet periods, respectively (CARE-Ethiopia, unpublished data). This resulted in an estimate of EB 0.12/person/hour in dry seasons versus EB 0.14/person/hour in wet seasons. This translates into a minimum daily wage of EB 0.73 to 0.85, roughly 26% on average of the official national minimum wage of EB 3 /person/day. Costs of the collecting sacks and locally made storage structures for feeds were added in, as were market values for cowpea and pidgeon pea seeds. An additional 15% miscellaneous overhead was included.

Costs for water were based on the construction outlay for a 60 000-litre water tank in Hodgson (1990: pp 30–35). The straight-line depreciation method was used to determine cost of the tank each year over a 10-year lifespan, with a salvage value of 0% (Mulugeta Assefa, 1990: p 83). Cost of each litre of water per year was derived by dividing yearly cost of the water tank by the volume.

Losses of calves to disease were estimated to be 25% of total mortalities during average years (Sileshi Zewdie, SORDU veterinarian, personal communication cited in Mulugeta Assefa, 1990: p 83). This confirmed results in Table 7.10. Although medicines for livestock have been offered free of charge to date, a payment system will come into effect in the future (Tafesse Mesfin, TLDP General Manager, personal communication). Mulugeta Assefa (1990: pp 83–84) thus calculated total health costs as if they were covered by the Boran and by assuming that one local veterinary scout could serve four encampments. Information on the costs of simple equipment, vaccinations and other medicines as well as the optimal periodicity of interventions were obtained from upublished SORDU statistics. Implementation of molasses and urea mixtures in a drought year was based on nutritive value (ILCA Nutrition Unit, Addis Ababa, Ethiopia, unpublished data) and costs of feeds (Ethiopian Sugar Corporation, Addis Ababa, Ethiopia, unpublished data; Ministry of Agriculture, Addis Ababa, Ethiopia, unpublished data), barrels and transport from the highlands to the Borana Plateau (Ethiopian Transport Authority, Addis Ababa, Ethiopia, unpublished data). A 10% loss and 15% miscellaneous overhead were added in the final calculations.

The herd model was programmed as an application of the Lotus 1-2-3 release 2.01 programming language (von Kaufmann et al, 1990). The model requires an initial herd structure and production parameter values based on field data. These include age, year-specific mortality rates, calving rates, animal offtake rates, milk production/ cow/ lactation, length of lactation and dry periods, per cent milk offtake, per cent milk intake, carcass dressing percentage and commodity prices. These data were obtained through cow history documentation from 90 producer interviews (Section 5.3.3: *Cattle production and pastoral wealth*) and interviews of traders and merchants (Mulugeta Assefa, 1990). Parameter estimates stratified by household wealth and type of rainfall year can be found in Mulugeta Assefa (1990). These include data for herd structures, live weights, dressing percentages, productivity of cattle, commodity prices, per cent of cattle sold, slaughtered or gifted.

Results: Table 7.11 summarises daily costs per calf for routine inputs of forage, water and prophyllaxis as well as emergency provision of molasses and urea. Legumes were costed from 60 to 125% more than the grass hay. Health and watering interventions were cheapest and ranged from 7 to 15% of the costs of grass hay. The molasses and urea mix had a similar per unit cost as the more expensive legumes. Forage and water interventions were to be implemented in the model for 120 and 210 days in both average rainfall and dry years while provision of veterinary care was to be continuous in all years. Molasses and urea mixtures were to be implemented for 180 days in a drought year. Details for price calculations are available in Mulugeta Assefa (1990; Appendix 3).

Table 7.11. *Summary of costs of forage, water and health interventions per calf on a daily basis in the southern rangelands.*[1]

Intervention	Cost/calf/day[2]
Grass hay	0.2
Acacia brevispica leaves	0.45
Acacia tortilis fruits	0.32
Cajanus cajan	0.35
Vigna unguiculata	0.41
Molasses and urea	0.42
Water tank	0.031
Health package	0.013

1 Details of cost determinations may be found in Mulugeta Assefa (1990; appendix 3).

2 Ethiopian Birr, where 1 USD = 2.05 EB.

Source: Mulugeta Assefa (1990).

The first analysis was a run of 10 average rainfall years for the control condition (no intervention) for each wealth class. Results were interpreted to indicate that all herds were capable of considerable net rates of growth under optimal conditions. Herds for wealthy, middle class and poor households grew from 91 to 265 head (+191%), 35 to 80 head (+128%) and 14 to 34 head (+143%), respectively (Figure 7.7a). Tabular data for herd sizes, outputs and monetary returns under this scenario are displayed in Mulugeta Assefa (1990: p 133). That pastoral herds can grow rapidly under good rainfall conditions has been shown elsewhere in East Africa. Meadows and White (1979) noted that cattle herds tripled in size during 10 years of high rainfall in Marsabit, Kenya. Other evidence from the southern rangelands suggests that cattle recovered very quickly from the 1983–84 drought during years of average rainfall (Solomon Desta, nd; see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*).

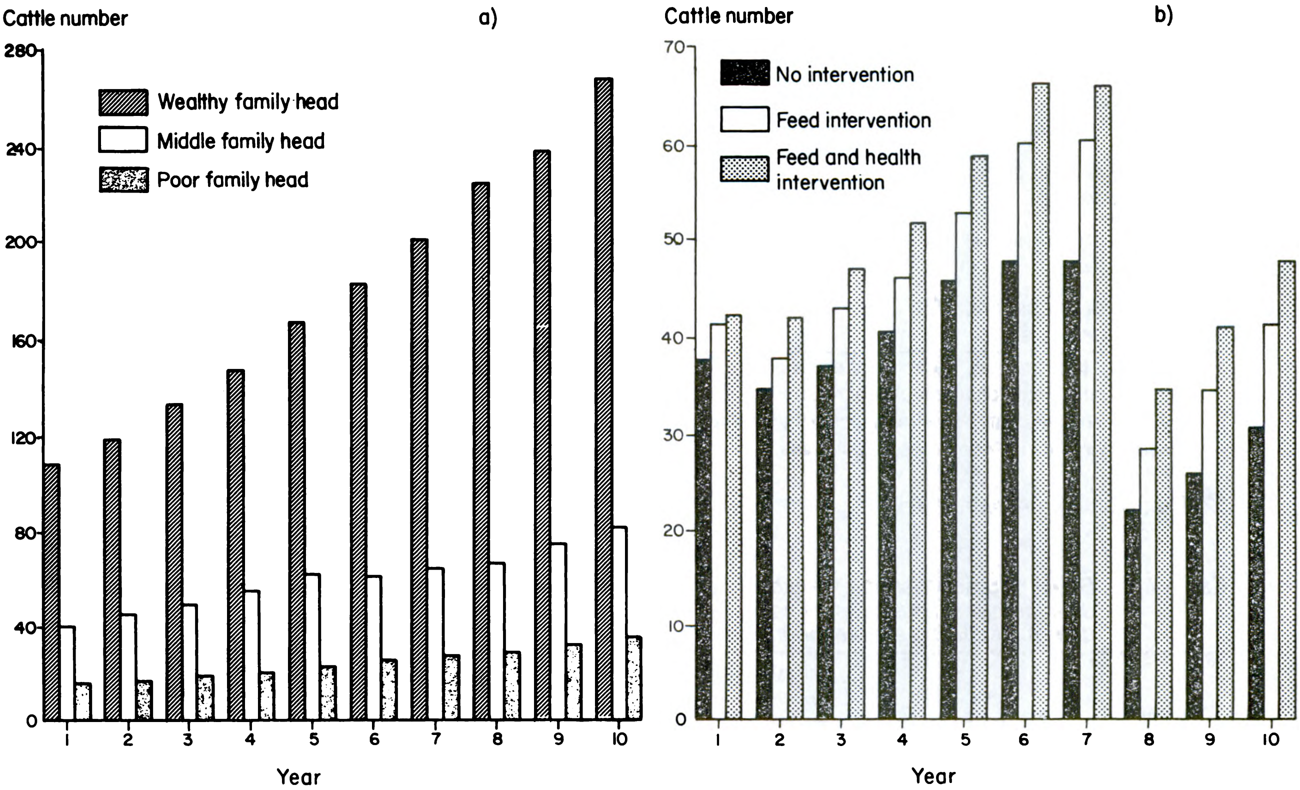
The next simulation was carried out assuming a varied and random sequence of rainfall years. Years 1, 3–6, 9 and 10 were considered to have average rainfall while years 2 and 7 were dry. Year 8 was a second consecutive dry year regarded as a drought year (see Section 2.4.1.4: *Climate, primary production and carrying capacity*). This sequence was run using the control (no-intervention) scenario as well as with various interventions.

The control scenario under variable rainfall produced markedly different results compared to those derived under a continuous regime of average rainfall. The net result was that herds of wealthy households grew from 91 to 124 head (+36%), but those for the middle class and poor declined by 9 and 6%, respectively. Dynamics for the herd of the middle-class household are shown in Figure 7.7b.

Mulugeta Assefa (1990) used an "average" feed input over 10 years to represent the modeled impact of the nutritional intervention. This consisted of using an average-priced forage for 9 out of 10 years and the molasses and urea mix for the drought year. This intervention under the variable rainfall scenario resulted in net increases in herd size of 37, 17 and 7% for wealthy, middle class and poor households, respectively. This suggested, compared to the control runs, that effects of this intervention could result in a greater impact on the middle class and poor than on the wealthy. This was due to nutrition being a less frequent cause of calf mortality in wealthy households compared to disease (Mulugeta Assefa, 1990; see Section 5.3.3: *Cattle production and pastoral wealth*). Adding a health package to the feed intervention nearly doubled the positive effect of intervention by causing increases in herd size on the order of 75, 34 and 14% for the wealthy, middle class and poor. Herd dynamics for a middle-class household under variable rainfall conditions based on feed and feed plus health interventions are shown in Figure 7.7b.

Herd dynamics have been portrayed to illustrate general features of the production system and the role of climate variability. Improvements in herd growth resulting from interventions, however, were dictated by modeling objectives. Analysis of NPVs is required to assess profitability. Tables 7.12 to 7.14 give details regarding effects of interventions on the NPV of cumulative net herd output per household in each wealth class. Because it was the cheapest feed, the grass hay yielded, relative to the control, the greatest effect of all forages in increasing NPV, for each wealth class. The middle class and poor appeared to be the most positively affected (Table 7.12). Adding the health package to the hay raised benefits further but the middle class and wealthy apppeared to be the most positively affected by the

Figure 7.7. *Results from a bio-economic herd model depicting: (a) cattle herd growth for three Borana wealth classes under 10 years of average rainfall; and (b) cattle herd growth for a middle-class Borana household under different intervention scenarios for a variable rainfall regime.*



Source: Mulugeta Assefa (1990).

Table 7.12. *Effect of production interventions involving calf feeding management on net present value (NPV) of cattle herds held by Borana households of varied wealth as determined using a bio-economic model.*[1]

Intervention	Wealthy family		Middle-class family		Poor family	
	NPV	%	NPV	%	NPV	%
Hay	22 920	94	11 155	124	3452	111
Acacia brevispica leaves	16 004	65	8975	101	2727	88
Acacia tortilis fruits	19 600	80	10 109	113	3104	100
Pigeon pea residue	18 770	77	9847	110	3017	97
Cowpea residue	17 110	70	9324	104	2843	92

1 Where NPV is defined as the net total of the discounted values of gross revenues and costs (von Kaufmann et al, 1990). NPV entries equal the sum of 10 annual net returns from implementation of the respective intervention. Units are in EB, where 1 USD = 2.05 EB. The per cent (%) values indicate the NPV resulting from intervention as a per cent of the NPV assuming no intervention. Differences in the relative increase in NPV from intervention among wealth classes largely result from variation in sources of calf mortality. Nutritional interventions are more important for the calves held by the middle class and poor.

Source: Mulugeta Assefa (1990).

Table 7.13. *Effect of production interventions involving calf feeding management plus a health package on the net present value (NPV) of cattle herds held by Borana households of varied wealth as determined using a bio-economic herd model.*[1]

Intervention	Wealthy family		Middle-class family		Poor family	
	NPV	%	NPV	%	NPV	%
Hay, plus health package	40 343	165	19 743	221	4345	140
Acacia brevispica leaves plus health package	33 427	136	17 564	197	3620	117
Acacia tortilis fruit plus health package	37 023	151	18 697	209	3997	129
Pigeon pea residue plus health package	36 194	148	18 436	206	3910	126
Cowpea residue plus health package	34 534	141	17 912	201	3736	120

1 Where NPV is defined as the net total of the discounted values of gross revenues and costs (von Kaufmann et al, 1990). NPV entries equal the sum of 10 annual net returns from implementation of the respective intervention. Units are in EB, where 1 USD = 2.05 EB. The per cent (%) values indicate the NPV resulting from intervention as a per cent of the NPV assuming no intervention. Variation in impact between these tabular values and those in Table 7.12 reflect impact of calf health intervention.

Source: Mulugeta Assefa (1990).

Table 7.14. *Effect of production interventions involving calf feeding management, health package and local water development on net present value (NPV) of cattle herds held by Borana households of varied wealth as determined using a bio-economic model.*[1]

Intervention	Wealthy family		Middle-class family		Poor family	
	NPV	%	NPV	%	NPV	%
Hay, health package plus cistern	43 088	176	20 956	235	4625	149
Acacia brevispica leaves, health package plus cistern	36 172	148	18 776	210	3900	126
Acacia tortilis fruit, health package plus cistern	39 768	162	19 910	223	4277	138
Pigeon pea residue, health package plus cistern	38 938	159	19 648	220	4189	135
Cowpea residue, health package plus cistern	37 278	152	19 125	214	4016	129

1 Where NPV is defined as the net total of the discounted values of gross revenues and costs (von Kaufmann et al, 1990). NPV entries equal the sum of 10 annual net returns from implementation of the respective intervention. Units are in EB, where 1 USD = 2.05 EB. The per cent (%) values indicate NPV resulting from intervention as a per cent of the NPV assuming no intervention. Variation in impact between these tabular values and those in Table 7.13 reflect impact of local water development. See the text for assumed impact of water development on calf growth and mortality rates.

Source: Mulugeta Assefa (1990).

combined intervention when compared to using hay alone (Tables 7.12 and 7.13). This was because, in general, calf nutrition deficiency is a more prevalent production constraint for the poor because of milk competition (Holden et al, 1991; see Section 4.3.5.4: *Dairy marketing, human welfare and calf management*). Despite their high costs, water tanks resulted in another positive increment to the NPV for each wealth class (Table 7.14).

In summary, work by Mulugeta Assefa (1990) confirmed that calf mortality rates merit attention for production intervention but that the type of intervention should be tailored to the wealth class of the household and type of rainfall year. Feeding packages should be the most important for herds of poor households while health intervention is for those of the wealthy. Field work and modeling results suggest that grass hay is the cheapest and easiest feed intervention to implement but households would be expected to tailor their own supplemental feeding programme based on the availability of local resources. For example, households in close proximity to valuable acacia trees and shrubs could make the best use of these while those cultivating valleys could so of cowpea or pidgeon pea residues. In general, even more expensive interventions such as veterinary extension and cement cisterns are profitable if they contribute to reduced rates of calf mortality.

The study of Mulugeta Assefa (1990) is very useful as a first step in integrating the many factors required for a comprehensive economic evaluation of calf mortality mitigation. Transferability of model results to real world production situations, however, is limited in several respects. First, being able to price inputs infers that there is certainty of their availability. That is commonly not the case. Whether it is cement, vaccines, health extension staff or molasses, the uncertainties about their availability are a more serious obstacle than price. For example, even smallholders in the Ethiopian highlands have difficulty in procuring reliably industrial by-products such as molasses and wheat-milling residues despite the fact they are in the vicinity of factories (D. L. Coppock, ILCA research scientist, unpublished data). The modeling also does not portray adequately day-to-day risks of implementing interventions. Risks of hay spoilage, cracking of water tanks, variable productivity of native legumes over space and time, distance to trek calves to clinics and shortage of grass for hay are all examples of the obstacles that keep more Boran from adopting such innovations. Thus, profitability should not imply that implementation is easy.

The second main problem is that the modeling methodology did not consider production risks of density-dependent interactions. These modeling scenarios are thus probably more relevant to conditions found in the drought-recovery phase rather than those in the high-density phase of the cattle population (see Section 7.2.3: *Anticipated short-term cycles*).

7.3.3.6 Cattle marketing

Offtake dynamics

If reducing calf mortality rates is the most viable production intervention, it has to be conceded that this could ultimately be unsustainable given the resource limitations. For example, without increased offtake, reductions in calf mortality could accelerate manifestation of the negative effects of the high-density phase of the cattle population in the form of reduced milk production, reduced animal condition and increased mortality. Even without calf-management interventions, strategies to increase offtake may be warranted given the apparent increase in the cattle population over the past 15 years, losses of drought reserves and the advent of severe drought-induced losses of livestock capital (AGROTEC/CRG/SEDES Associates, 1974h; Menwyelet Atsedu, 1990; Solomon Desta, nd; see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*).

It is contended that leaving regulation of the cattle population to the environment does not create a viable development situation. Creative means to increase offtake are well justified to help stabilise the system during high-density phases and limit impoverishing losses of livestock capital during drought. While increasing offtake could lessen risks of environmental degradation, degradation is rather too difficult to monitor and evaluate in the context of promoting sustainability of production (see Section 7.2.2: *Anticipated long-term trends*). One solution is to maintain an increasing cattle wealth through enhanced calf recruitment but transformed into other forms of security compatible with traditional goals. As previously mentioned, this is consistent with the conceptual model of Sandford (1983a: pp 39–43) in which efficient opportunism is the ultimate development goal for African pastoralism (Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*).

Stimulating cattle offtake: Despite the contention that cattle marketing may substantially increase as the Boran become more dependent on grain purchases (see Section 7.2.2: *Anticipated long-term trends*), it remains unclear whether such increases in offtake would be sufficient to markedly reduce the risks of system destabilisation, losses of herd capital or environmental degradation. The extent to which increased cereal cultivation or small ruminant production would compensate for a growing need to sell cattle is also unclear. The following discussion offers some practical considerations for stimulating cattle offtake in the context of improving the standard of living and economic security of the Boran. Promoting offtake merely for cash accumulation is recognised as a nontraditional value and is not a viable approach. Cattle offtake that is not translated into other forms of security for the people undermines their immediate survival (see Section 7.3.1.2: *Grazing management*).

The graph depicting results from empirical modeling of cattle population dynamics from 1982–2006 was augmented with a horizontal line at a stocking rate of 20 head/km^2. This represents a risk threshold for the cattle population entering the high-density phase (Figure 7.1a). This threshold comes from an analysis in Pratt and Gwynne (1977: p 112) who considered 20 cattle/km^2 as the optimal stocking density for 600 mm of annual rainfall in East Africa. Above this threshold density-dependent interactions that reduce cattle productivity were postulated to increase. This is also consistent, in general, with opinions of Borana herd owners expressed during the high-density phase in 1989–90 (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). It is recognised here, however, that variation in annual rainfall will play a very large role in the effectiveness of such a guideline; for example, in a dry year 15 head/km^2 could be the threshold while in an unusually wet year 30 head/km^2 may be the threshold.

The reason the threshold concept is postulated to work here is largely because the regional herd is under a high degree of spatial confinement and rainfall is reasonably predictable (with the probability of having a near-average rainfall year being around 0.8 (see Section 2.4.1.4: *Climate, primary production and carrying capacity*). When the regional herds exceed a density of about 20 head/km^2, the risk of the herd suffering losses from a moderate decline in annual rainfall becomes greater. A more conservative approach would emphasise a carrying capacity of 217 000 head for the region (Section 2.4.1.4: *Climate, primary production and carrying capacity*). The figure of 300 000 head is used here for illustrative purposes and represents a compromise between short-term economic security and risk management over the medium term. Controversies concerning the carrying capacity concept are addressed in Chapter 8: *Synthesis and conclusions.*

If a regional population of over 310 000 head (20 head/km^2) becomes risky, it is noteworthy that this population level was reached during 13 out of 25 modeled years (Figure 7.1a). Annual modeling results illustrated in Table G1, Annex G, indicate that in 1990 there was a cattle population of 334 000 head supporting some 77 500 people or 13 839 households at 5.6 persons each (Mulugeta Assefa, (1990: p 15). The ratio of cattle to people in 1990 was 4.3:1, with a food-energy deficit of 46%. Livestock census data from Solomon Desta (nd) for Arero district in the late 1980s suggested that some 23% of the cattle were mature males, 50% mature females, 12% immature males and 15% immature females.

Extrapolating from data collected by Mulugeta Assefa (1990: pp 1, 15) it is further stipulated that 18% (2491) of all households were wealthy, 31% (4290) middle class and 51% (7058) poor. Sixty-five per cent of all cattle (217 100 head) may thus have been owned by the wealthy, 25% (83 500 head) by the middle class and 10% (33 400) by the poor. For mature males (the most marketable component), of the total population of 76 820 most (67% or 51 469) were owned by the wealthy, 25% (19 205) by the middle class and 8% (6145) by the poor. In terms of households, this indicates that wealthy households had 20.6 mature males each, the middle class 4.5 and the poor 0.9 each.

To avoid undesirable effects during the high-density phase, the ideal situation should have been to encourage an offtake of at least 34 000 head and attempted to keep the high-density phase of the population at around 300 000 head, or even less in the future. The 34 000 head represented roughly half of the inventory of mature males and 66% of the numbers held by the wealthy. The challenge, then, is how to translate a potential loss of 34 000 head into an alternative investment for these households. Such investments only need to be less risky than the risk of losing animals during the high-density phase. Considering that 15% of the regional herd was lost in 1989–90 and perhaps another 50% in 1991, these risks are considered to be very high (see Section 6.3.3: *Drought effects in 1990–91*). There are costs and risks to households and the society at large from keeping too many mature males in the high-density phase. These include the forage consumed by unproductive males that could otherwise be eaten by milk cows, a higher probability that forage in drought reserves will be compromised before it is acutely needed and a higher risk of mature females dying should there be a dry year. These problems are appreciated by Borana elders (D. L. Coppock, ILCA research scientist, unpublished data; Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*).

The role of local development projects: The wealthier households could be expected to shoulder the burden of increasing offtake during critical times for the good of the community. The wealthy already destock by contributing animals to fund projects that develop or maintain wells and large ponds. This can involve hundreds of animals in any given year (see Section 7.3.1.1: *Water-development activities)*. By contrast, while construction of cement water tanks may be important to the community overall, it offers less scope for stimulating animal offtake. This is because of logistical problems which constrain building a large number of tanks in any given year as well as their low cost. For example, with an average of 10 households per encampment, there may be around 1300 encampments in the study area; and if only half of these desired water tanks, with eight bulls sold per tank (Hodgson, 1990), this implies an offtake of 5200 head in total. The reality is that less than 10 tanks have been built per year in the past (C. Fütterknecht, CARE-Ethiopia, personal communication). Even if 20 tanks could be built each year, it would take over 30 years to satisfy demand. Water tanks are thus a means to provide for only small increments of offtake each year.

Banking: Another option is banking livestock wealth in the form of simple savings accounts. There have been branches of the Commercial Bank of Ethiopia in the southern rangelands since 1985 and bank managers have remarked that the Boran should consider managing some of their animal assets as cash reserves (Bekele Tadesse, Commercial Bank of Ethiopia, personal communication). Local bank representatives have campaigned to encourage them do just that but the attempt has apparently not been fruitful (Bekele Tadesse, Commercial Bank of Ethiopia, personal communication), partly because the local administrators were not providing adequate political support to the process. In memos to the central bank office in Awassa, Bekele Tadesse (1986) reviewed the local banking situation in the southern rangelands. He noted that even though the agropastoral Burji to the north of the Boran were using the bank in Agere Mariam, pastoralists throughout southern Ethiopia in general showed no similar inclination, using banks mainly to replace worn or damaged currency. It was recommended that more seminars be conducted to inform all local people about the use of banks (Bekele Tadesse, 1986).

Banking obviously offers substantial barriers and risks, especially for the uneducated. Lack of education outreach to the Boran thus becomes a major constraint in this regard (Chapter 8: *Synthesis and conclusions*). Furthermore, banking has also been traditionally viewed by agricultural scientists as economically noncompetitive with livestock in terms of returns on investment (J. Eckert, Colorado State University, personal communication). Livestock traditionally serve as a hedge against inflation and a means to mitigate the effect of droughts (Section 6.4.4: *Traditional drought-mitigation tactics*). It is speculated here, however, that the scientists have failed to consider financial interventions on the basis of risk management. Research into risk management of animal assets may be very timely for systems under increased population pressure. As will be reviewed in this and later sections, strategic banking is justified for the Boran in terms of risk reduction and famine mitigation for the pastoral households as well as capital generation for communities.

It is understood that the risks of maintaining large herds as traditional investment are becoming greater today than in the past because of overpopulation. That large herds are kept by the Boran primarily as investment yielding social and economic benefits was confirmed by interviews (Coppock, 1992b). If a wealthy herd owner was to sell a fully grown male under the favourable market conditions during the high-density phase, he or she would eliminate the risk of losing that animal should a dry year suddenly arise or because of incompetent herding as this is reportedly an increasing problem for the wealthy (Coppock, 1992b). If an animal is lost while on *forra* in a remote area, there is no certainty that the carcass will be put to use, in many cases only the hide may be retrieved (Coppock, 1988). Besides reducing household vulnerabilities banking could also benefit poorer neighbours and kins since it would mean less competition for forage to their herds. This assumes, however, that households would not produce more animals to quickly fill a void left by banked animals. Social pressure on the wealthy to move excess animals elsewhere has been reported in some *madda* during the high-density phase of the cattle population (D. L. Coppock, ILCA, unpublished data).

Since a mature animal wouldn't grow any more, the herd owner's main risk of banking it would be in the form of inflation estimated at 2.6% per annum in Ethiopia during 1980–87 (IBRD, 1989: p 164). But this would be somewhat offset by the 6% interest on the saving accounts (Bekele Tadesse, Commercial Bank of Ethiopia, personal communication). Inflation has probably accelerated recently following the change of government in 1991 and currency devaluation in 1992 (D. L. Coppock, Utah State University, personal observation). It is important to note that a diversification of assets should ideally provide an improved combination of returns and low risk. That bank funds could be subjected to devaluation by inflation, monetary policy and political instability suggests that a major drawback of this intervention lies in the dynamics of the national government (Chapter 8: *Synthesis and conclusions*).

Banking interventions would have to be implemented in a step-wise manner. For example, three males banked per wealthy household (14% of the mature male inventory per wealthy household) would yield an offtake of 7473 head. With a value of EB 250/head this would yield a total of EB 1.8 million. In addition, if one male were banked for each middle-class household (22% of mature male inventory per middle-class household) this would yield an offtake of 7058 head with a value of around EB 1.7 million. The increase in savings accounts would constitute a major infusion of capital for local urban development; but it is important to note that urban ethnic groups other than the Boran would probably benefit from an increased flow of loans. Step-wise destocking could also have important effects in terms of conserving resources in certain *madda*, but the greatest initial effects would probably be in terms of improving terms of trade for pastoralists during times of drought (Section 7.3.3.7: *Mitigation of drought impact*) and providing capital for banks.

There may already be banking occuring among the Boran. There were 106 savings accounts under

Borana names held at the Yabelo Branch of the Commercial Bank of Ethiopia in 1991 (Commercial Bank of Ethiopia, unpublished data). While many of these account holders are probably educated urban dwellers, it is suspected that some are influential pastoralists from the traditional sector with urban connections (Bekele Tadesse, Commercial Bank of Ethiopia, personal communication). These bank accounts have an average balance of EB 1260, with a range from EB 6 to 40 000. Wealthy herd owners in some *madda* were under increasing peer pressure to bank a portion of their cattle wealth during the high-density phase of the late 1980s (D. L. Coppock, ILCA, unpublished data). A survey of 30 leaders throughout the western Borana Plateau revealed that they realised that their traditional way of living was changing rapidly (Coppock, 1992b). Nineteen of the 30 were aware of the banking system, and 10 of the 19 were interested in becoming involved in banking. They reportedly suffer from lack of knowledge concerning alternative means of keeping wealth (D. L. Coppock, ILCA, unpublished data).

There are significant problems in making banking a reality for a large segment of the Borana population. Suspicions regarding the practice must be overcome and those who have used banks to date could be useful in a public relations programme. New administrative procedures may have to be devised to accommodate illiteracy in the population and facilitation of deposit and withdrawal of funds may have to include some degree of bank decentralisation and/or mobility in remote areas. Some social costs of banking have to be anticipated. While the ultimate decision to sell an animal may rest with the herd owner, this can be strongly influenced by communal debate (Coppock, 1992b). This implies that people have vested interests in each other's cattle. To what extent banking could "privatise" an animal is unclear.

Having more animals out of the system by way of creating another form of wealth may also compromise the ability of the poor to stake claims for animals from the wealthy of the same clan, which is a traditional means of wealth re-distribution (Section 2.4.2.2: *Some cultural and organisational features*). The social rewards of contributing cattle to community projects and to the poor likely outweigh any that can accrue from banking. Perhaps the ultimate constraint to banking is the cultural value of pastoralists to possess large herds and a lesser interest in saving large sums of money. But this could change with generational shift of values (Coppock, 1992b).

A sustainable yield scenario: Given the above scenario that around 30 to 50% of the herd (34 000 head) could be taken off through a combination of local development projects and banking, it needs to be stressed that there would be little interest in such activities during the drought-recovery phase. Interventions of increasing offtake are only viable during the high-density phase (Section 7.4: *Component interventions and system dynamics*). Indeed, recovery from drought would be a time of bank withdrawals and efforts to stimulate growth in livestock assets. The next issue then becomes how to maintain a level of sustainable harvest to keep the herd size in the vicinity of 300 000 head on an annual basis in normal rainfall and dry years during the high-density phases. If animal wealth were banked, the net result would be increased economic security and growth per pastoral households.

The following analysis dealing with sustainable yield assumes that: (1) the composition of the regional herd is similar to that previously mentioned (Solomon Desta, nd); (2) calving rates vary from 0.75 to 0.53 in average rainfall and dry years, respectively; (3) average rate of calf mortality is 21% in average rainfall and dry years with no interventions; (4) death rates of other immatures vary from 8% (average year) to 10% (dry year; Mulugeta Assefa, 1990: p 90); and (5) death rates for mature animals vary from 6% (average rainfall year) to 10% for dry year (Mulugeta Assefa, 1990: p 90). The annual intrinsic rate of increase (births minus deaths) for a herd of 300 000 head is on the order of 23% and 11% in average rainfall and dry years, respectively. Canceling this out would require offtakes of 69 000 or 33 000 head per annum while the net annual increase after routine sales is lower than that.

Assuming at least 80% of annual household income is derived from cattle sales and that being EB 74, 356 and 627 for poor, middle-class and wealthy households, respectively (Holden and Coppock, 1992), this implies a total annual cash demand for EB 3 611 389. At EB 250 per head, 14 445 animals would need to be sold to cover this figure. This makes the rate of herd increase in an average rainfall year more on the order of 18% or 54 000 head. In a dry year the need for grain almost doubles. If it is assumed that: (1) nonessential purchases are foregone and most of the income is spent on grain so that overall cash needs do not increase (Cossins and Upton, 1988a: p 125); and (2) cattle prices drop to EB 175 per head as a midpoint between average rainfall year and drought conditions (Cossins and Upton, 1988a: p 128), it may be inferred that routine offtake in a dry year could climb to some 21 000 head. The net rate of increase in a dry year would thus be 4% or 12 000 head. All considerations of stimulating offtake assume that animals which are sold leave the system.

We note from this analysis that attempts to maintain a yearly level of 300 000 head is a greater challenge in average rainfall years than destocking from 334 000 to 300 000 head taking the benchmark year of 1990 (above). However, the net increase in dry years may be negligible. If calf management interventions served to reduce mortality rates by half, in average rainfall years the net increase after sales would be 65 000 head or 21.7%, while in dry years it would be 20 000 head or 6.6%. In the future higher offtakes may be facilitated by an increasing need to purchase ever more grain as a result of population growth (Figure 7.2) and this may control livestock population pressure, failing that it is unlikely that there will always be sufficient community projects to encourage offtakes of a regulatory magnitude given a succession of average rainfall years. Given the reported increased use of money in recent years (Coppock, 1992b), development of Service Cooperatives (see Section 1.4.3: *The SERP and the Pilot Project*) should stimulate additional offtake if locally desired consumer goods such as grain, clothing, hand tools and cement are offered for sale (Hodgson, 1990; Hogg, 1990b). Still this may only have a minor effect on the cattle population, however. Banking may thus remain as an important option to stimulate offtake but the scale of offtake required to stabilise the system may be unmanageable. Even if every wealthy and middle-class household anually banked from five to two animals, respectively, this would only account for 39% of the annual herd increase in an average rainfall year.

Some comments regarding effects of accelerated offtake on the human component of the system warrant mention. The low ratios of livestock to people in pastoral systems often indicate that the scope for increased offtake is poor (Coppock et al, 1985). It is argued, however, that if such offtake is confined to male animals held by wealthier households, opportunity may exist to shift herd composition in favour of more milk cows and thus increase food security during interdrought periods. As will be discussed, protection against drought should also be improved as a result of banking males because of the poor terms of trade during drought between livestock and grain (Section 7.3.3.7: *Mitigation of drought impact*). If the present composition of 23% mature males and 50% mature females were shifted to 12% mature males and 61% mature females in a herd of 300 000 head, this would mean an annual yield of 115 million MJ GE from milk and this could reduce the current annual energy deficit from 46% to 35% (Figure 7.1c).

Although the task of managing risk through growing cattle offtake may appear daunting, a major effort to coordinate cattle sales to finance local development projects and promote banking of livestock wealth is needed. Average rainfall years are interrupted by dry years and this may serve to regulate cattle population growth to a high degree (Mulugeta Assefa, 1990). Around 15 000 cattle reportedly died in the dry season of 1991 (Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). Regulation by the vagaries of climate implies, however, wastage, so that ways to conserve wealth through an intervention such as banking are important. Arguments that banking is not a viable economic option for pastoral producers need to be reassessed in the light of risk management. Research needs to determine the break-even rates of return from banking that could justify banking interventions. It is also contended that activities in public relations by development agents such as SORDU to promote banking may be more consistent with their technical, logistical and budgetary constraints than are large projects in range management.

Increase in cattle prices: A recent loosening of price controls and transport restrictions for some agricultural commodities in Ethiopia (Ethiopian Herald, 1990) may mean prices for Borana cattle will increase. By early 1991 cattle prices reportedly had risen to about 30% over the previous year (Solomon Desta, TLDP economist, personal communication). Should prices rise to a level competitive with those offered by the black-market trade with Kenya, the Boran would prefer to sell within Ethiopia because it is logistically simpler (Coppock, 1992b). But prices would need to increase considerably for this to occur as black-market prices may average at least 150% greater than those offered internally (FLDP, nd). Should Ethiopian prices become competitive this coul mean capturing about 17 000 head of cattle per year otherwise sold to Kenya (Hodgson, 1990: p 177). Despite the fact that the Boran seek higher prices for their cattle, general increases in price are hypothesised to reduce the overall throughput of cattle sold by them (Coppock, 1992b: see Section 4.4.4: *Traditional marketing rationale*). This would work against the trend among the Boran toward increased cattle sale to buy grain as a result of population pressure (Section 7.2.2: *Anticipated long-term trends*).

7.3.3.7 Mitigation of drought impact

Mitigation of drought impacts on pastoralists has been the subject of much research. Generally it is thought that pastoral populations are increasingly vulnerable to drought due to the effects of overpopulation, range degradation and loss of traditional forage reserves with their buffering capacity (see Section 6.1: *Introduction*). Consequences of such a generally destablised system include increased pauperisation of pastoral peoples with a declining capacity for post-drought recovery (Moris, 1988; Sperling, 1989). This may also be exacerbated by inappropriate development tactics (Hogg, 1980; Toulmin, 1986).

The Borana system of southern Ethiopia, long considered one of Africa's most productive and stable rangeland environments (Pratt, 1987a), is now thought to be sliding into a situation of increasing poverty, severe density-dependent interactions and increasing susceptibility to drought as experienced by other pastoral peoples (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). Although drought-induced mortality of people may have been negligible in the 1980s, the spectre is one of a growing risk of large-scale human catastrophe in the future, traceable ultimately to a growing human population that remains isolated, has restricted opportunities to emigrate and is increasingly dependent on un- reliable grain markets.

Mitigation of effects during and after droughts

Prioritising rehabilitation measures following drought implicitly acknowledges that little can be done in terms of prevention. Rehabilitation can also be expensive, while it is unlikely that the needs of the Boran for post-drought credit or donations to reconstitute herds (Toulmin, 1986) could compete favourably with other groups in Ethiopia. When droughts occur in the country the entire nation can be affected (RRC, 1985). Farming populations in the highlands that are more vulnerable to drought than pastoralists (Webb et al, 1992) also carry more weight both agriculturally and politically in Ethiopia so limited aid for drought-recovery would most likely be directed to highland systems first.

Employment options: Current strategies to better protect the Boran from the effects of drought are necessary, but some of those are less realistic than others in terms of effective implementation. For one thing, they should be implemented with special consideration of certain groups (e.g. poor female heads of households) that are more vulnerable than others and should receive priority for interventions (Holden et al, 1991).

The simplest option is to provide more non-pastoral employment opportunities at strategic times. This requires agencies to plan in advance and yet be flexible in program delivery. For example, setting aside major projects in bush control for times of drought not only provides, and jobs hence income during the hard times, but may also prepare range sites for faster rehabilitation during the drought-recovery phase of the cattle population (Section 7.2.3.1: *Range ecology*). These projects could pay for themselves through charcoal production provided that lack of the capability for restricting the scope of charcoal-making, once techniques become widely known, can be dealt with (Section 7.3.1.4: *Site reclamation*). Similar timing of projects in construction and/or maintenance of water points and roads would also be useful. But planners should see to it that a high percentage of the population are targeted to participate which means that projects should be widely distributed. Provision of jobs would be most useful during November through March in a second consecutive drought year (Section 6.3.1.5: *Household economy*).

The next advocated tactic of mitigating the effects of drought is promotion of camels for transport (for hauling grain from town) and milk production (Section 6.3.2: *Drought effects in the upper semi-arid zone*). The effective numbers of camels for each intervention would vary markedly across the study area. For example, if the target is to facilitate acquisition of two male draft camels per encampment, about 2700 will be required. But if the goal is to facilitate acquisition of one milk camel per household, nearly 14 000 of them would be required. Given the existing population of 4700 camels in the study area during 1986 (Assefa Eshete et al, 1987: p 9), these proposed additions are quite large. If the Boran were to trade cattle for camels, this could only be achieved during the high-density phase of the cattle population when cattle assets are high. Another intervention using livestock involves promotion of small ruminant production, but sustaining this may be relatively more dependent on timely (and logistically difficult) veterinary support.

Little has been studied on the Borana Plateau regarding nutrition and disease interactions that have been observed to kill many cattle in other pastoral systems during drought (Grandin et al, 1989). It is hoped that even though animals may be predisposed to disease through poor nutrition, a considerable proportion of losses may be avoided if more attention was given to identifying and controlling key diseases. But this requires more investigation.

Interventions which are less likely to succeed are those that involve large inputs of resources to implement or those of which success is dependent on external factors. A good example of the latter is supplementation of milk cows or calves with molasses and urea mixtures (Cossins and Upton, 1988a; Mulugeta Assefa, 1990). Although Mulugeta Assefa (1990) found molasses and urea supplementation of calves to be potentially profitable even when transport costs were included, difficulties in securing sufficient quantities during times of drought could be enormous.

A good example of an intensive intervention are the drought fodder banks based on *Opuntia* and *Atriplex* spp, with test plots at several sites in the southern rangelands (Pratt, 1987a,c). The concept involves using *Atriplex* spp for protein and energy and spineless cactus for moisture as the basis for a survival ration for animals during drought (de Kock, 1980; Shoop et al, 1977). Menwyelet Atsedu (1990: pp 54–78) contrasted the nutritive values of standing crops and established species in SORDU propagation sites. These included *A. nummularia*, *A. canescens*, *A. rhagioides* and *A. undulata* as well as introduced and local lines of *O. ficus indica* var *inermis*. Details of this evaluation are reported in Menwyelet Atsedu (1990).

Among the *Atriplex* species, *A. undulata* had the highest values ($P<0.05$) per plant for total and edible biomass (1932 and 365 g dry-matter per plant, respectively). *Atriplex undulata* and *A. nummularia* had the highest ($P<0.05$) CP content (22.5 and 21% on a dry-matter basis, respectively), and both were among the highest in terms of IVDDM (67% for *A. nummularia* and 60.7% for *A. undulata*). Compared to the local cactus, the exotic line had over twice the dry weight with a slightly lower ($P<0.05$) moisture content (85.9 vs 92.6%). No differences were apparent among cacti in terms of per cent CP (=6.35%) but the local line had a higher ($P<0.05$) IVDDM (81 vs 76%). This was interpreted to indicate that *A. undulata* and the exotic cactus would be the best combination for drought fodder banks on the Borana Plateau.

Although such fodder banks are reportedly successful in Saudi Arabia and the USA (Menwyelet Atsedu, 1990: p 54), it is debatable whether they would be useful in the southern rangelands. This is because: (1) unless sexual reproduction is controlled, the spineless cactus can revert to unusable spiny forms (Turner and Costello, 1942; Benson, 1969; Hyder, 1981); (2) consumption of salty *Atriplex* can increase water requirements and instill a reduced tolerance of saline water (Wilson, 1966) especially since water in the Borana wells is often saline (Nicholson, 1984)); and (3) feeding *Opuntia* can result in laxative effects and diarrhoea (Samish and Ellern, 1975; Gibson and Nobel, 1986).

Even if these did not exist, a more significant problem may be amounts of the fodder bank necessary to have an effect on reducing mortality of calves during drought. For example, if the first year of a drought is targeted (because it would be a time of higher absolute calf mortality; Section 6.3.1.2: *Cattle productivity*) it is assumed that: (1) a 40-kg calf requires 7.3 MJ of metabolisable energy (ME) per day for sustenance (Mulugeta Assefa, 1990: p 74); (2) the calf needs four litres of water per day (Tesfaye Wogayehu, 1990: p 1); (3) calves need to be fed for six months; and (4) an average encampment of 10 households has 39 calves (as inferred from the number of milk cows in 1983 (Table G1, Annex G)). The metabolisable energy in edible *A. undulata* is 365 g x 18 MJ GE/kg x .607 IVDDM x 0.81 (ME coefficient)=3.23 MJ ME/plant. The 39 calves require 51 246 MJ ME for six months, so 15 865 plants would be required for the fodder bank. Given an optimal density of 1 plant/3 m^2 (Menwyelet Atsedu, 1990: p 61), an area of 4.7 ha is required only for the *Atriplex*. Each cactus would yield 30 litres of water (Menwyelet Atsedu, 1990: p 69) and the calves would require 28 080 litres over six months. Assuming that the cacti are also spaced at 1 plant/3 m^2, the number of plants required is 936, or an additional 0.28 ha. In total about 5 ha is thus needed per encampment. For 1383 encampments this would total 6915 ha, or 0.44% of the study area. The opportunity cost of land close to encampments that would be planted with *Atriplex* and *Opuntia* needs to be considered for other types of rainfall years. This analysis itself does not consider the implementation costs or logistical problems of supplying seedlings and clearing an area (Pratt, 1987c: p 2). Whether the pastoralists are willing to engage themselves in such a labour-intensive activity is another question; they have been commonly unwilling to do so even in simpler range development projects (Hodgson, 1990). In addition, the fact that families may periodically move their place of residence would be another disincentive for individual investment in such sites. The Boran are willing to pay for interventions that they feel are important (Hodgson, 1990), so that should always provide the ultimate test.

Finally, it has often been inferred that the Borana have little to sell during drought that has any significant value, but one commodity has been overlooked. Each encampment has tonnes of manure stacked in large mounds that could be marketed to the highlands as fertiliser if an organisation such as SORDU could facilitate the activity by making cattle trucks available for manure transport. The economics of such an effort are unclear, but it merits consideration. A long-term question is whether exporting nutrients from the rangelands would undermine productivity.

Policy options and infrastructural constraints: Cossins and Upton (1988b: p 256) noted the importance of the rapid decline of the terms of trade during drought for the Boran. They further stated that the solution would not be found in local improvements in marketing but instead in national policies for increased food security. Presumably this was referring to policies that encourage more grain production in the highlands, and policies which facilitate more opportunistic and free-flowing movement of grain to the lowlands and livestock to the highlands during times of stress.

One element of the decline in the terms of trade is an increased price for grain due to a low supply and high demand. Local grain production is virtually eliminated during drought and the capacity for deliveries from the highlands is also reduced because, at least in the 1980s, drought occurred at the same time there too. This reduced national grain production and precluded the possibility of surpluses for the rangelands (Maxwell, 1986 cited in Cossins and Upton, 1988a: p 128).

Franzel et al (1989) reviewed the negative impacts of marketing regulations on grain production and distribution in Ethiopia as implemented by the socialist government. They noted that the fixed production quotas and producer prices, as well as regulation of interregional trade and markets, had compromised the national objectives of increased grain production and food self-sufficiency. It was contended that quotas were often inequitable, low producer prices yielded disincentives for grain production and use of inputs and interregional trade restrictions limited access of consumers to grain at cheaper prices. They noted that at current fixed prices, using fertilisers was economic at only one of 35 sites for maize and 12 of 28 sites for wheat. They speculated that price rises on the order of 90% for maize and 73% for wheat would make fertilizers profitable at over 70% of these sites. They felt that the quota system should initially be adjusted in recognition of region-specific characteristics and eventually reduced in favour of providing more incentives and services to private producers. Finally, it was stated that relaxing interregional trade restrictions would be an inexpensive means to help ensure that grain-deficit regions are adequately supplied, with better prices for both producers and consumers as a result. Recent policy initiatives in Ethiopia (Ethiopian Herald, 1990) may result in some improvements in grain production and marketing that could benefit the lowlands in the future. Peasant producers in 1990 will be allowed to sell all their production on the open market as interregional trade restrictions have been loosened (Solomon Desta, TLDP economist, personal communication). One lingering problem has been the effects of government trucking monopolies and rural insecurity due to weapons proliferation. This constrained delivery of grain to the rangelands during the 1990–91 drought, resulting in some of the highest cereal prices in memory and putting the Boran at risk of famine (Section 6.3.3: *Drought effects in 1990–91*).

The other element of the unfavourable terms of trade on the Borana Plateau is the low price of livestock due to high market supply and low local demand. This kind of squeeze may periodically eliminate any advantages accrued from general increases in livestock price that may avail the Boran better terms of trade in average rainfall or dry years. Presumably one way to help alleviate this problem would be to facilitate purchase of stock by external agents who can sell animals in more favourable markets elsewhere in the country. Solomon Desta et al (nd) noted the problems the Boran had in selling their animals locally during the drought in the past and remarked that external purchasing agents had to cease activities as well. SORDU stopped purchasing stock because of insufficient watering capacity from rainfed ponds on their holding ranches. Cattle bought by the national meat board and taken north of the study area to the Alem Tena and Kuriftu holding grounds did not bring good prices and the spread of disease among the animals led it to halt operations. The Ethiopian Livestock Development Project usually would buy animals and trek them to Melge Wordo for slaughter during nondrought years. During the 1983–84 drought, however, the lack of grazing and water along travel routes led it to cease the activity. These examples all point to the lack of adequate resources to hold and/or trek animals out of the rangelands during drought. Either more attention needs to be given to secure these resources in advance or external agents must be able to rely on trucking to move animals further up country.

Avoiding the ill effects of drought

Banking: Review of options presented thus far makes it apparent that, despite cultural and logistical barriers, promotion of offtake of cattle through banking would be the most effective means of buffering the population from the ill effects of drought. This is because: (1) pre-drought banking would help conserve the monetary value of cattle and thus somewhat cushion the decline in the terms of trade for grain; (2) wasteful losses of stock could be reduced; (3) competition for forage would be lessened in the early stages of a drought to the benefit of milk cows and would serve to reduce pressure on forage reserves; and (4) following a drought there could be a source of local credit for people interested in restocking while a stabilised population could offer a viable local source of animals for redistribution. The key is not only getting the pastoralists interested in banking but also devising a system that allows people in remote areas easy access to their money. Thus, bank personnel should be able to anticipate needs by monitoring the situation through a technical agent such as SORDU. Presumably the failure of the long rains in any given year should be a sufficient indicator that a stressful situation is underway.

The next question is to compare banking options versus the traditional strategy of attempting to outlive a drought by gradual herd depletion. Two- and three-year droughts are considered in this analysis. Data on family sizes and cattle holdings are derived from Mulugeta Assefa (1990: p 15) and Table 7.15 displays the major findings. These are summarised by wealth class:

Wealthy families: A wealthy family is supposed to have 6.4 persons and 24 mature male cattle and is dependent on milk from 39 cows. During the first year of a drought the calving percentage may drop to 53%, with a decline in the milk yield per cow of 16% (Section 6.3.1.2: *Cattle productivity*). The total yield of 14 584 MJ GE would just about cover total human energy demand of 14 950 MJ GE and without any livestock having to be sold or slaughtered. In an extreme case during the second drought year, if the percentage of cows in milk dropped to 10% and milk yield per cow to 50% of pre-drought figures, the total yield of 1638 MJ GE covers only 11% of household energy demand (Table 7.15). Assuming a worst-case terms of trade of 75 kg of grain per every 250-kg animal sold (Cossins and Upton, 1988a), the family would have to sell 10 males (42% of the pre-drought inventory) in the second year to have sufficient food energy from grain, but this is based on the tenuous assumption that there would be no voluntary reduction in energy demand (Webb et al, 1992). A three-year drought may occur only once in a century (Cossins and Upton, 1988a) and if it assumed that one occurs and milk production stops totally, and the terms of trade remain at the level of the previous normal year, another 11 head would have to be sold to cover grain requirements, resulting in near depletion of the mature male component of the herd. Despite such loss of capital livestock, the wealthy families would have food throughout and would be less likely to have to sell productive elements of the herd such as cows or heifers. The situation for the middle class and poor would be much worse.

Middle-class families: With the middle class having 4.8 persons, nine mature males and 14 cows per household, these families could get only 47% of their energy needs from milk during the first drought year and, assuming an intermediate terms of trade of 350 kg of grain per male animal sold, one such would have to be sold to cover the deficit. By the third year of the drought the remaining eight males would have to be sold to cover the 95% energy deficit. By the second year of the drought eight more animals have to be sold and this has to include cows and heifers. In sum, the middle class could have enough food but at a substantial loss to their productive resources.

Table 7.15. *Projected food energy deficits, cattle sales required to provide sufficient grain and cattle numbers banked to provide equivalent food security for Borana households of varied wealth during two- or three-year droughts in the southern rangelands.*[1]

Wealth category	Total energy required (MJ GE)	Per cent energy covered by milk	250-kg cattle sold for grain	Per cent of inventory[2]	Cattle banked for security
Two-year drought:					
Wealthy	29 901	54	10[3]	11	3
Middle class	22 426	26	9[3]	26	3.1
Poor	26 163	7	12[4]	92	4.4
Three-year drought:					
Wealthy	44 851	36	21[3]	23	6.3
Middle class	33 638	17	17[4]	48	5.5
Poor	39 245	5	13[4]	100[5]	7.3

1 Where energy requirements are based on 2336 MJ GE/person/year (FAO/WHO, 1973); people and cattle per household were from Mulugeta Assefa (1990); and cattle productivity was derived from Donaldson (1986) and Cossins and Upton (1988b). Drought terms of trade of grain from the sale of 250-kg cattle is assumed as 350 kg/animal in year 1 (i.e. EB 0.70/kg live weight) and 75 kg/1 animal in year 2 (i.e. EB 0.30/kg live weight) and year 3 (Cossins and Upton, 1988a). Banking assumes a conserved value of EB 1/kg live weight.

2 Sales as a per cent of pre-drought inventory, where the wealthy, middle class and poor have 91, 35 and 13 head, respectively (Mulugeta Assefa, 1990).

3 Only mature males sold.

4 Mature males and other sex and age classes sold.

5 Insufficient cattle for food security.

Poor families: For the poor, with 5.6 persons, three mature males and five cows per household, only 14% of their energy demand is provided as milk, and two males need to be sold in the first year of drought. In the second year another 10 must be sold to cover a 99% energy deficit, virtually decimating their herd. In year three the poor face starvation.

The preceding discussion does not even consider cattle losses as a result of starvation or disease. Material presented in Section 6.3.2.1: *Livestock* indicates that mortality losses typically exceed sales by 10-fold. The reason that the Boran emerged from the last drought without total herd decimation was probably because human food intake dropped dramatically and some income was derived from nontraditional sources (Section 6.3.2.2: *Human welfare*). Relatively few animals were slaughtered and most that died on *forra* were probably unutilised.

If the pastoralists were to bank some animals prior to the above hypothetical drought, it is argued that the situation would be much better because the value of cattle would have been conserved. The calculations presented in Table 7.15 contrast drought induced sales versus banking and consider variation in terms of trade for each year. Had families banked in anticipation of a two-year drought, the losses of livestock through trade would have been reduced on average by 67%. The middle class would not have lost all of their male cattle capital while the poor would not have had to dig as deeply into their pool of cows and heifers and these would not have been decimated. For a three-year drought the losses of stock through trade would have been reduced on the order of 69%, considered here for the wealthy and middle class only. The middle class would have been saved from selling cows or heifers. The poor would have to bank over seven animals to keep them supplied with grain over three years, but this is unrealistic (Table 7.15). The poor, however, could benefit from the increased stability of the inventory of the wealthier classes through food sharing (Webb et al, 1992).

In anticipation of a two-year drought, if wealthy and middle-class households banked three head each and half of all poor households banked one head each, the total offtake would be about 24 000 head with a pre-drought value of EB 6 million. Such action would reduce pressure on forage reserves during the high-density phase and bring environmental security. This analysis suggests that under the present reality of high population densities and dependence on grain, retention of males for drought security is a very poor alternative to banking. The practice was more valid in previous generations when per capita resources were more abundant and grain was less necessary to supplement human diets during times of stress. Mature males have other uses in the society, such as for gifts and ceremonial slaughter (Asmarom Legesse, 1973). These uses, however, are probably relatively minor overall and it is not expected that the number of animals banked would affect the supply of animals used for these social purposes.

Grain storage: Another pre drought measure for food security is grain storage. Although the Boran already have built corn cribs to store home-grown maize, they have no experience with grain storage for dry or drought years. Both CARE-Ethiopia and SORDU have initiated grain storage projects. The philosophy behind these projects is to have the Boran save money and animals by purchasing grain when the terms of trade for livestock are favourable, usually after the long rains in July and August. The typical pattern to date, however, has been for the Boran to wait and sell stock in the dry season when they have a specific food problem and hence suffering from poorer terms of trade even in years of average rainfall (Coppock, 1992b). The Boran reportedly understand this shortcoming on their part. The problem is that in general the Boran deal with emergencies after they occur. They thus act as "optimistic gamblers", hoping the weather will break in their favour and that procrastinated sales will be avoided altogether (Coppock, 1992b).

Hodgson (1990: pp 86–97) reviewed attempts by CARE-Ethiopia to get the Boran interested in underground, bottle-shaped grain stores already employed by farmers to the north of the rangelands. To make them, after a hole is excavated in the ground its walls are lined with cement (at a cost of EB 50) or hardened by a week-long fire fueled with wood. After filling the store with grain (the capacity can be several hundred kilograms), a tight-fitting lid is put on and covered with soil so as to maintain an anaerobic environment and protect against insects.

In a comparison of the two types of stores, it was found that the cement-lined variety reduced moisture losses of grain to 2% versus 16% for the fire-hardened one. But it was conceded that improvements could be made to the latter in terms of a longer period of firing and lining the sides with dried grass to better insulate the grain. Besides loss of moisture, grain stores have problems with termites penetrating cracks, frequent opening of the lid allowing oxygen to enter and immobility. The other problem is the difficulty the Boran have in buying cheap grain locally in bulk. Supplies are somewhat limited and merchants buy and hoard grain right after harvest in order to make higher profits during the coming dry season (Hodgson, 1990). In addition, if pastoralists wanted to buy grain from the Agricultural Marketing Corporation (AMC) in the highlands, they would have to overcome a number of bureaucratic obstacles in the process. Such purchases had to come through Service Cooperative (SC) channels and very few of these were developed in the rangelands (see 1.4.3: *The SERP and the Pilot Project*).

As part of the development of SCs on the Borana Plateau, SORDU has planned to construct large central grain stores for each. These are expensive, however, and administrative and logistical details have yet to be finalised (R. S. Hogg, TLDP consultant, personal communication). Fundamental to the success of these large grain stores is the evolution of SCs into viable entities that benefit the people and gain their trust (Hodgson, 1990: pp 93, 102; see Section 1.4.3: *The SERP and the Pilot Project*). Surveys by CARE-Ethiopia indicated that given a choice the people prefer to store grain at home (Hodgson, 1990: p 93).

Considering the foregoing scenarios reviewed for food security and banking, it is apparent that in an average rainfall year (with calving rates of 0.75 and milk energy yield per head of 840 MJ GE), middle-class and poor households would require something on the order of 137 and 552 kg of grain for complete food security while the wealthy would need grain on a discretionary basis only. But in a dry year the same situation holds for the wealthy and the grain needed increases for the middle class and poor to 330 and 625 kg per household, respectively. For a two-year drought the wealthy would require some 764 kg, the middle class 921 kg and the poor 1351 kg. Even if these estimates are 50% too high, they still serve to show that home storage of grain is probably only realistic for a normal rainfall year, based on the grain store capacity indicated above. The SC stores would be more practical in dry and drought years.

7.4 Component interventions and system dynamics

The underlying assumption of this chapter is that the Borana system is now changing rapidly as a result of internal and external forces. Increased pressure on resources has created problems but new windows of opportunity for development are also opening that did not exist 10 years ago. In this scenario former intervention approaches can now shift from extensive and top-down to more intensive and bottom-up ones, augmented with thoughtful policies. This is true, however, only for production processes that are not too risky. Intensification here mostly implies more efficient management of existing resources. Pastoralists should not be held to intensification standards applicable to smallholders in higher potential systems because rangeland environments are inherently more variable. Hard-won production improvements could easily be lost as a result of environmental perturbation. Importantly, it is accepted that the Boran are not becoming more interested in land management, for example, because they desire to intensify and "develop" their economy. Rather, they are being forced to consider intensification so as to promote their survival. This perspective agrees with the theory of rural change advocated by Boserup (1965).

Table 7.16 summarises windows of development opportunity that are postulated to be either gradually closing or opening in the Borana system over the long term. Those that are closing are based on increasing access to ecological resources or technical interventions targeted towards traditional production surpluses that are now in inevitable decline. Far more windows may be opening than closing, however. Opportunities to intensify cultivation on appropriate sites, improve access to

Table 7.16. *Summary of development windows of opportunity that are gradually closing or opening in the Borana system as a result of a long-term trend of declining numbers of cattle per person.*[1]

Development windows	
Closing	**Opening**
Extensive water development	Management of agropastoralism
Dairy technology	Management of human emigration
	Livestock and dairy marketing
	Banking livestock capital
	Demand for participatory development
	More intensive range management

1 Windows which are closing are based on extensification of the system or interventions that deal with traditional production surpluses. Those which are opening involve opportunities for intensification and risk management. See text for assumptions and qualifications for anticipated trends. See also Chapter 8: *Synthesis and conclusions.*

Source: Coppock et al (1990).

markets and enhance management of calves, other herd assets and human emigration are all widening. This is because there will be more demand for these technologies, services and policies in the future compared to the recent past.

Table 7.17 summarises windows of development opportunity that are postulated to open or close in the context of the interdrought cycle of the cattle population over the short term. Interventions which have greater chance of succeeding under low stocking rates should be implemented in the drought-recovery phase. Those which rely on increased resource pressure and producer risks to promote adoption should be implemented in the high-density phase. All this implies that these interventions could be adopted, dropped and re-adopted in a cyclic fashion. Thus, the fact that a particular innovation may be discontinued after a few years does not mean that it would not be re-adopted. This poses a major difficulty to developers or scientists who observe this system for only one or two years because the problems one observes may be largely dependent on whether the person was present during the drought-recovery phase or the high-density phase of the cattle population.

For short-term management of the interdrought cycle, this analysis implies that agencies which promote innovations in a pastoral setting must be very opportunistic and flexible in programme delivery. This agrees with Westoby et al (1989) who noted that bureaucratic constraints often preclude more effective and opportunistic implementation of management and research programmes in variable environments. Administrative and project-planning procedures too often commit organisations to programmes that suddenly become obsolete.

7.5 Management of human emigration

The pastoral population on the central Borana Plateau may be growing at a rate of 2.5% per year, consistent with estimates for semi-settled pastoralists elsewhere (see Section 2.4.3: *Human population growth*). Human population growth has been postulated as a major source of system instability in terms of declining per capita supply of resources (Section 7.2: *Anticipated long-term trends).* Because there are relatively few opportunities for expansion of grazing area, development of sustainable agropastoralism and because markets are commonly unreliable, increased grain dependence aggravated by a growing population increases the risk of famine.

For 1989 it was estimated for the study area that 75 000 people were dependent on some 314 000 cattle for an overall ratio of cattle to people of 4.2:1. This means an annual energy deficit of 46% (Table G1, Annex G). If it is assumed that 300 000 cattle represents a reasonable compromise between short-term human welfare and reducing risk of negative density-dependent interactions (Section 7.3.3.6: *Cattle marketing*), halving the annual energy deficit to 23% would require a reduction in the human population of 39 000 to yield a cattle to human ratio of 8.4:1. Towns and villages in or near the rangelands are characterised by high unemployment rates, even among urban dwellers, so prospects for increasing employment opportunities for pastoralists over the short term are nil (Girma Bisrat, PADEP Coordinator, personal communication). Even if it were only desired to stabilise the population in the study area at current levels, this

Table 7.17. *Summary of development windows of opportunity which are postulated to open or close based on the interdrought cycle of cattle population dynamics in the Borana system.*[1]

Open development windows	
Drought-recovery phase	High-density phase
Site reclamation	Livestock assets for water development
Improved calf management	Livestock assets for grain storage
Livestock supplementation	Improved calf management
Sustainable cultivation	Banking livestock capital
Milk marketing	Grazing management
Small ruminant marketing	Cattle marketing
Greater impact of health interventions on cow milk production	Small ruminant marketing Milk and butter marketing

1 Windows open in the drought-recovery phase depend on lower stocking rates of cattle for effective implementation. Windows open in the high density phase depend on higher stocking rates of cattle for effective implementation. See text for assumptions and qualifications for anticipated patterns. See also Chapter 8: *Synthesis and conclusions.*

Source: Coppock et al (1990).

would require creating around 2000 jobs per year to offset the intrinsic rate of increase.

Boran leaders express concern that despite population growth, they expect that indispensable younger males will be leaving the system and that this will create labour shortages for well-watering and herding cattle (Coppock, 1992b). This suggests that young males view their chance of a good life and gaining wealth in the traditional sector as slim. This outflow of males may bode unfavourably for women and children who will have to assume duties of these males in addition to their owen traditional roles (Coppock, 1992a). Attempting to ameliorate future labour constraints with more births could be adopted as a strategy by the herd owners thus spurring population growth further (D. L. Coppock, ILCA, personal observation). Where the emigrating males go, how many there are and what they do where they go remain unclear. It is speculated that some reside in agropastoral communities near the rangelands and others are supposed to work in the livestock black market with Kenya or other contraband trade (D. L. Coppock, ILCA, personal observation; P. Webb, IFPRI, personal communication). Emigration rates among the Boran have been assumed to be low (AGROTEC/CRG/SEDES/ Associates, 1974e; 1974f) but more research is needed on this.

Despite the fact that human population density is the acute cause of increasing poverty and higher risks of famine, the main opportunities to manage population growth are medium to long-term in nature. The only short-term option is birth control but it is felt that this would be exceedingly difficult to implement. The Boran may have traditional forms of birth control, still the fundamental social value for women remains having many children (M. Bassi, Institute of Ethiopian Studies, personal communication). In any event this is a priority topic for future research.

The Boran can emigrate only if given some education or training and a job opportunity. It is unclear how many pastoral children attend elementary schools in the southern rangelands but it is believed to be very low. It is also assumed that boys rather than girls tend to receive educational opportunities (D. L. Coppock, ILCA, personal observation). Boran leaders say that they increasingly understand the value of education for their youth, but have been fearful of sending their children to school because it deprives them of their current and future labour pool. They realise that educated youths will probably leave (D. L. Coppock, ILCA, unpublished data).

A cadre of educated Boran could greatly facilitate some aspects of community development, especially diversification of assets (Section 7.3.3.6: *Cattle marketing*) while banking livestock capital could also provide funds for the development of towns if promoted in the context of a larger development strategy. The future of the Boran is thus highly dependent on the future growth and development of towns such as Yabelo, Mega, Negele and Moyale (Chapter 8: *Synthesis and conclusions*). Even if thousands more Boran children started school today, the effect on Boran society of emigration as a result would not be felt for at least 5 to 10 years.

Chapter 8

Synthesis and conclusions

Summary

The objectives of this chapter are to: (1) offer justification for continued investments in rangeland development in Ethiopia; (2) forward an integrated goal for developing the Borana pastoral system; (3) outline tactics for a best-bet development strategy to meet this goal; (4) note major constraints for implementing these tactics; and (5) summarise major research implications of this systems study.

The current development picture in the southern rangelands is bleak. As a result of the 1990–91 drought, around 50% of the regional cattle herd perished and roughly 200 000 pastoralists are receiving food relief. What used to be referred to as a model of sustainable pastoralism in Africa is now suffering problems regarded as endemic to pastoral Africa in general. The fundamental cause is multifaceted. Human population growth appears rapid, but it is not appreciably different from that of similar systems. The lack of a means to release human population pressure is hypothesised as the root cause of the problem, and this has been exacerbated by the cultural isolation of the Boran from the rest of Ethiopia and limited economic opportunities outside the pastoral sector. The cattle population is increasingly limited by land availability and the ratio of milk cows to people is probably in a precipitous decline. This has led to economic adjustments which include peri-urban dairy marketing and emergent agropastoralism. Negative effects are magnified as the finite resource base is becoming smaller. Population growth, both for the Boran and neighbouring ethnic groups, is now harming their production systems because people are reportedly residing in, or otherwise using, internal and external grazing reserves, which used to be held as buffers to protect cattle herds against drought to an increasing degree. Mix these problems with a dry-year probability of 0.2, and the recipe is disaster.

This negative trend has occurred despite large investments during the 1970s and 1980s. Although it is fortunate that roads and markets are now in place to accomodate future changes in the system, there are several reasons why development planners and expert consultants failed to envision the current situation. First, it was wrongly assumed that the Boran had Western values and were eager to raise cattle for cash; second, there was a poor understanding of how population pressure drives social and economic change. Earlier interventions mostly occurred when it was not necessary for the Boran to change their traditional lifestyle. Now, because of a high population density, they have to change in order to better feed themselves, but the problem today resembles more crisis management rather than development. Some of today's crises could have been averted if the same attention had been given to education and development of human potential as was given to stimulateing cattle production and offtake. Planners will be pleased to know that the Boran would market a higher percentage of cattle in the future and, on average, these will be younger animals. This is not, however, due to a revolution in commercial attitudes but rather to the Boran being forced to sell more animals to buy grain. One consequence of this is that as the Boran are now vulnerable to unstable markets, cattle inventories could be depleted to an extent that endangers asset accumulation and drought recovery, and hence aggravate poverty.

The goals of rural development should include: (1) agricultural growth in the form of livestock production; (2) poverty alleviation; and (3) increased ecological sustainability. If no measures are taken to promote economic development of the Borana system, the chance for agricultural growth will decline, poverty will increase, and ecological sustainability will be compromised by increased cereal cultivation on fragile upland soils to mitigate famine risk and from additional bush encroachment and soil erosion induced by cattle grazing.

Because of their large areal and high population density, the highlands should receive priority for agricultural development in Ethiopia. The rangelands cannot be ignored in the national interest, however, because they will increasingly serve as the extensive breeding grounds for animals used in the highlands and for diversification of exports. It is speculated that the highlands of the future will become crowded to the extent that smallholders will be less able to control the entire process of producing large stock from birth to finishing and will demand a greater supply of cattle for finishing or draft that have been bred elsewhere. Preconditions may now exist, in both the highlands and lowlands, to achieve the goal of national agricultural integration envisioned in the early 1970s if policies and provision of technology and inputs are adequate. The highlands and lowlands offer complementary production advantages which can be exploited. Benefits of national integration now occur in two directions; besides smallholders benefitting from an enhanced supply of range-bred stock,

populations like the Boran are in dire need for highland grain at reasonable terms of trade to offset chronic risk of famine.

The broad view is that interventions in the southern rangelands need to promote sustainability of the traditional social order as well as ecological sustainability of livestock production. Both are inter-related. Famine risk, poverty and the undermining of cultural values threaten the social order. Increased competition and density-dependent patterns of livestock production will be gradually forced more households out of the traditional sector during droughts, the population of peri-urban poor would increase and this could become a negative factor in the social welfare of small towns. The failure to deal with these problems could cause the system to collapse possibly as a result of increased regional insecurity and enhanced difficulties in maintaining operation of the deep wells without coordinated human inputs. Without the deep wells in full operation, the livestock production system could be markedly less efficient and unsustainable. The technology for raising well water under low-input conditions is deemed inappropriate at this time. Enhancing prospects for ecological sustainability is a longer-term issue that requires a hierarchical, step-wise approach to rural development. If the production system is not stabilised in response to drought, there are negative implications for the Boran in terms of loss of animals that could otherwise be marketed and growing commercial offtake for the nation.

Although the challenge is daunting, the fundamental premise of this chapter is that the entire Borana system can be managed to increase agricultural growth, alleviate poverty and reduce risks to the environment using several key interventions in tandem. These measures should also help stabilise the system in response to drought. This has positive implications for reducing the outward flow of destitute people over the short term and reducing loss of milk cows. Reducing milk cow losses deminishes the need for unsustainable cereal cultivation during drought recovery. It also could assist efforts to preserve the Boran cattle breed, because the need for the Boran to trade for inferior highland cows during drought recovery would be lessened.

The time when one development agency or a few technologies could have a significant impact on the Borana system is now over. Managing the system for widespread impact today requires a greater focus on policy and coordinated action among several development agencies and government ministries. The strategy advocated here is also not unduly expensive to implement.

The theory of local system dynamics forwarded in the previous chapter, implies that development action must deal with two phenomena: (1) the long-term trend of a decline in the ratio of cattle to people; and (2) the inter-drought cycle consisting of drought-recovery and high-density phases. Development action must also deal with problems in order of their immediate importance to Borana society: (1) improve food security; (2) reduce risks of animal production and asset accumulation; (3) enhance livestock production and herd turnover and (4) deal with ecological sustainability and poverty over the longer term through population management. Assuming that the first goal can be achieved, attainment of the second goal is the key to everything else. Some interventions can address both the long-term trend and interdrought cycle simultaneously.

Using the framework above, means to deal with the long-term trend can be started now, but the effects will not be felt for a few years. In contrast, the interdrought cycle can be dealt now and produce results more rapidly. An example is described in which the drought-recovery occurs from 1992 to 1996 and the high-density phase occurs after 1997. In general terms, the drought-recovery phase is reached when cattle stocking rates are <20 head/km^2 and the high-density phase when stocking rates are >20 head/km^2. This schema is overly simplistic because variability in rainfall or incidence of epidemic disease could disrupt herd growth patterns. The interdrought cycle may be quite predictable, however, considering rainfall. For example, there is a 0.75 chance that the years 1992–96 will have one dry year or less and will thus support rapid herd growth. There is a 0.25 chance that lack of rainfall would slow herd growth. Once the high-density phase occurs, there is a 0.5 chance of low rainfall in at least one of the first three years and thus a high probability of a drought-induced population crash. This underscores the impression that drought impact is as much influenced by cattle population as by rainfall and leads to the speculation that a major crash could now occur once every 5 to 10 years unless action is taken to stabilise the system.

Measures to deal with the long-term trend are needed to maintain favourable terms of trade of livestock for grain, stabilise the cattle population in response to drought and stimulate Borana migration. Ultimately, the future of the Boran will be greatly influenced by the growth of small towns in the rangelands, both as market outlets and sources of employment. The step-wise approach is to (1) improve food security through local cereal production as a temporary measure and by opening regional marketing channels and (2) to increase the ratio of cattle to people by incrementally increasing livestock-carrying capacity and stimulating human emigration. Major activities include national, regional and local policy initiatives to: (1) stimulate maize production to promote surpluses in the southern highlands, encourage interregional commerce and de-regulate producer prices for livestock and grain; (2) encourage local maintenance and development of infrastructure and transport networks in the southern rangelands to improve market access and promote growth of towns like Yabelo, Moyale, Mega and Negele; (3) support development agencies in the southern rangelands and encourage their interaction with the Boran on the basis of participatory development that focuses on felt needs of the community; (4) devise a land-use policy in recognition of the need for the Boran to cultivate only on ecologically sustainable sites and maintain viable grazing areas within *madda*, which will provide a framework for reclaiming drought reserves from human encroachment; (5) increase Boran access to elementary education; and (6) initiate plans to increase access of the Boran to the commercial banking sector and consider strategies to use banked livestock capital to stimulate economic growth in the small towns.

Strategies developed to deal with the drought-recovery phase during 1992–96 should complement those employed by the Boran and should include: (1) growing maize; (2) selling milk and small ruminants to town dwellers; and (3) attempting to build-up cattle herds. Policy measures should aim at (1) improving food relief activities; (2) promoting favourable terms of trade of livestock and milk for grain by improving market channels (above); (3) taking advantage of opportunities to export sheep from the southern rangelands; and (4) allowing cereal cultivation in ecologically sustainable sites. Technical interventions should be focused in peri-urban locations for both pastoralists and farmers; this acknowledges logistical constraints for extension and that good ideas will be disseminated to outlying areas by Boran who visit market centres. Technical perspectives should give priority to (1) crop management to improve sustainable yields on appropriate sites, enhance crop diversity to reduce risks and promote crop–livestock interactions; (2) extending household-level grain storing, concepts to improve seasonal terms of trade; (3) enhancing cow milk production through extension of acaricides; other health measures and improved calf management using grass hay and native legumes to reduce risk of calf mortality and thus lengthen the duration of lactations; (4) improving veterinary service for small ruminants; and (5) developing options and incentives for the Boran to bank livestock capital. For outlying communities, the drought-recovery phase is also the time to: (1) promote site-restoration activities, including burning and regulated charcoal production for bush control; and (2) give encampments easier access by camels thereby enhancing their ability to transport grain from market. All supplies and services should be paid for by the Boran as this will encourage to test their priorities. As the Boran will be unwilling to sell cattle at this time, small ruminants may have to be sold to generate funds.

Tactics to deal with the high-density phase could start around 1997 and these should also complement those employed by the Boran. Some such as growing maize and selling dairy products are similar to those in the drought-recovery phase but others include: (1) accomodating increased cattle grazing; and (2) reducing the risks incurred by holding more cattle under more precarious environmental circumstances. Additional policies or procedures should ensure that agencies are prepared to: (1) cope with distributing food relief; (2) encourage projects that develop or maintain water points or build grain stores funded by cattle sales; (3) encourage the banking of livestock capital; (4) ensure that drought reserves are capable of handling an adequate number of cattle during a dry year and (5) market cattle to the highlands or for export. For activities 3 and 4 traders should coordinate their efforts to remove marketed cattle from the system. Technical perspectives should give priority to (1) adapting grazing management plans tailored for a particular *madda* under resource stress; (2) improving drought reserves including distribution of water and grazing; and (3) improving calf-feeding management by using hay and native legumes. Assuming that many strategies will be implemented, the next interdrought cycle after 1997 should be less catastrophic than that from 1992 to 1997.

In summary, interventions can be grouped according to objective: (1) food security is dealt with by encouraging maize production on suitable sites, opening regional markets, de-regulating producer prices and extending health services to livestock; (2) risk mitigation is achieved in part by improving food security, but also by banking livestock capital, reclaiming drought reserves and stimulating offtake to fund community projects; (3) livestock production and herd turnover should be enhanced by factors listed in item 2, because increased offtake during the high-density phase should reduce the density-dependent effects on cow milk production and animal mortality; (4) poverty is alleviated over the short term by banking livestock capital and increasing livestock production and herd turnover; and (5) risks of ecological unsustainability should be reduced by banking livestock capital, reclaiming drought reserves, using restoration methods and grazing management to increase grazing resources available to select *madda*, and by improving food security which would lessen the need for cultivation. The effects of increased human migration would not be felt for a number of years, but would include improved food security, risk mitigation and poverty alleviation.

One intervention, the "keystone" intervention, exceeds all others by having positive impact on food security, risk mitigation, livestock production and poverty alleviation; this is banking livestock capital. The constraints for implementing this intervention include: (1) potential distrust by the Boran of banking; (2) barriers that exclude illiterate people from using the banking system; (3) lack of bank branches in the area; and (4) factors such as inflation which are subject to national currency management. Even under conditions of moderate inflation, banking livestock capital could be an effective means to ensure asset accumulation that is less dependent on ecological system dynamics.

Although the other interventions in combination could have significant impact, they are more difficult to implement compared to banking livestock capital. Constraints include: (1) limited manpower and funds for extension and land-use monitoring; (2) inadequate access to sufficient foreign exchange to procure veterinary supplies, spare parts and other necessities (this is despite the fact that range livestock are intended to be a major generator of foreign exchange); (3) difficulties in development agencies and government coordinating their efforts to affect policy changes and work together to solve important problems; and (4) difficulties of the national economy in producing and distributing consumer goods. Projects perceived as important to the Boran can be paid for in local currency from livestock sales, and this is not viewed as a major obstacle. The irony is that lack of substantial development impact is not due to a lack of technology or inappropriate resistance on the part of the pastoralists.

Efficient implementation of the development programme referred to above requires that some routine information be collected concerning cattle herd dynamics, land use, range trend and felt needs of the community on an annual basis. This information could be quantitative or qualitative in nature, and could also be used to validate and/or improve upon ideas proposed in the theory of local system dynamics. Interpretation of range trend data, in particular, may be complicated by the cyclic pattern of cattle herd dynamics. Herbaceous cover dynamics may appear cyclic rather than linear and trends may be difficult to discern. Similarly, bush establishment may appear as an episodic phenomenon during the high-density phase of the cattle population.

Future research priorities should largely involve sociology and economics. These could include study of: (1) banking livestock capital to recommend asset management strategies for pastoral households and the role banked funds could play in urban development; (2) human population growth and the fate of Borana emigrants; (3) the degree to which the traditional social order can cope with stress and eventual loss of labourers; and (4) implications of system change for vulnerable groups such as women and children. Adaptive research could be directed towards problems involving sustainable cereal cultivation. The need for traditional livestock research is relatively minor.

Finally, implications of research findings for 28 major themes are highlighted. These include equilibrial system features, effects of the Boran on the environment, system sustainability, biodiversity, conservation of indigenous livestock breeds, gender issues, livestock production, pastoral production efficiency, upstream versus downstream research, production interventions versus those which mitigate risks, evolution of dairy marketing and agro-pastoralism, collaboration between research and development agents, and the value of systems science for research, development thinking and education.

8.1 Introduction

This chapter attempts to summarise key ideas from previous chapters into a concise development strategy for the southern rangelands. The chapter has several interrelated objectives. One objective is to offer a justification for continued investment in rangeland development. Another is to relate aspects of a proposed development strategy to making progress in attaining three desired outcomes of agricultural growth, poverty alleviation and increased ecological sustainability (Vosti et al, 1991). Another objective is to outline the practical implications of a best-bet strategy in terms of development priorities and tactics, as well as needs for further research. Readers are urged to consult other chapter summaries for details on the structure and function of the Borana production system. These are not reiterated here.

8.2 Development implications

8.2.1 Future role of the lowlands in the national economy

Because highland systems in Ethiopia comprise nearly 40% of the land area, over 85% of the human population, over 70% of the livestock and nearly all of the cereal production of the nation, it is clearly appropriate that the highlands should receive priority attention for agricultural development compared to the rangelands. It is argued, however, that the rangelands cannot be ignored in a national strategy emphasising the highlands because the rangelands will remain as the critical breeding grounds for livestock used domestically and for export. It is contended that a sustainable increase in the supply of livestock from the rangelands can be promoted by very cost-effective policies and procedures that are in line with national priorities.

Livestock development in the highlands today may be largely defined as promotion of more efficient crop–livestock interactions to enhance the important economic roles that livestock play for smallholders (McIntire and Gryseels, 1987). Research about the evolution of agricultural systems, however, suggests that production priorities and constraints will continue to change in the highlands as a result of population pressure and competition for resources (Boserup, 1965; Jahnke, 1982). Such continual change is assured by the fact that rates of net population growth in many highland systems exceed 3.5% per year, with a doubling time of 20 years (EMA, 1988). If urban absorption of rural people remains low, highland systems will become more crowded and cereal cultivation will take up an even higher percentage of grazing land, making it increasingly difficult for highlanders to raise large number of livestock, particularly under extensive conditions. One result of this may be, for example, that rather than raise cattle from calves, highlanders may be forced to trade more for feeder cattle for short-term finishing on crop residues and procure mature or near-mature oxen for draft. In effect, demand for linkages, as described in Section 1.4.5.6: *Smallholder fattening programme*, should intensify. In addition to domestic demand, demand for livestock for export may also increase. Ethiopia has a dire need for hard currency to help rebuild the national economy. Live sheep and cattle will remain as key options for strengthening and diversifying exports (FLDP, nd).

The source of animals to meet increasing demand will be the rangelands. One irony is that while insufficient rainfall is often viewed as the primary constraint for livestock production in rangeland systems, it is variable rainfall which will preserve the rangelands as the centre for extensive livestock production by excluding most other agricultural activities. The potential for the rangelands to supply the rest of the nation with animals remains largely unexploited. If the Borana situation can be considered as representative of Ethiopian pastoral situations in general, the demographic, economic and social pre-conditions are now in place to accelerate rates of animal offtake given adequate market access and reasonable prices.

The Boran have an acute and increasing need for highland grain. Without this grain at favourable terms of trade, risk of famine is now high. A national strategy should recognise comparative advantages for commodity production in different agro-ecological zones and exploit this through policies and procedures which: (1) encourage increased cereal production in the highlands to promote surpluses for export to the rangelands (especially maize); (2) promote settlement of regional political disputes which threaten security and commerce; (3) improve infrastructure and transport capability; (4) deregulate prices; and (5) diversify trade and promote competition among traders. Such scenario of interzonal integration was envisioned for Ethiopia at least by the early 1970s and was the justification for the SLDP and TLDP. Despite past frustrations, recent efforts to liberalise interregional trade, together with increased population pressures that will continue to force both farmers and pastoralists to become more market oriented, may now help speed the attainment of national agricultural integration.

In terms of promoting the flow of livestock from the lowlands, Ethiopia has a large stake in the ecological sustainability of rangeland ecosystems and in maintaining a viable population of pastoral producers. Policies and interventions in the rangelands should promote: (1) poverty alleviation to improve human welfare and enhance rural security; and (2) long-term ecological sustainability for livestock production. Means to implement these interrelated objectives are discussed in Section 8.2.3.2: *Overview of strategy*.

8.2.2 Have past pastoral development projects succeeded in the southern rangelands?

As reviewed in Chapter 7, the perceived outcome of development activities in the southern rangelands since the 1960s includes: (1) creation of a larger, and potentially less stable, regional cattle herd that periodically degrades the environment; and (2) the rise of a human population that is increasingly dependent on famine relief and rehabilitation. There has been no documented increase in cattle offtake or a widespread and sustained improvement in human welfare as a result of veterinary campaigns or the development of ponds, roads or markets. Any increased production accruing from interventions has probably been absorbed to a large extent by a growing subsistent population rather than marketed. Livestock commercialisation has probably also been hindered by interregional trade barriers, poor transport capability and low domestic prices that encourage rather than discourage international black-market activity. These are common pastoral development problems also experienced elsewhere in Africa.

It is nevertheless concluded that, while past impact of infrastructural improvements appears minimal, it is now fortunate that roads and markets are in place. They will become the lifeline for a society increasingly dependent on nonpastoral resources as a result of rapid population growth. Impact of development intervention is thus a function of timing in relation to population pressure. The Boran are not becoming more commerce-oriented because they want to, but because they have to. This picture fits general conceptual models of agrarian change (Boserup, 1965; 1980).

8.2.2.1 Development expectations and faulty assumptions

Expectations for rapid pastoral development in the 1970s and 1980s were unrealistic, and in part this was due to faulty assumptions in the project planning stage. That pastoralists desire to increase cattle sales to make money is an example of cultural bias of the West. The Boran clearly have their own traditional social and economic value for cattle, and have traditionally had a low demand for money. Their tendency has always been to try to accumulate cattle and avoid sales as much as possible (Coppock, 1992b). It is the increased need for human food that propels livestock commercialisation and diversification today, not a new rationale among the Boran to raise incomes and acquire material possessions. Development planners thus failed to appreciate a cultural rationale for animal production that differed from their own.

Another example deals with the desire of planners to see more marketed offtake of immature cattle to benefit fattening schemes of smallholders in the highlands, also consistent with a Western ideal (von Kaufmann, 1976). This perspective fails to take into account that sales of immatures are contrary to the traditional rationale of herd accumulation through trade. Matures are traditionally prioritised by pastoralists for sale because production costs are negligible and gross income is higher, allowing purchase of needed commodities with left-over funds to buy replacement calves. This simple strategy allows for both the purchase of commodities plus herd growth of households.

Availability of immatures for sale will increase in the Borana system, thus satisfing the vision of planners. This trend will not come, however, because the Boran desire to develop cattle production in the Western fashion, but rather because the increasing need to sell animals to purchase grain will gradually deplete older classes of animals traditionally preferred for sale. More immatures for sale thus indicate an increasing level of poverty in Borana society, a decline in herd assets per capita and lower capability for animal replacement. Like the postulated increase in cattle offtake in general, the increase in sales of immatures will please development planners, but it is happening as a result of the economic destruction of traditional Borana society. While a shift to livestock commercialisation is necessary because of a rising population, this involves painful social costs.

Another Western development bias involves the apparent lack of appreciation that some planners and researchers have for extensive interventions in the promotion of increased animal production and human welfare. The perceived lack of appropriate production technology for rangeland systems means that range science has been relegated to an inferior status within agricultural research. Extensive interventions are those which tend to increase animal numbers rather than productivity per head. An increase in animal numbers can actually be more valuable to households than increased production per head because this can lead to more marketing and production options and can better mitigate risks. Increasing numbers is also less dependent on labour inputs and less risk.

The Boran have noted the many positive effects of veterinary campaigns, roads, ponds and markets on their lives; these benefits have been commonly reported in terms of increased animal numbers. Aside from using interviews, the effects of development projects on their lives besides increasing their herd, are difficult to monitor or measure. Still, extensive interventions implemented in the southern rangelands since the 1960s have probably played a valuable role in delaying the onset of widespread poverty in Borana society. Opportunities to extensify further are now limited, however, which opens windows of opportunity for improvement of some aspects of resource management and animal production that were not considered a decade ago. This again is so largely because the people have no other choice.

Finally, another major strategy that underpinned livestock development activities in the southern rangelands was to obtain animals for export to generate foreign exchange. The essence of the overall strategy was thus extractive in terms of demands for the highlands and for export; and the focus was on more animal production and stimulating offtake. Although Borana leaders participated in some aspects of infrastructure planning in the 1970s and 1980s (Menwyelet Atsedu, Colorado State University, personal communication), only recently has the primary project emphasis shifted to participatory development involving the Borana people as a whole (see Section 1.4.3: *The SERP and the Pilot Project*). Even if TLDP management had desired to broaden their mandate to include more participatory development in earlier activities, they would have been constrained by fund allocation restrictions. Project management usually has had to obtain permission from donors outside Ethiopia before even minor modifications in project delivery could be considered (Menwyelet Atsedu, Colorado State University, personal communication).

The emphasis on extracting animals from the system has probably had both positive and negative attributes. It is positive in that it has resulted in development of local infrastructure. The region could have easily been ignored otherwise. The negative side is that initiatives to improve the lives of producers did not receive the same kind of attention as stimulating livestock production from the beginning. It is unfortunate that resources were not directed towards human development through education, vocational training or other participatory development back in the 1960s or 1970s. The greatest challenge today in the southern rangelands is dealing with human overpopulation. It has been estimated, just for the study area, that dramatic improvements in food security would only result from reducing the human population by 50% (i.e. by 39 000) and by providing employment for a net increase of 2000 people each year. With no education or training possibilities combined with lack of employment opportunities a potentially explosive situation is created. The extreme cultural and political isolation of pastoralists in Ethiopia has erected barriers against their emigration into urban areas; and this has contributed greatly to their precarious circumstances today. This problem would have obviously been easier to address 20 years ago than today when it has become a case of crisis management.

In sum, past livestock development in the southern rangelands is a disappointment in some respects, but it has not completely failed. There have been some notable achievements. The improved infrastructure, in particular, is becoming tremendously important and will contribute to saving and improving the lives of pastoralists. Expectations of development activites were inappropriate in many respects, and development and system change take a long time. Importantly, pastoral development did not perform poorly because of a lack of technology, but rather because Western-trained planners and expert consultants had a faulty understanding of the social, cultural and demographic features of Borana society. The task is for national personnel and expert consultants to become more familiar with the dynamics of pastoral systems. This will enable the design of more appropriate development strategies.

As will be seen below, Borana society is in acute crisis today. This is largely due to human population growth, compounded by few emigration outlets, both for the Boran and their neighbouring ethnic groups. This has led to dangerous densities of population in an inherently risky environment; population growth has begun to swallow up traditional grazing reserves and related resources which used to promote stability under drought perturbation. Importantly, the crisis does not mean that traditional pastoralism has failed or is unsuitable for the rangelands. In another sense, the cirisis can be interpreted to show that pastoralism has been too successful for its own good, in terms of promoting a growing population of producers. Most of the constraints for ameliorating the crisis are found outside, not inside, the pastoral sector.

8.2.3 A development strategy for the southern rangelands

8.2.3.1 What if nothing is done?

The current situation in the southern rangelands is disastrous (Bocresion, 1992; C. Fütterknecht, CARE-Ethiopia, personal communication). Roughly 200 000 beneficiaries in the region are now receiving food relief, and around 50% of the cattle population was lost as a result of the 1990–91 drought. Some "good news", however, is that different ethnic groups are seeking ways to improve their situation by reaching agreements aimed at promoting improved regional security (Bocresion, 1992).

The scenario of worsening poverty and instability in Borana supports the view that African pastoral systems are in jeopardy and must receive priority attention for urgent relief and rehabilitation rather than the "luxury" of well-planned efforts to promote economic development (Jahnke, 1982). It will be argued, however, that there are some aspects of economic change which could swiftly mitigate the current crisis. Jahnke's (1982) perspective may thus be too simplistic. Again, this dire situation of the Boran appears to be relatively recent (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*). This undermines the long-held view that the Borana system is an exemplary model of sustainable range animal production in Africa (Alberro, 1986; Pratt, 1987a).

Whether at national, regional or local scales of resolution, rural development can be thought of as an attempt to attain progress towards three desired outcomes of: (1) agricultural growth; (2) poverty alleviation; and (3) increased ecological sustainability of agricultural enterprises (Vosti et al, 1991). If we were to ignore the situation in Borana by not facilitating interregional market linkages, avoiding opportunities for participatory development and not attempting to implement viable technical and policy interventions, long-term population trends should result in the Boran living in an increasingly precarious condition. Using a conceptual model of Vosti et al (1991) as a reference framework, patterns should consist of: (1) declining livestock production and asset accumulation per capita (i.e. a drop in agricultural growth); (2) increasing poverty; and (3) increased scope for environmental degradation. Food relief will no longer be an occasional measure; it will always be needed. An increasing number of Boran will attempt to leave the system, but without facilitation this flow is expected to be minor. Young men, in particular, will seek opportunities to participate in black-market trade, try marginal farming in areas adjacent to the rangelands and the few with some education may hope to become shop keepers in local towns. Others may essentially live off the streets of small towns. Women probably will have fewer options. Details for the main trends are as follows:

1) Declining cattle production and asset accumulation per capita occurs because the cattle population is limited by the available land yet the human population continues to grow. See Section 7.2: *A theory of local system dynamics*. If agricultural growth is defined as a per capita sum of annual production of crops and livestock in energy terms, and averaged over five consecutive years to see trends, the trend may be for agricultural growth to initially increase as cultivation expands. Once the most viable cropping areas have been cultivated and the human population continues to surge, the forecast is that agricultural growth will decline. If land is permanently degraded by either upland cultivation or bush encroachment (see below), its carrying capacity for cattle may be compromised and agricultural growth would decline more quickly.
2) Increased poverty results from high human population growth on a finite resource base. Because per capita cattle holdings will decline, a growing percentage of households will dip below an animal-asset threshold that makes them vulnerable to dropping out of the system in the event of drought or animal disease epidemics. In the case of drought, the severity of its impact will be greater because of the loss of internal and external grazing reserves. Fewer households will be able to return to the system because the competition for cattle and other resources will be intensified. The most visible result of this trend will be an increased peri-urban population pockets of the poor. They will depend on daily sales of things like milk, eggs, firewood and charcoal for their survival. Producers who remain in the system will, on average, have a smaller cattle holding consisting of younger cattle with a higher percentage of females; more small ruminants may be held as a diversification strategy (Coppock, 1992b).
3) Cultivation would spread because of a chronic threat of famine. Cultivation could be increasingly difficult to control and its practice on upland soils is expected to be the major source of rangeland degradation in the future. Cultivation on lowland soils will be far more sustainable, but will compete with other strategic uses of valley bottoms. The future of traditional leadership structures will have a large bearing on resource regulation, whether it is the spread of cultivation or charcoal-making. The future of the *Gada* and related social structures is not clear. If the male youths do not embrace traditional leadership duties, the prospect is that traditional knowledge and enforcement of resource use regulations could wane (see Section 2.4.2.2: *Some cultural and organisational features*).

Granted that all this paints a dismal portrait of the future of the Boran, what are the consequences of these trends for local urban centres and the nation at large? In other words, does it make any difference outside the traditional system how bad the situation becomes for the Boran? For local urban centres such as Yabelo, Mega, Moyale and Negele, it is likely that a growing number of unemployed pastoral emigrants would negatively affect the general social welfare. The needs of the nation in terms of animal offtake could also be affected, and it is possible that both positive and negative results could occur: It is conceivable, for example, that one benefit could be an increased supply of marketable sheep from producers diversifying to cope with increasing poverty, as long as epidemic diseases of sheep are controlled. Increased sheep production and offtake, however, could also result from higher prices and improved marketing channels and without the spectre of negative system change.

For cattle, it is assumed that prices will increase to become more competitive with those of the Kenya black market (Solomon Desta, TLDP economist, personal communication). If the extent of poverty increases, cattle inventories per capita would become smaller and less diverse for producers who remain in the system. This could result in an increasing pressure on households in trying to retain cattle for wealth accumulation; marketed offtake could then decline over time in conjunction with an increase in price. This tendency would be somewhat offset by an increased need to sell cattle to buy food, unless small ruminants emerged as a viable substitute. One negative means to spur cattle offtake over the longer term would be to keep cattle prices low, but this strategy would only redirect offtake to Kenya. The strategy could also undermine survival of poor households and lead to more emigration of poor people to local urban centres.

A positive solution would be to promote interventions that improve household wealth and security and obtain offtake from a sustainable population of producers. The encroachment of people and livestock into traditonal grazing reserves is another critical issue. A more stable cattle population, with highlands grain available at favourable terms of trade, should help stem the need for the Boran to cultivate. There should thus be long-term implications of this strategy for ecological sustainability of the system.

Finally, it is proposed that it is in the long-term interest of the Ethiopian Government to encourage development among the Boran to help preserve the traditional social order. If this is not done, the entire production system could become unsustainable. There would be no other means to ensure, for example, that the wells operate efficiently in dry seasons. Without other viable technical options, human labour remains as the best means to ensure that the system continues to provide animals for the rest of the nation. The social order ensures well operation and maintenance. A loss of social traditions also implies that indigenous production-related knowledge about land use, forage and animal management could be lost.

In sum, the problem becomes how to achieve agricultural growth, reduce poverty, improve prospects for ecological sustainability, enhance stability and predictability in the production system, and increase the economic contribution of the Boran to the rest of the nation. A possible solution to this dilemma is described below.

8.2.3.2 Overview of strategy

The following scenario offers a number of options. These options are structured to deal with a hierarchy of priorities. The options also vary in their degree of immediate applicability. Despite that some ideas cannot be readily implemented, they are forwarded to illustrate important system interactions and constraints that must be overcome if sustainable development has any chance of happening. Although the Boran find themselves in a difficult situation today, they do have two major advantages that could help them dig their way out of the crisis and create wealth: (1) the Boran have an explosive capability to generate animals; and (2) they have a high degree of open-mindedness concerning the adoption of appropriate innovations. The main challenge is how to help the Boran better manage and accumulate wealth accrued from animal production to benefit themselves and the society at large.

General strategy

Priorities are listed in order of their importance as follows. Each priority has a short and long-term dimension. Priorities are interrelated in that attainment of one goal increases the likelihood that subsequent goals can be realised. The priorities are: (1) improve food security; (2) reduce risks associated with animal production and asset accumulation; (3) improve livestock production and herd turnover; and (4) enhance emigration of pastoralists out of the system in a fashion which is beneficial to the society at large; and (5) increase prospects for the long-term sustainability of the system based on social and ecological factors. Importantly, the applicable time scales for the attainment of each goal vary. Efforts to improve food security must be tried now. Interventions to reduce producer risks can begin now, but the benefits would not be realised for a few years. Interventions to enhance system sustainability are intertwined with the others and could begin soon. Realising the goal of system sustainability, however, would require a time frame of a generation or more.

If it is assumed that the first priority of food security can be dealt with, attainment of the second priority is the key to everything else that follows. The one linch-pin of the entire strategy is instituting an alternative wealth storage from cattle to simple savings accounts in local banks. Over the long term, it is proposed that the future of Boran society be strongly linked to the growth and economic development of local towns such as Yabelo, Mega, Negele and Moyale. These are the source of market outlets and jobs. The banking linkage would actually help the towns prosper with the help of the Boran, thereby completing an economic loop of mutual assistance. Storage of animal wealth in banks may not always offer the best mix of returns and risk reduction compared to investment in urban commercial opportunities, but banking is thought to be the most appropriate option for the largest proportion of the pastoral population.

Pastoral development in the southern rangelands has to be fundamentally based on further expansion and development of major towns. In total these towns may have an urban population of around 30 000 today. Considering the 15 475-km^2 study area, the total pastoral population may be around 85 000 (Section 7.2: *A theory of local system dynamics*). The urban population may thus constitute a surprising 35% of the regional population of 115 000.

The towns currently provide the major local markets to absorb sales of animals and dairy products. The major employment opportunities in these towns appears to be shop keeping and government administration. Ideally these towns should offer more job opportunities for unskilled labourers in the future to facilitate emigration of people out of the pastoral sector. There is little doubt, however, that there are high rates of unemployment among urban dwellers in these towns today; so it is recognised that prospects for job creation based on existing resources are nil (Girma Bisrat, PADEP Coordinator, personal communication). Officials responsible for regional development planning must consider creation of labour-intensive industries in these towns. These could include efforts to create value-added products based on local resources such as hides and skins or industries which complement or substitute for cross-border commodity trade with Kenya. These are important topics for investigation by expert consultants. If capital is a major constraint for developing local industries, it is to be recalled from Chapter 7 that there is tremendous potential for generating such capital if the Boran could be enticed to manage some of their cattle assets as savings accounts in local banks as part of their risk-management strategy.

It was calculated that if each middle class and wealthy family in the study area were to bank the value of one to three head of male cattle per household, respectively, this would generate the equivalent of US$1.7 million per year from an offtake of 14 500 head. If the regional cattle herd could be held at less than 300 000 head, this could also reduce risks of animal mortality and production decreases due to density-dependent interactions. This invokes concepts of sustainable yield. The offtake of 14 500 head is just 26% of a net annual increase of 54 000 head in an average rainfall year, which was calculated after subtracting 14 000 head for routine purchase of grain and other essentials. In a dry year, the net increase may be much smaller (on the order of 12 000 head) because grain purchases rise and cattle production slightly declines.

Implementation details

Implications of the systems theory: In Section 7.2: *A theory of local system dynamics,* it is proposed that two fundamental patterns influence system change: (1) a long-term trend based on the declining ratio of cattle to people; and (2) interdrought cycles based on variable stocking rates of cattle that force social, economic and production adjustments by the Boran on a year-to-year basis. The interdrought cycle consists of a multi-year drought-recovery phase followed by a potentially multi-year high-density phase. The most important period to exploit for faster development impact is the interdrought cycle. For long-term system management, it is important to deal with long-term trends. In addition to the drought-recovery and the high-density phases, drought itself comprises a third system phase. Means to deal with drought are considered more in the context of relief and rehabilitation, however, and measures to deal with drought are described in Section 7.3.3.7: *Mitigation of drought impact.*

It is proposed that following the aftermath of the 1990–91 drought, the years 1992–96 will constitute the drought-recovery phase. There is a high probability that the years 1992–96 would have adequate rainfall to allow substantial herd growth with roughly a 75% chance that these five years would contain one dry year or shorter. There is thus about a 25% chance that rainfall would be markedly below average for two or more years, which could disrupt rapid growth of the regional cattle herd that is otherwise anticipated during the drought-recovery phase.

Many Boran will go hungry throughout the drought-recovery phase and thus will try to expand cultivation. Those in peri-urban locations that are unable to secure enough home grown grain will try to purchase it by selling milk and small ruminants. Milk will be sold from a food-deficit situation and small ruminants will substitute cattle for sale, where possible. The people will try to produce and accumulate cattle as quickly as they can. Male cattle will be traded for cows, where possible, to obtain milk cows from farmers in the southern highlands. The southern highlands will increasingly serve as a reservoir for cattle to restock the southern rangelands after droughts. Crossbreeding highland and lowland stocks may endanger genetic conservation of the Boran breed (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics* and Section 5.4.5: *Cattle growth and implications for breed persistence*).

Around 1996–97, it is postulated that cattle production per unit area would peak. This assumes near-average rainfall during these years. Density-dependent factors, due to increased competition among cattle for a finite base of forage, will then begin to cause cattle productivity to decline per head and per unit area in subsequent years. Fewer Boran will be hungry compared to the drought-recovery phase, but they will need to increase their efforts to cultivate once again. Cattle sales to procure grain will increase from a larger standing herd, in addition to sales of small ruminants. Sales of milk and butter from peri-urban producers will surge from an increasing food-deficit situation.

The high-density phase would begin around 1997. There is a 50% chance, based on rainfall probabilities, that the first three years of the high-density phase (i.e. 1997–2000) would have near-normal rainfall. Under these conditions it would be a time of subtle, but chronic, decline in livestock productivity, increased cultivation, increased conservatism and risk-averse behaviour among producers, and increased chance for grazing-induced establishment of bush seedlings and other forms of range degradation. Prospects for range degradation may increase if rainfall is slightly above average (Section 7.2.3.1: *Range ecology*). Calf mortality should rise and milk production should decrease, even if adult cattle are able to hang on and survive. As argued in Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*, the devastation on the production system from drought in recent times is caused by low rainfall in conjunction with high stocking rates and gradual loss of grazing reserves. All this combines to dramatically increase risks of widespread animal mortality because of insufficient supplies of forage energy. There is a 36% chance that there would be one dry year in the three-year period from 1997–2000 and a 14% chance of two or more dry years. The problem then becomes that at high stocking rates, there is about a 50% chance overall of a drought-induced population crash during the first three years of the high-density phase.

There are key technical and policy interventions which should be implemented to: (1) lessen the negative effects of the long-term trend; or (2) promote step-wise development impacts during the interdrought cycles. Impact of interventions employed during the interdrought cycle will vary depending upon whether they are implemented during: (1) the drought-recovery phase or (2) high-density phase.

Whether it is short or long-term, impact on human welfare can only be achieved if there is the political will and logistical capability for implementing development intervention. Importantly, widespread impact from policy and technical interventions can only be achieved if the various governmental and nongovernmental agencies arrive at a new plane of dialogue and cooperation. Mobilising the human population for improved range development over the long term is far beyond the capability of SORDU to undertake on its own. Other key players include the Borana leadership, the commercial banking sector, the Ministries of Agriculture and Education, local politicians and international organisations.

Best-bet interventions are described below according to development objective and the time scale of impact. Readers should consult previous chapters for particulars that underpin development concepts.

8.2.3.3 Interventions to lessen negative effects of the long-term trend

Managing the long-term trend primarily involves policies and procedures which affect patterns of human settlement, carrying capacity for livestock, food production in the form of per capita milk yields and rates of human emigration out of the pastoral sector. Some of the key ideas are as follows:

1) It has been proposed that the recent severity of crashes of the cattle herd because of low rainfall is to a large extent the result of a gradual loss of reliable grazing reserves or fallback areas, both internally in the southern rangelands and externally in adjacent regions. Hence reclaiming internal fallback areas should be a high priority for stabilising the system. It needs to be considered, however, whether people now forced to live in fallback areas could be moved elsewhere if water and other supporting resources could be developed. SORDU has considered moving households at Did Hara *madda* in response to environmental degradation (SORDU, 1991), so such concepts have been considered before. A partnership needs to be formed between Borana leaders and local development agents to study possible solutions to this problem now. This may also require research as to current use patterns of fallback regions and whether traditional resource-use customs of the Boran are being enforced or not (see Section 8.3: *Research implications*). The intervention involving banking livestock capital (see below) could be important in this activity. People using drought reserves should be identified with respect to their home *madda*. Adjustments to destock the home *madda* in order to re-accomodate the migrants could be made by banking the value of excess animals.
2) As shown in Chapter 7: *Development-intervention concepts*, there are many opportunities for small-scale production impact at the *madda* or *deda* level of resolution. These involve opportunities for technical intervention and resource management that together could have a marked effect on range reclaimation and thus increase its carrying capacity and improve

pastoral flexibility over time. A sustained and routine dialogue needs to be opened between the Borana leadership and development agents to prioritise self-help projects with this long-term goal in mind. Ultimately, the most effective approach may involve initial technical assistance from the development agents, with the Boran taking responsibility for financing, implementing and managing any given project. The success of any given project may depend on whether it is implemented in the drought-recovery phase or high-density phase of an interdrought cycle (see below). Along these lines, development and governmental agents should determine whether the Boran desire outside support to augment traditional resource-use regulations that have become less effective under population pressure (see Section 7.3.1.4: *Site reclamation*). Development agents should become more familiar with such customs, even to the extent of transcribing them and using them as a basis for local resource-use policy. The senior leadership of the Boran should be intimately involved in such a process.

3) Policies and procedures which increase widespread access of young Boran to primary education need to be implemented soon, although effects of education on increasing rates of emigration may not be felt for a number of years. Emigration is also dependent on opportunities outside the pastoral sector. Costs of extending education could be borne, at least in part, by the Boran if creative approaches are pursued. It is anticipated that the Boran are much more open to educating some of their youth compared to a generation ago, although fear that education could accelerate loss of key labourers may remain a prominent concern especially among large herd owners (see Section 7.5: *Management of human emigration*). The degree to which females as well as males could receive education is subject to the gender biases and priorities of Borana society. It is speculated that males with primary education may have a greater tendency to leave the system permanently compared to females. Economic diversification of the production system may thus depend to a greater degree on educated females who remain. Educated females could thus have a key role in facilitating risk management initiatives such as banking livestock capital on a sustained basis, because this requires some degree of literacy in the population (see below).

If efforts to stimulate emigration out of the Borana system are successful, one negative result may be that shortages of key manpower may ultimately occur. One example is the need for strong men to raise water in the shaft of the deep wells. It is not likely that women or children could substitute very effectively in this regard. If shortages of key labour begin to occur, SORDU and other agents need to consider replacement innovations. One such example is the recent effort to reduce the depth of some well shafts by lowering the surface access area using excavation with heavy machinery (Tilaye Bekele, TLDP, personal communication). Such an intervention could reduce the labour requirement by reducing the length of the human chain needed to raise the water.

The negative aspect of such an innovation, however, is that the well modification may need to be accompanied by new practices that protect the right of the poor to access resources. Like installation of diesel pumps, any intervention that dramatically reduces the need for labour in the wells runs the risk that influential people can then take control of wells for watering only their large herds. Traditionally the wealthy have been dependent upon the poor for labour, and compensation is made accordingly. Rapid removal of this dependency could accelerate wealth stratification and bode unfavourably for the society overall. In sum, SORDU needs to have a periodic policy review of its intervention concepts and weigh impacts of its actions taking into consideration the system dynamics at all times.

4) Policies which continue to stimulate population growth of the small towns in the rangelands are important if growth can be managed and negative aspects of resource use minimised. Recent growth of the small towns has reportedly been due in a large measure to immigration from other parts of the country. Since urban growth could translate into an increasing local demand for milk, butter, beef, small ruminants and poultry products, it has significant implications for creating larger market opportunities for the Boran. One negative aspect of urban growth, however, could be increased peri-urban cultivation on fragile upland soils by immigrant farmers and an increasing demand for firewood and charcoal that could place new and growing pressure on the surrounding areas, leading to environmental degradation. Lack of a high demand for fuel locally in the past may have discouraged illegal charcoal production.

Improved cultivation practices among urban farmers could be a first step in promoting integrated resource use in the southern rangelands, and this is also within the logistical capability of the Ministry of Agriculture with branches in the Borana towns (see technical perspectives below). With regard to the use of fire wood, it is proposed that SORDU initiate some pilot study as to whether the Boran in *madda* surrounding urban areas could control this themselves. While this may not appear as a sound idea at first, experiences near Awash Park in the Ethiopian Rift Valley suggest that pastoralists can be very effective in monitoring resource use by town dwellers (C. Schloeder, Ethiopian Wildlife Conservation Organisation, personal communication). Pastoralists near towns have a vested interest in not allowing urban dwellers to exploit resources without payment such as maintaining a viable community of indigenous trees for their browsing livestock especially since these are in decline. The fact that the Afar and Kereyou pastoralists, like the Boran, are heavily armed, makes merely the threat of enforcement sufficient to discourage overharvesting of trees.

5) Another long-term perspective that should receive attention now is whether a viable urban development strategy for towns such as Yabelo, Mega, Negele and Moyale based on local industries is feasible. As already proposed earlier in this section an economic link of mutual benefit between these towns and the pastoral population is a vital concept in regional development. Development of labour-intensive industries should be linked to provision of capital loans by local banks made possible by Borana livestock sales. Recommendations for urban development strategies require considerable creativity and know-how. Such task falls in the domain of expertise consultants and experienced planners. To the extent that government offices support the economy of these small towns, considerable thought needs to be given as to whether government presence should be consolidated or diversified in terms of location. Abruptly closing government offices would probably have considerable negative effects on the economy of towns such as Yabelo and Negele.

6) Banking livestock capital in the form of male cattle is envisioned as an intervention with major implications for managing the system over the short to medium term, and as such is forwarded as an intervention in the context of the interdrought cycle (below). The alternative of keeping cattle wealth as bank accounts also has implications for risk management and food production over the long term in that it could promote a gradual increase in the proportion of milk cows in the regional herd without compromising the asset accumulating and risk mitigating capability of households. Otherwise it is envisioned that the Boran will increase the proportion of milk cows as a tactic to offset human population pressure and maintain per capita milk production with a proportional decline in their capability to mitigate economic risks. Without opportunities to bank livestock capital the outcome of the situation would probably be one of increased rates of households dropping out of the system following droughts and other perturbations, along with increased expansion of cultivation. In order to ensure that banking livestock capital has a positive effect on the production system, by reducing competition for forage among cattle, measures should be taken to facilitate purchases that result in animals being taken out of the system after they are sold.

7) Export of cattle and sheep from the rangelands is reported to comprise one of the most important sources of foreign exchange for the nation. Given this, it is unfortunate that range-development groups such as SORDU are unable to come by even very modest amounts of foreign exchange on a regular basis to secure resources they need for efforts to improve livestock production and human welfare among the Boran. There is, for example, a need to import veterinary supplies, arboricides, acaricides and a regular allotment of fuel for the maintenance of infrastructure. Policies which serve to recognise the return from livestock production to the nations' foreign exchange balance, and hence facilitate access by range-development groups to a modest amount of foreign exchange, are desireable.

   The Boran have repeatedly stressed that they can compensate investment for water development and veterinary support projects through increased livestock sales. Such compensation even in local currency is better than nothing. It may be argued that to be truly sustainable, development of the southern rangelands should never rely on any foreign exchange. While there is some validity to this argument, if this is to be the case, then expectations for development impact should be lowered. Earlier in this chapter it is argued that increased famine and other disruptions to the social order in Borana will bode unfavourably for the national economy. The long-term picture suggests that in the absence of reliance on foreign exchange, Ethiopia must develop its own capabilities to produce pharmaceuticals, chemicals and fossil fuel.

8.2.3.4 Impact in the interdrought cycle

Development interventions must be segregated according to the two phases in the interdrought cycle. Those dependent on low stocking rates would be more successful in the drought-recovery phase; those dependent on high stocking rates would be more successful in the high-density phase. The current interdrought cycle is stipulated for the period covering 1992–97. There are some policy interventions described in the context of the inter-drought cycle that could also be forwarded with the aim of mitigating the long-term negative trend (above). They are listed here, however, because their impacts could be felt over the short or medium term as well.

Impact in the drought-recovery phase, 1992–96: The top priority overall is to improve food security. Secondary priorities are to begin setting the stage for improvements in risk management of pastoral assets and reducing environmental degradation.

The following interventions are considered important because they complement tactics that the Boran would be employing any way during 1992–96. These tactics include: (1) growing maize for food (2) selling milk in peri-urban areas; (3) selling more small ruminants; and (4) trying to build up their cattle herds through recruitment and trade.

Policies: The concepts governing intervention policies and procedures should be as follows:

1) Today the top national priority is to facilitate the continued presence of international organisations which are actively feeding people in the southern rangelands.
2) At regional and national levels, policies that could have the most positive impact in reducing the need for relief grain within a couple of years would be those that encourage higher production of maize in and facilitate its free flow to the southern highlands. It is recognised that increased cereal production and promotion of a freer flow of commerce involves complex regional and national issues (see Section 8.2.1: *Future role of the lowlands in the national economy*). Allowing, for example, animal prices to rise in Borana to levels that are competitive with Kenya could also shift the flow of marketed livestock from Kenya back to Ethiopia. This could help complete regional linkages in the livestock-for-grain trade at more favourable terms for producers. Improved terms of trade and the increased reliability of markets should have a big and relatively rapid impact in helping peri-urban Boran feed themselves by selling animals and possibly reduce their need to expand cereal cultivation on fragile upland soils.

   If the international market for sheep exports is promising, or if it is deemed that the domestic demand could be better supplied, then another policy initiative should be to actively push for increased sheep offtake from the southern rangelands. The Boran have shown themselves to be responsive to such demand in the past. This is not the time to push for increased cattle offtake because sales could work against the interests of many Borana households who are primarily interested in building up herd numbers.
3) Measures originating from regional or national levels and directed at improving access of pastoralists in remote areas to regional markets, so they can sell perishable commodities such as milk and butter, are also important. These include supporting road-maintenance activities, grass-roots service cooperatives (Hogg, 1990a) and rural bus service and other means of transport. Local policy makers should also consider whether the activities of itinerant traders could be facilitated.
4) At the local level, policy makers and land-use planners should be guided by perspectives given in Section 2.4.1.4: *Climate, primary production and carrying capacity* and Chapter 3: *Vegetation dynamics and resource use*, to identify valleys where cultivation by the Boran could be permitted with little risk to the sustainability of soil resources. In total area these may comprise less than 10% of the study area. Ways should be explored to convince the Borana leadership that it is to their self-interest to restrict cereal cultivation to conserve range resources for livestock and limit ecological damage to upland soils. Ultimately, it is conceded that cultivation can only be controlled if the Boran are convinced that a balance between livestock production and cultivation is in their best interest as a society. Proclamations made at the 1988 *Gumi Gayu* assembly suggest that the leadership seeks to sustain their natural resource base (Section 2.4.2.2: *Some cultural and organisational features*).
5) Policies that promote saving accounts in banks by pastoralists need to be reviewed now. Considerations as to whether more branch banks should be opened in the local towns and whether bank procedures can be creatively modified to accomodate illiterate people should figure prominently in these policies as well as incentives for pastoralists who are wiling to bank some of their livestock assets. Extension services dealing with banking livestock capital should focus on those Boran who apparently are already involved in the banking system (see Section 7.3.3.6: *Cattle marketing* and Section 7.3.3.7: *Mitigation of drought impact*). Implementation of such measures would have to forge new partnerships among the Borana leadership, SORDU, nongovernmental organisations, the

banking sector and local government administrators. Given the right information and easy access, some Boran could begin banking a few animals even during the drought-recovery phase. The most favourable time for promoting the practice, however, would be in the high-density phase (see below). Pastoralists that take to this strategy would accumulate cash assets for coping with unfavourable terms of trade during drought.

Banking is also an intervention with a prospect for major impact that is more consistent with the highly constrained extension capabilites of development organisations. But detailed research that focuses on the risk, in the different phases of the interdrought cycle, of banking versus holding livestock may need to be undertaken (see Section 8.3: *Research implications*).

Banking livestock capital is forwarded as the single most comprehensive measure to encourage agricultural growth, reduce poverty, increase system stability and minimise the possibilities of environmental degradation. The key is that increased animal offtake can benefit production, and if offtake can be conserved as wealth, the producers benefit in several ways. If means can be found to give illiterate people access to the banking system, and their anxiety about this new practice can be reduced if not removed, the only constraint of this intervention may be national policy involving management of inflation.

Technical interventions: Technical interventions fall more in the traditional realm of efforts targeted at improving commodity production and the priority concepts for the drought-recovery phase involve improving food production (especially grain and milk). Compared to policy interventions, technical interventions will be much more difficult to implement, especially if they require significant extension work. This is not because of constraints arising from the indigenous environment *per se*, but because lack of manpower, fuel and vehicles greatly limits the capability of extension services in meeting routine needs in a pastoral community in which producers are widely dispersed. Priority interventions should thus be those that the Boran can carry out themselves. An example of this is hay-making using local grasses. Development agents need to make good use of group seminar formats and community meetings to extend new ideas to the Boran. This could partially compensate for the lack of easy mobility that now characterises extension service. In any event some of the technical concepts are:

1) Cultivation will expand. However, if it does not expand over the short term, there is a serious risk of famine. One means to discourage expansion of cultivation to unsuitable sites is to enhance production on the more suitable ones such as valley bottoms. By doing that the negative consequences of expanding cultivation on the system could be minimised, especially if provisions could be made to also maintain strategic grazing resources. If the long-term trend is well managed, the need for cultivation may decline in the future which implies that cultivation may be a solution for crisis management only over the medium term.

Nothing short of sending in the army would discourage the Boran from cultivating now. So SORDU, the Ministry of Agriculture, and non-governmental organisations need to make a combined effort to diagnose sources of inefficency in local maize production and promote basic interventions for sustainable crop production. These could include introducing and improving site selection, tillage, planting, weeding, intercropping and managing soil nutrients using crop rotation and manure. Such efforts should begin with the peri-urban farmers. Experience has shown that the Boran learn quickly, taking good farming ideas back to remote locations. The problem is that yields are probably low and extensive methods pose a larger threat to the environment. It was stated in Section 7.3.2: *Land-use policy and agronomic interventions*, that the Boran will probably not intensify cultivation until they perceive that the benefits of intensification outweigh the costs of the additional labour. A case in point is the better use of the mountains of manure at encampments. Simply providing a better means for the people to transport manure from corrals to the fields could do if soil fertility is the primary crop–production constraint. Hodgson (1990) demonstrated that even simple two-wheeled carts were not sustainable in the southern rangelands because of a lack of welding and metal-working capability in the urban sector.

Three guiding principles are important for crop production interventions: (1) introduction of forage intercrops with maize will fail unless they are dual purpose and also provide food for people; (2) new intercrops should lower the risks of cultivation by providing food for people under rainfall conditions when maize fails because of other reasons; and (3) a major problem with sustaining new crop varieties in the rangelands is merely a reliable source of seeds. Yohannes Alemseged (1989) convincingly demonstrated that dual-purpose cowpea was the best intercrop among the species he tested in terms of yield of seeds and forage and with low competition with maize. Cowpea is also perceived by the Boran to be more successful under less rain than maize. Dual-purpose cowpea should thus form the basis of crop production intervention strategies. Access to seed could be facilitated by improved interactions among the Boran and local farmers. Procedures that facilitate these interactions would have to be sought and actively promoted.

2) A related topic includes extending improved means to store grain and thereby reduce losses to pests and capitalise on seasonal marketing strategies to improve terms of trade of livestock for grain (Hodgson, 1990; Coppock, 1992b). Improved grain storage at the household or encampment level can involve storage below or above ground; more effort needs to be made as to whether regional grain stores managed by development agencies are feasible. While the need for improved grain storage will be high during the drought-recovery phase, this will be a time when the average Boran household will be less able to pay for interventions through cattle sales. However, both ability and willingness to pay should increase during the high-density phase.

3) The next priority is to increase milk production. As shown earlier in this volume, fundamental shortages of water and forage prohibit improved and sustainable feeding strategies for milk cows under existing conditions. This is true even though forage quantity is less of a problem for cows during the drought-recovery phase because of reduced competition resulting from lower stocking rates. So solutions connected with increased milk production lie more in the realm of animal health.

With a decline in central government authority in 1991, it is expected that the Boran now routinely burn the rangeland to cope with bush encroachment, improve forage quality and control tick infestation. While the ultimate danger may be that the Boran will burn areas too often because of a growing demand for resources some benefits are probably already being realised for the production system over the short term. A survey of 560 milk cows in 1989 revealed that 15% of their teats were closed off due to tick damage. If the healthy teats are unable to compensate for the damaged ones, this problem may have very significant implications in reducing milk production in the system. Ticks have been mentioned as one of the major constraints for animal production here. Acaricides were invented over 50 years ago, and yet they have not been available in Ethiopia for some time. The notion that range development requires new technology is undermined by the fact that existing technologies have gone unimplemented. There have been several reasons forwarded as to why acaricides are not available in the southern rangelands since the SLDP (1973–81). The ultimate constraint is the fact SORDU cannot gain access to sufficient foreign exchange to import acaricides; this is viewed as ironic since the southern rangelands have been expected to be a major generator of foreign exchange from exports of cattle and sheep (as discussed above). But even given the acaricides, SORDU would have a difficult time extending this service because of shortages of vehicles and trained manpower. Devising sustainable means of extending the use of acaricides in Borana could have important impacts on livestock productivity and human welfare. It would also give a much needed boost to improved public relations with the pastoralists.

4) Increased milk production is related also to the ability of cows to maintain long lactations. Lactations in the Boran cattle breed can easily be lengthened by simply keeping calves alive (Donaldson, 1986). Improved calf-feeding management in the form of grass hay, with local legumes providing protein supplements, should be extended soon. While it is envisioned that hay-making would be beneficial to milk production, human labour and calf nutrition during the high-density phase, there could be significant impact for some households during the drought-recovery phase as well.

The major benefit of hay-making intervention should be in terms of improved calf condition and reduced mortality rates with the associated effect of extending lactations, especially in dry seasons. The initial target population should be the poorer households in peri-urban locations that have a higher risk of losing calves connected with their daily need to sell milk to purchase survival rations of grain (Holden et al, 1991). That the initial target population should be in peri-urban locations is fortunate since this reduces logistical demands on extension agents. Extension should focus on proper hay preparation to minimise risks of spoilage and means to protect hay fields from grazing stock using the *kalo* concept or integrating hay fields within crop exclosures. Establishing new grass swards for hay production should focus on the best local species, considering ecological niches and other factors mentioned in Section 2.4.1.5: *Native vegetation* and Section 7.3.1.4: *Site reclamation.* Feeding packages involving native legumes should be tailored to the local availability of nutritious browses and crop residues such as cowpea (Section 7.3.1.3: *Forage improvements*). Improved management of cowpea residue in terms of encouraging leaf retention at harvest and proper storage should also be a priority.

5) Other means to promote longer lactations by avoiding calf mortality involve improved veterinary extension services. Mulugeta Assefa (1990) found a marked contrast between the likelihood of health delivery for adult cattle versus that for calves. Adult cattle have an advantage because they can be walked to clinics for attention, not calves. Hence priority intervention in this respect must involve improved health care for calves delived at the "farm gate", and animals held by all wealth classes should receive this attention. Calves of the poor are more vulnerable to diseases exacerbated by lower planes of nutrition caused by milk restriction. Calves of the wealthy have a higher plane of nutrition, but are still vulnerable to disease outbreaks encouraged by lower management inputs per calf.

   Just improving health extension for calves in peri-urban locations would be a major achievement, and would again be consistent with the limited logistical capabilities of the SORDU veterinary service. As reviewed in Section 5.4.3: *Cattle mortality and health*, SORDU's veterinary service has been difficult to sustain. This is due to difficulties in importing veterinary supplies and shortages of vehicles and fuel for extension. Earlier attempts have been made to train Boran as "veterinary scouts" and serve as local extension agents, but this has also proven unsustainable. There have been recent initiatives to have the Boran pay for veterinary service and this should improve prospects for sustainability as far as funding in local currency is concerned. Until problems of logistics and funding are solved, there is little hope that widespread improvements in veterinary service will take place. This is why hay-making should be the top priority in coping with calf losses caused by interactions between poor nutrition and disease.

6) Small ruminants reproduce quickly and can help households recover from drought by providing a substitute for cattle as sale item (Coppock, 1992b). Given that providing health care appears to be the major production constraint, improved veterinary extension service for sheep and goats is desirable, even if restricted to focus on households in peri-urban locations.

7) The drought-recovery phase is characterised by lower stocking rates of cattle compared to the high-density phase. Because lower stocking rates result in less demand on grazing resources, efforts to reclaim or rehabilitate degraded sites should be undertaken in the drought-recovery phase on a *madda*-specific basis. While the effects of site reclamation on carrying capacity and milk production may not be felt for several years, the possibilites for implementing such projects are greater in the drought-recovery phase, mainly because a smaller cattle population increases the chance that standing swards can be set aside for burning during dry periods. In general, the Boran should prioritise sites for attention, and should be responsible for implementing and funding projects with initial technical assistance from SORDU. Pilot projects could focus on *madda* either in peri-urban areas or those involved in the development of SCs (Hogg, 1990a). Interventions directed at site reclamation could include prescribed burning of bush-encroached sites where the grass layer has recovered, followed by hand-felling of noxious adult trees, application of arboricides to stumps and charcoal-making to recoup labour costs (Section 7.3.1.4: *Site reclamation*). While using fire alone may be the only sustainable management practice at this time, fire may not get rid of all adult trees. Arboricides have been shown to be necessary to prohibit bushy regrowth of some species, and are very cost effective. Some bush-control projects could be delayed, however, until the next drought to provide a source of employment if regulated charcoal-making is deemed as an appropriate means of generating income.

8) Given the acute need of the Boran for better access to markets, development agents should consider means to help people far from markets procure preferably male camels to transport goods. This may involve organising prospective buyers to visit as a group camel markets outside of Borana territory. The primary advantage camels have for the Boran is in increasing their capability to obtain large quantities of grain from markets away from their encampments. While initiatives regarding camel acquisition could start during the drought-recovery phase, the ability of the Boran to pay for them would be greater in the high-density phase after their cattle herds have recovered their numbers.

Intervention impact in the high-density phase, 1997–?: The top priority overall is to help the Boran better manage risks of retaining their accumulated assets of cattle. This involves economic and ecological management concepts. Food security will still be a problem as long as the long-term trend is not being effectively arrested, and this also remains as a priority. The next priority would be facilitating using livestock capital to improve the production system in terms of maintenance of water points and related activities.

The following interventions have been evaluated as important because they complement tactics or attitudes that should characterise the Boran more during the high-density phase. These include: (1) greater attention to local and regional grazing management under high stocking rates to maintain milk production and reduce risks of cattle mortality; (2) selling more cattle and butter in addition to small ruminants and milk; (3) efforts to improve water resources in order to diversify grazing resources; and (4) more conservative production attitudes, especially among the wealthy.

All of the activities initiated during the drought-recovery phase (see above) should be on-going except perhaps site reclamation based on prescribed burning since heavy cattle grazing would reduce the likelihood that large standing crops of grass could be maintained in the high-density phase. Because herd inventories will have grown, the capability for the Boran to pay for any service during the high-density phase will be much improved. They will also be conscious of the greatly increased risks of cattle mortality resulting from low rainfall so that the wealthy or others desiring more influence in the community may use the opportunity to divest of some cattle to gain social benefits and status by contributing donating to important community projects (Coppock, 1992b).

It is assumed that by 1997 a rational strategy to de-populate grazing areas reserved for times of drought will have been employed (see above). If not, the danger of catastrophic herd loss due to drought will remain.

Policies: Concepts for policies and procedures for the high-density phase are as follows:

1) Assuming that the regional cattle herd will grow steadily during the drought-recovery phase, by the mid–1990s the risk of climate-induced herd losses and famine will begin to rise once again. Relief and rehabilitation agencies should be prepared for this scenario. In addition, planners could delay community works projects (i.e. road maintenance, bush clearing etc) that require large inputs of labour for implementation after the onset of drought to help meet a higher demand for paid employment.
2) Given some initial years with near normal rainfall, development should be prepared to deal, during the high-density phase, with an improved opportunity for projects funded by proceeds from cattle sales. These prominently include efforts to maintain or re-excavate wells, desilt ponds and construct cisterns and grain stores. Preparations to exploit the situation should include providing fuel and spare parts to allow reliable use of heavy machinery, facilitating access to critical construction materials, and instituting means to coordinate the collection and disbursement of project funds generated from livestock sales. Sales should be coordinated with traders to help ensure that once cattle are sold they are removed from the system and not merely recirculated within it.
3) The high-density phase is the time for a major push for the community to bank livestock capital. Acute fears of extensive animal losses among the community should accelerate demand for this intervention, especially among wealthier households. *Madda* with cattle herds that have restricted access to grazing reserves could be prioritised for this activity.

Technical interventions: As in the drought-recovery phase, these interventions fall more in the realm of commodity production. They are :

1) Interventions such as hay-making and collecting leguminous supplements for improved calf management should be more important to the Boran during the high-density phase when resource competition intensifies.
2) It is when resources are under pressure that opportunities for improved grazing management approaches exist at the *madda* or *deda* level of resolution. Concepts forwarded in Section 7.3.1.2: *Grazing management* could be applied on a case-by-case basis. The Boran should be encouraged to pay for grazing-management-project inputs using livestock sales.
3) Range planners should consider whether technical improvements in maximising forage abundance or water distribution are warranted as regards grazing ranges reserved for times of drought. In consultation with Borana leaders, such grazing reserves should be well understood in terms of their areal extent, site diversity, likely standing crops of forage at the beginning of a drought, water resources and temporal patterns of use by cattle during a multi-year drought. Armed with such knowledge, planners could better anticipate the capacity of grazing reserves to buffer the effects of cattle overpopulation. Estimates of potential cattle mortality due to the insufficient capacity of grazing reserves could provide quantitative targets for regional initiatives to bank livestock capital and help to minimise losses of pastoral assets.

8.2.3.5 Intervention impact in the interdrought cycle

Assuming that markets are opened, inflation managed, some cattle assets banked, grazing reserves reclaimed, and some groups of the pastoral population emigrate out of the system at increased rates, the subsequent drought-recovery phase after 1997 should be less catastrophic than the one during 1992–96. A larger percentage of the population would have some cash assets, fewer milk cows would have died as a result of density-dependent interactions and there would be a declining need for the Boran to cultivate. Under proper management the system would essentially become less dynamic in terms of the "boom and bust" cycle as driven by dramatic changes in the cattle stocking rate. Consequently, the drought-recovery phase starting after 1997 would be shorter than the one in 1992–96, and this could slightly reduce the length of time in which to implement range rehabilitation projects which are dependent upon low stocking rates. Virtually all of the development-intervention concepts employed in the first interdrought cycle would remain very useful and valid; it is just that the need could be less acute. Offtake of cattle could be more predictable, possibly to the benefit of national economic planning.

8.3 Research implications

8.3.1. System monitoring

Efficient implementation of the development strategies described herewith require that some routine data be collected. Hypotheses described in Section 7.2: *A theory of local system dynamics* can form the framework of testable ideas within which to collect information. Development agents need to have an even better understanding of cattle population dynamics, status of the grazing reserves, extent of cultivation and the problems the Boran have with managing grazing and water resources. Given that operating funds are commonly very limited, monitoring of trends should involve qualitative as well as quantitative methods. Quantitative monitoring could involve use of aerial survey once every few years, if research budgets allow. Alternatively, or as a supplement to aerial survey, road networks could be driven during important times of the year to provide objective assessment of land-use trends on a year-to-year basis. Quantitative monitoring could also include routine surveys of the volume of local markets, diversity of commodities sold and their prices. Qualitative monitoring, in contrast, could include having development agents attend important community meetings and record felt needs of the Boran to see how these change over time. In all cases data should be collected to help development agents understand why certain trends are occurring.

By the late 1980s SORDU was focused on monitoring and evaluating range trend (Hacker, 1988a,b). The theory of local system dynamics forwarded in Chapter 7 has great implications for the interpretation of range trend survey results. If cattle stocking rate has the greatest effect on range utilisation, then it would be expected that the long-term pattern for basal cover and standing crop of herbaceous species would appear cyclic, rather than linear, despite variation caused by annual fluctuation in rainfall. During the drought-recovery phase of the early 1990s, basal cover and standing crop of herbaceous plants might have higher values compared to those collected in the high-density phase of the mid- to late-1990s. Measures of these attributes could increase again during the subsequent drought-recovery phase. Patterns would also be greatly complicated by variation in rainfall during either phase.

In sum, definite trend could be exceedingly difficult to detect; this is especially true if sampling precision is poor. To conserve operating resources, it could be useful to restrict data collection to high-density phases only. Monitoring bush encroachment is a bit more straightforward, but may also be subject to problems of interpretation. The theory of system dynamics predicts that establishment of woody seedlings is not a gradual phenomenon, but is more episodic in nature. Some years have an explosive increase in seedlings while in many other years establishment is negligible. The greatest rate of seedling establishment should occur during years of above-average rainfall in the high-density phase of the cattle population, with other ecological factors held relatively constant (Section 7.2.3.1: *Range ecology*).

8.3.2 Research priorities

The framework proposed in Section 7.2: *A theory of local system dynamics* is essentially a series of hypotheses concerning important interactions. These require testing using interdisciplinary methods. There may not be scope to do so in the forseeable future, however, given other urgent priorities for collecting information to help mitigate the effects of the current crisis in the southern rangelands.

It is forwarded that the most important research questions in the southern rangelands today involve social science and economics. In particular, it is important to know how the human population is coping with problems that have arisen from high population growth and perennial drought. For example, little is known concerning: (1) detailed dynamics of human population growth, including effects of changing social values and outside inputs on rates of birth and mortality; (2) whether there have been recent changes in settlement patterns and their implications for resource use; (3) who is emigrating out of the system, why and what happens to emigrants; (4) whether the traditional social order (the *Gada*) is able to cope with severe stress or not; and (5) implications of change for the most vulnerable groups in Borana society, namely women and children. It is also important to consider adaptive research regarding factors that could promote sustainable cereal cultivation. Needs for livestock research are relatively minor, except for a study dealing with alleged dilution of the Boran breed by highland stock.

It has been argued in Section 8.2.3.1: *Overview of strategy* that using banked livestock capital as a stimulus for local urban development is important for completing a development loop of mutual assistance between the Boran and town dwellers over the longer term.

Investigation is required as to whether feasible options exist for initiating small-scale industries in towns such as Yabelo, Negele, Mega and Moyale. Research is also needed to better quantify risks of banking versus holding wealth as livestock so that a portfolio management approach to maximise returns can be recommended.

8.3.3 Other research implications

A brief summary of the major implications drawn from research findings is presented here. There are implications here for basic and applied science. Perspectives are organised with respect to 28 important themes. For detailed discussion of research results, readers should consult sections of preceding chapters.

1) **Equilibrial versus non-equilibrial systems:** Currently there is a controversy concerning to what degree range-production systems exhibit equilibrial or non-equilibrial dynamics (Ellis and Swift, 1988; Westoby and Noy-Meir, 1989; Bartels et al, 1990; de Leeuw and Tothill, 1990; Behnke and Scoones, 1991). To recapitulate, equilibrial systems are characterised by more internal and negative feedback loops between vegetation and people. At certain stocking rates livestock productivity can be depressed due to stringent competition for resources; such competition may be exacerbated by consumer-induced declines in the productivity of the forage resources themselves.

   Livestock can affect major changes in plant species composition and vegetation structure. And people can be more important than climate in affecting ecological trends; in this respect concepts such as carrying capacity are more relevant.

   Dynamics of non-equilibrial systems, in contrast, are more strongly affected by climate. Internal interactions are less important in causing trends, and carrying capacity is thus a less relevant concept. One key implication of this distinction in system behaviour is that environmental degradation in non-equilibrial systems can be more attributable to variation in long-term patterns of climatic conditions such as rainfall. Degradation in equilibrial systems, in contrast, is more easily traceable to activities of humans and livestock. Both types of systems probably exist in East Africa (see Section 6.4.5: *Equilibrial versus non-equilibrial population dynamics*).

   Indicators here suggest that the Borana system tends to exhibit equilibrial characteristics with stocking rate strongly mediating effects of annual rainfall on livestock and human populations. This agrees with more classical concepts of pastoral system dynamics (Pratt and Gwynne, 1977; Lamprey, 1983). Density-dependent effects on cattle productivity and mortality rates appear to occur. Cattle grazing probably facilitates bush encroachment, and thus system structure, by reducing risk of fire for woody seedlings. Grazing also encourages erosion on some landscapes. To infer that the system is equilibrial, however, should not imply that it is static. It is very dynamic within broad limits of stocking rates (i.e. within 10 to 30 head of cattle/km^2). Annual stocking rates that vary so widely require different tactics to manage the system as a whole. Westoby and Noy-Meir (1989) contend that in contrast to equilibrial systems, non-equilibrial systems require opportunistic management. This perspective seems to equate an equilibrial with a static state. It is clear, however, that the equilibrial system of Borana also requires opportunistic management to deal with the long-term trend and phases in the interdrought cycle (see Section 7.4: *Component interventions and system dynamics*).

   One problem seems to be how the term "equilibrium" is defined and interpreted. If an equilibrium implies that populations of plants and people vary little from year to year, it is difficult to conceive of any range environment that would conform to this. On a continuum of equilibrial to non-equilibrial system behaviour, the Borana system appears to exhibit a higher degree of equilibrial characteristics within broad limits of stocking rates. The cattle population is very dynamic, and the situation requires opportunistic management. Because the system tends to be equilibrial, more development options are possible than if it were non-equilibrial. Predictable pressures on the system can create opportunity for positive change.

The Borana system tends to be equilibrial due to: (1) the relatively high annual rainfall; (2) dominance of perennial herbaceous species; (3) soils and landscapes that have tendencies to erode under high levels of livestock use; and because (4) cattle and human populations are spatially confined (access to land by both is limited). Increased population growth, both within Borana society and among other neighbouring ethnic groups, appears to be the major contributor to increased spatial confinement. Development interventions which have served to improve access to permanent water source and reduce risk of disease to both livestock and people have probably helped to promote population growth. It is therefore likely that both population growth and development processes have contributed to encouraging a more pronounced, equilibrial behaviour of the Borana system in recent years. But this assessment may also be a creation of the inability to better observe population dynamics over narrower spatial and temporal scales of resolution.

2) **Effects of pastoralism on the environment:** As alluded to above, the Boran have certainly had important effects on their environment. Roughly 40% of the study area is now occupied by dense woody vegetation while 19% has suffered soil eroision. It is very likely that both trends are attributable in large measure to cattle grazing. While some aspects of degradation may have happened recently, others have probably taken hundreds of years.

It was stated in Section 3.4.2: *Environmental change,* that high rates of population growth have recently compromised traditional patterns of resource use. The pattern is decribed as a "patch dynamic"; i.e. the Boran used a mixed-savannah region intensively for a number of years, bush encroachment occurred, the people moved elsewhere allowing the original vegetation to gradually recover as a result of rest from grazing, plus successional processes and bush fires. This cycle may have taken several generations to complete. The problem today, however, is that the people have been forced to become more sedentary because a high population density restricts options to move. The net result is a general increase in bush encroachment, with less opportunity for sites to rest and recover from grazing. Hence the only means to re-establish the traditional pattern is to dramatically reduce the human population.

While less than 5% of the study area was under cultivation through the mid-1980s, the prospect remains that cultivation could dramatically increase to offset risks of famine. If cultivation spreads unabated to shallow upland soils, it is foreseen that the danger for erosion over the short or medium term could greatly exceed that observed from decades of past use by cattle.

While it is more straightforward to assess grazing or cultivation-induced erosion as having negative impacts on system productivity, it is more difficult to generalise concerning effects of bush encroachment. Effects of woody species on the herbaceous community vary according to the type of woody species and site. Effects can be positive, neutral or negative. Overall, however, it is concluded that effects are eventually negative with respect to cattle production.

Given the relatively high rainfall, vegetation communities dominated by woody plants may represent the most stable condition for this system (Pratt, 1987a). If this is the case, the Borana Plateau may have been densely wooded prior to the arrival of pastoral peoples thousands of years ago (Lind and Morrison, 1974). Habitual burning by pastoralists may have established and maintained the mixed savannah which we see disappearing today. The ability to maintain this less stable ecological system may thus have been compromised by high population growth and government policy which prohibited range burning from 1974 to 1991.

While impacts from severe erosion could be taken as permanent, impact from bush encroachment could be reversible to a high degree. If population pressure can eventually be reduced by facilitating emigration of people out of the system, and if traditional management practices such as prescribed burning can be re-established, many bush-encroached areas could probably be recovered.

Effects of pastoralism on rangeland environments have recently received much attention (Winrock International, 1992). In a broader sense, however, it remains unclear which situation constitutes the greatest threat to Ethiopia, degradation of the highlands or the lowlands. It is thought that degradation in the highlands may be more critical. This is because the highlands have much higher densities of people and animals, higher rainfall, greater opportunities for expansion of cultivation and a larger prevalence of readily erodible landscapes (EMA, 1988).

Finally, it has been hypothesised that nutrient transfer by cattle from grazing areas to encampments via faeces is important in encouraging bush encroachment within the framework of the traditional patch dynamic. There are no data, however, to test this assertion and this could be a topic for future research.

3) **Awareness of the Boran concerning environmental issues:** Borana leaders are aware that their system is becoming overpopulated with people and that stocking rates of cattle are often high. They also equate heavy cattle grazing with bush encroachment and soil erosion. Proclamations made at the 1988 *Gumi Gayu* assembly were dominated by concern over resource use, and included measures to protect valuable trees, promote fodder banks, secure grazing for *forra* cattle herds and encourage better maintenance of water points. Many leaders appear to realise that their traditional way of life is coming to an end in several respects. They rarely offered, however, ideas as to how the traditional social order could better cope with stress and change. It has been mentioned that on some issues, the Boran need the help of government to regulate some aspects of resource use that the traditional system is unable to deal with.

4) **Sustainability:** This study was never intended to address concepts of system sustainability as they occur in the literature today (Vosti et al, 1991; Flora, 1992). Sustainability can be viewed from ecological, agricultural, social and/or economic perspectives. Precise definitions of sustainability remain elusive. It is reasonable, however, to offer some insights on sustainability of the Borana system based on our experiences here.

Concerning ecology, it is claimed that the cumulative effects of bush encroachment and erosion have indeed reduced land access, and thus carrying capacity, for cattle over the longer term. Informants have reported that the Borana system was dominated by more grasslands and open savannahs 30 years ago. We have no means, however, to determine what a reasonable baseline condition is and thus what the true extent of the impact has been. It is also debatable how important the loss of grasslands and savannahs is for system resilience compared to acute loss of grazing reserves due to human population growth in recent times.

For animal-based agriculture and economics, empirical models suggest that per capita food production in terms of milk and asset accumulation measured in herd size are both in a rapid downward trend. This is due to the increasing imbalance between the numbers of people and those of cattle. The acute nature of this trend dictates that this is the first "sustainability issue" to be dealt with in development strategies. Until people's needs can be better met over the short term, questions of long-term sustainability of the environment are less relevant.

It has also been forwarded that the Ethiopian Government has a stake in maintaining the social sustainability of the Boran system to promote the production of livestock for the rest of the nation. The immediate threats to the social order are famine and increasing poverty. Without a viable social order to coordinate labour to extract water from the deep wells in dry seasons, it is conceivable that the livestock system could suddenly become much less productive. A collapse in the social order could thus undermine system sustainability much faster than ecological degradation could.

It is important to note that the primary benefit of destocking, with compensation in the form of banked livestock capital, is in terms of system stabilisation and improvement of human welfare over the short to medium term. It is less justifiable at present to advocate destocking to preserve the environment.

5) **Sources of system destabilisation:** The crisis in Borana today, similar to that of other pastoral systems, is due to high rates of human population growth in an environment which is increasingly finite in terms of resources. The rate of population growth, however, is not excessive and is comparable to that for other semi-settled pastoral groups. The main problem appears to be lack of opportunities for people to emigrate outside of the pastoral sector. Lack of urban job opportunities is an important bottleneck, but so is the lack of education. It is unfortunate that efforts to develop the human resource in the southern rangelands have been far less than those employed to stimulate livestock marketing. The situation has probably been greatly exacerbated by the cultural and political isolation of the Boran from mainstream Ethiopian society. Farming peoples in the highlands are also experiencing population bottlenecks that continue to spur emigration in ever-growing numbers. It is supposed that farming people can emigrate much more easily to the urban sector than pastoral people like the Boran.

6) **Change in human population growth:** A review of secondary information suggests that

the human population in Borana is growing at about 2.5% per year, with a doubling time of 28 years. This is in line with estimates of population growth for other semi-settled pastoralists. It has been speculated that the net rate of population growth is increasing, and sources of this increase could involve increased provision of food grain and health care, less adherence to traditional rules concerning reproductive behaviour and/or that the *Gada* cycle which imposes rules on reproduction is temporarily affecting only a smaller cohort of individuals in the population. The Boran believe, however, that any recent increase and there being no epidemic diseases is due to luck.

7) **Biodiversity and the conservation of nature:** As with sustainability, this study project was not originally intended to examine concepts of biodiversity as they occur in the contemporary literature. In perhaps the most comprehensive range-oriented review to date, West (1993) defines biodiversity as a multi-faceted phenomenon involving a variety of organisms, their genetic variability and the ecological units in which they occur. What are included as important components of biodiversity are largely shaped by the values of the observer; some argue, for example, that indigenous people be included as well. Despite problems with definitions and functional interpretation of the importance of biodiversity, West (1993) argues that concern for maintaining or enhancing biodiversity will increase among donors who fund projects in the developing world. In the developed world debate may increasingly centre on which species are functionally redundant, and whether or not species *per se* are the best currency to deal with. In the developing world, however, the problem is more basic and deals with a lack of information on types of organisms that occur and how they could be affected by land use.

Given the acute nature of human crisis in the Borana system, it is offered that biodiversity is not a research priority at present. Our survey results provide only some preliminary information on the types of plants and animals present in the Borana system and one view of an appropriate schema of ecological site classification. Traditional uses of many plants by people and livestock have also been tabulated along with some possible trends regarding the abundance of woody species under heavy cattle grazing (see Section 2.4.1.5: *Native vegetation*, Section 2.4.1.6: *Native fauna* and Section 3.3.5.2: *Household use of plants and pastoral perceptions of range trend*). The region has a rich flora and fauna, but trends in abundance or diversity of these organisms as affected by human activity are not documented.

Future studies that try to assess biodiversity in the southern rangelands may first need to consider how woody encroachment affects biodiversity at the site and landscape levels of resolution. Attempts to enhance biodiversity could conflict with strategies to maintain the southern rangelands for cattle grazing. For example, although a high degree of woody encroachment may be unfavourable for cattle production, this may represent the best system state for biodiversity in terms of the number of plant species and a suitable habitat for wildlife.

Policy issues also bear on biodiversity, at least, with respect to highly visible species of wildlife. Informants report that there has been a decline in the abundance of large wild mammals in the past 30 years and this is thought to be due, in part, to the lingering effects of conflict between Ethiopian and Somali forces during the late 1970s. One impression is that the three government cattle ranches, which have existed since the late 1970s, appear to have served as refuge for wildlife because of low stocking rates and the exclusion of the Boran and their herds (see Section 2.4.1.6: *Native fauna*). It has been recently decided to return these areas to the Boran. This is an important gesture in light of severe resource constraints in the system, but it may bode unfavourably for wildlife. Similarly, pond development that increased access of the Boran to previously underutilised areas since the 1960s may have affected the local abundance and diversity of native organisms. Future strategies to maintain water development projects may consider effects on native organisms in addition to effects on the Boran production system as a whole.

8) **Drought impact:** Monitoring of drought impacts in 1983–84 suggested that: (1) people were only marginally affected in terms of famine-induced mortality; (2) many households in one region even reported births during the drought; and (3) the drought had differing effect on various sex and age classes of cattle. Still herds were decimated overall; the difference in the effect of drought on cattle versus people underscores the role of drought in exacerbating poverty. Roughly 45% of the milk cows, 90% of the calves, but only 22% of the mature males died (Donaldson, 1986). The higher survival rate of males is speculated to be due to their lower nutritional requirements compared to cows and their greater mobility. This result testifies as to the value of mature males in reducing the risk of

cattle loss during drought. Patterns of cattle mortality suggested that deaths occurred in "waves"; it was hypothesised that the more productive animals died first, leaving a nucleus of less productive but hardier animals. This was also confirmed by cow-history analyses. This suggests that attempts to improve the local Boran cattle via breeding to enhance productivity would not be sustainable.

Finally, a recall survey in one region suggested that camels died to a similar extent as cattle during the 1983–84 drought. The advantage of camels, however, appears to be their continued milk production, which allows camel owners to sell milk during drought when prices are high. This is in stark contrast with the terms of trade of other livestock products for grain that fell dramatically.

9) **Efficiency of pastoral production systems:** As in other African pastoral systems, once the high stocking rate is factored in and milk is included as a major product for people, the efficiency of the traditional pastoral production of the Borana system exceeds that for commercial ranching in a comparable setting in terms of energy yield per person and per unit area. Commercial ranching produces more meat per head, however. This shows, in general, that commercial ranching is a poor alternative for a subsistence-oriented pastoral society. This anomally, however, has been amply demonstrated here and elsewhere in terms of the incongruity of production objectives and human demographics between the two modes of operation. The one problem with the pastoral system compared to modern ranching, however, is that the higher stocking rates of pastoral systems increase the danger of risks for environmental degradation and system instability in some situations.

10) **Productivity of range livestock:** It is commonly assumed that compared to unimproved animals in higher potential areas, range livestock have a lower level of productivity, whether caused by breed characteristics, climate or both. There is no strong evidence to support this view for the southern rangelands. Limited data on small ruminants suggest that their productivity is similar to that in other systems. Performance of unimproved Boran cattle under pastoral conditions appears similar to the lower end of the spectrum for unimproved animals reared on research stations elsewhere in Africa. Under low stocking rates and favourable rainfall, it is hypothesised that the productivity of the Borana cattle system can be extremely high. Compared to higher rainfall areas, range systems also have the advantage of a lower incidence of many important diseases (Sileshi Zewdie, SORDU veterinarian, personal communication). Provided adequate rainfall, the highest rates of production per head would have occurred in 1985–86 and again in 1992–93. Production is thus cyclic in nature as mediated by stocking rate.

A related issue is the precision of cattle production studies in different environments. It has been hypothesised that cattle productivity in the southern rangelands is markedly affected by rainfall and stocking rate. Research results thus need to be qualified with respect to these variables in any given year. One result of the failure to do this are studies that do include sufficient animals but that yield widely differing statistics for the same system in different years. Ideally, productivity should be evaluated under experimental conditions at an assortment of stocking rates and rainfall years. Mean figures could then be calculated as weighted averages that consider the relative frequency of different background conditions.

The one major production feature that requires intervention in the Borana system is the problem of calf mortality. This is an appropriate strategy because it builds on traditional values and requires a small amount of strategic resources that are locally available. Tactics would vary, however, according to the type of rainfall year and wealth of the producer household. Wealthy households appear to have more problems with calf diseases while poorer households appear to have more problems with calf nutrition. It is also proposed that calf mortality can be density dependent under high stocking rates. The most sustainable improvement in reducing of calf mortality would probably be achieved along with a concomitant increase in animal offtake.

The typical nutritional research concept in seasonal African environments is that ruminants are primarily limited by crude protein in dry seasons. This implies that other nutrients are less limiting. From Section 7.2: *A theory of local system dynamics*, it is offered that sequential changes in stocking rate during the interdrought cycle affect nutritional constraints in a stepwise manner. This is an ecological, rather than mainstream agricultural, view of nutritional dynamics.

Using the period 1985 to 1990 as an example, it is hypothesised that minor nutrients like minerals could have been a more pervasive constraint for cattle nutrition when the stocking rate was less than 10 head/km^2 in 1985. When herds began to recover during 1986 to 1988, protein might have emerged as the principal problem in dry seasons. By 1989, however, herd owners reported that cattle were unable to regain condition even during the long rains even though precipitation was above average. From 1989 onwards, when the stocking rate was greater than 20 head/km^2, energy was likely the problem because of forage competition. When energy is the problem in a risky rangeland environment, the best measure is some creative destocking to avoid system collapse. The point is that the model of protein limitation has only limited utility, even in situations where protein supplementation of mature cattle is feasible. This illustrates the value of an interdisciplinary view that involves animal production and ecology.

As with other pastoral systems, the central question in Borana seems to be how to stimulate more offtake of animals in such a way as to not compromise pastoral security based on animal assets. Improvement of cattle productivity overall should benefit from increased offtake. And to bank livestock capital (described above) are forwarded as the best-bet means to achieve greater cattle offtake.

11) **Compensatory growth of cattle:** Claims that adult range cattle are unable to compensate for periodic deprivation of water or for nutritional deprivation as calves, are results falsified by controlled trials. In fact, the animals have exhibited considerable ability for compensatory growth under the experimental conditions employed. One implication of the calf growth trial is that as long as the calf lives, regardless of the level of early nutritional deprivation, the odds are that it will attain a level of lifetime productivity similar to animals that have not been deprived. Under conditions imposed in our trials, calves were eventually abe to compensate for milk "lost" to people as offtake.

Long-term growth patterns are thus controlled to a large extent by the environment. Risks of extensive weight loss by cows at some point during their productive lifetime are very high. This can effectively cancel out expensive inputs administered to the animal as calves. Calf feeding for sustainable improvements in growth is thus very risky and inappropriate. As long as cattle are marketed as matures, calf feeding for improved selling weights is irrelevant.

Calf growth rates were improved to the greatest degree by provision of improved forage and water in contolled trials. This suggests that in drier environments, water availability may be a significant constraint in the ability of animals to make use of improved forage supplies.

12) **Conservation of indigenous livestock breeds:** As reviewed in Section 1.2: *The lowlands and pastoralism in a national perspective*, the Boran cattle breed is important in terms of its productivity, durability and marketability for domestic use and export. There has been concern as to whether this breed is in danger of genetic dilution from inferior breeds from the southern highlands. This concern may have already spurred action, as one of the objectives of the Ministry of Agriculture in establishing a ranch at Did Tayura, north of Yabelo, was to promote the genetic integrity of the Boran through on-station breeding programmes.

The Boran trade their male cattle for highland cows during drought-recovery periods to speed up recovery of milk production and herd growth potential (Tafesse Mesfin, TLDP General Manager, personal communication). This underscores the value of male cattle for post-drought trade in the Borana system, and it also shows that cattle in the southern highlands are serving as a stable reservoir to add resilience to the performance of the range sector. The extent of the trade remains unquantified. It also remains for research to document whether the alleged genetic dilution is truly a long-term threat. If highland cows perform poorly under stress in the rangelands environment, it is possible that the long-term effect on the Boran gene pool is negligible (see Section 5.4.5: *Cattle growth and implications for breed persistence*). It is also unclear whether this trade is a recent strategy to help cope with increasing equilibrial dynamics of the production system or a practice that has gone on for many generations. If the former situation is true, preservation of the Boran breed may be yet another benefit of attempts to better manage and stabilise the pastoral system in response to drought.

13) **Pastoral social organisation and resistance to change:** It has almost become folklore in African development circles that pastoralists are very independent, conservative and fiercely resist outside efforts to improve their lot in life. There is no evidence, however, to support this position from the southern rangelands as observed during the 1980s. The Boran are open-minded to appropriate ideas and have in fact pioneered some of their own concepts in resource management. In this they could be an appropriate model for the introduction of new development concepts in semi-arid Africa. Part of this may be due to the persistence of their traditional social structure which can greatly

facilitate communication with development agents, and it has aided project implementation in the past. Research that can enable outsiders to better understand the internal workings of the society and show how the social order can or cannot cope with new pressures would be very valuable.

Even though it has been relatively easy to work among the Boran in the past, they have become rightly suspicious of government from their experiences with Peasant Associations, national recruitment for the military and fulfilling mandatory quaotas for livestock sales in the 1970s and 1980s (see Section 1.4.3: *The SERP and the Pilot Project*). To what extent their full trust can be won back by the new government remains unclear.

14) **Development constraints:** One of the only intervention concepts that is entirely independent of external resources is hay making using local grasses and native legumes to provide improved feed for calves. Most of the others, either directly or indirectly, rely on some degree of external support. Granted the sustainability and appropriateness of such interventions are open to debate, the problem then becomes whether any substantial improvement in human welfare is possible without stronger linkages to the rest of Ethiopia. The Boran are willing to pay for innovations they consider valuable; so realistic demand for development for which they will contribute at least in kind is presumed to exist. Most of the production and development constraints enumerated in Chapter 7: *Development-intervention concepts*, are considered to lie outside of the pastoral sector. This discounts the notion that the main constraints to change are caused by inappropriate pastoral attitudes or behaviour. The inability of the nation to meet adequately many routine needs of food or other commodities is paramount. To the extent that national development initiatives improve the functioning of commerce and the creation of urban job opportunities, they should also have positive effects on Borana society.

15) **Top-down versus bottom-up innovation concepts:** Experience here suggests that top-down innovation concepts such as the pond scoop, the improved butter churn, pasture improvements using exotic herbaceous forages, drought fodder banks using *Atriplex* and *Opuntia forages* and stimulating cattle growth through early nutritional supplementation of nursing calves will not succeed. Because the Boran appear unwilling to risk valuable cattle to pull the pond scoop which seems an extended project to them; the butter churn may have been more relevant 30 years ago when per capita milk surpluses were more common; exotic herbaceous forages appear unproductive due to constraints of rainfall and/or air temperature; drought fodder banks are impractical given the scope of the problem of sustaining thousands of cattle during drought; and attempting to stimulate cattle growth over a three or four-year time horizon is simply too risky according to the Boran. In contrast, innovations devised on the basis of grass-roots knowledge of the community such as hay making, use of native legumes, cement cisterns, banking livestock capital and strategies to mitigate calf mortality appear far more appropriate given the cultural attitudes and their greater reliance on local resources. These innovations are thus much more likely to have their impact.

There has been a debate recently regarding an appropriate mix of "upstream" (i.e. high-tech) versus "downstream" research activities in sub-Saharan Africa (Winrock International, 1992). Whether it involves developing appropriate technology or gaining key insights for the interdisciplinary systems approach, this study project of the Boran system speaks for the value of downstream research in which the beneficiaries of development play a significant role. The value of upstream research in this project has been relatively played down.

16) **Linkages among development entities and research institutions:** In our experience, the collaboration between grass-roots development agencies and researchers has proven to be fruitful (see Section 1.4.7: *Interaction between research and development and project impact*). Creative development agents helped complete the loop between the Boran and researchers to create a more participatory farming systems research approach. One paradox is that while researchers are pre-occupied with creating technological interventions and generalisable system perspectives, they can be blind as to the complexity of the day-to-day lives of rural people and how this complexity constrains adoption of innovations. Development agents can help provide the eyes and ears for research. Today, the research establishment is under increasing pressure to demonstrate the impact of their efforts on people. Both in terms of helping understand real problems, extending appropriate technology more rapidly and the widespread dispersal of project results in the scientific literature, collaboration between research and development workers can be mutually beneficial. One drawback in this

respect is the fact that researchers and development agents have different perspectives, education, values and goals. This makes truly mutualistic collaboration difficult, unless the focus is clearly agreed to be solving acute problems of people in a given setting. That was the source of our success at integration here.

17) **Interventions that increase production versus those that mitigate risks:** Whether the intervention is reclaiming drought grazing reserves, banking livestock capital, facilitating sustainable agropastoralism, educating pastoralists to leave the pastoral sector, forging durable links between pastoralists and farmers or assisting the smooth functioning of markets and viable terms of trade, the most important initiatives for the Boran today involve dealing with a crisis situation. This means expanding the social and economic options for the people to enable them to be more opportunistic in coping with a rapidly changing world. Such action gets its mandate, in part, from populations being in a very precarious position with respect to their baseline resources compared to the past, and embodies the philosophy of Sandford (1983a) who considered "efficient opportunism" to be the fundamental element of sustainable pastoralism. In this view technological improvements, are considered very minor in their potential impact and are said to serve more of an ancillary role. Today the questions should revolve more around how livestock assets can be used to improve the human condition rather than a singular focus on livestock productivity *per se.*

    The irony remains, however, that most research and extension personnel are inculcated with the ideology that improved technology is the only solution. Risk mitigation appears more complex and beyond the domain of any one development agency. It is proposed that while individual agencies can each make a positive contribution to pastoral risk mitigation, the most effective approaches would involve interagency efforts that coordinate policies and procedures that deal major blows to the problem. The issue then becomes one of effective dialogue and policy formulation among institutions which increasingly affect the destinies of people like the Boran.

18) **Forage improvements:** Forage trials indicated that dual-purpose annuals such as cowpea (*Vigna unguiculata*) and lablab (*Lablab purpureus*) were the highest producers of seed and forage. It is contended that forage extension should focus on plants that help the people feed themselves first. Cowpea appears to offer the best possibilities as an intercrop with maize. For range improvements, the best bet is to stick with the most promising native species of grasses and browse. These have the advantage of proven persistence in the environment. Herbaceous exotics, in particular, appear to have their growth constrained by low rainfall and/or cool ambient temperatures. For calf forages, the best intervention by far is hay making using indigenous grasses.

19) **Gender issues:** From two independent surveys, it was somewhat surprising to find that 20 to 25% of household heads were women. This tendency may be more pronounced in peri-urban areas occupied by a higher proportion of poor and middle-class households (Holden and Coppock, 1992). Many of the technical intervention concepts forwarded in this volume should be targeted towards women in peri-urban locations. The social and economic status of women, and whether their roles are changing in Boran society, should be more a focus of research. If more young men leave the system, the spectre is that women and children will assume more labour responsibilities. Whether new duties for women will include more strategic and managerial tasks is unclear.

20) **Impact of cement cisterns on labour and water use:** Provision of local water tanks did not appear to reduce the time women spent collecting water in dry seasons nor did it seem to alter markedly the pattern of water usage by people in the household. The additional water provided by water tanks appeared to be directed towards calves. Uncertainty in the length of any given dry season means that water will still be used very conservatively. The fact that water tanks did not alter women's work schedules should not imply that they don't have other benefits in terms of improving the quality of life for women.

    Despite results of oral surveys in which women always indicated that they worked long hours every day, direct observation of married Borana women on a 24-hour basis suggested that they spend around 30% of their waking hours in activities associated with leisure in the dry season (Coppock, 1992a). Other studies of time allocation in wet periods indicated that they have ample time to incorporate activities such as hay making into their schedules (Coppock, 1991). Ultimately, whether women would use more of their time to implement innovations will depend, to a large extent, on how they value leisure time in comparison to benefits perceived to result from innovations.

21) **Livestock marketing:** Analyses of market records from the early 1980s confirmed that

cattle were the dominant species sold and mature male cattle were the most common age and sex group marketed. This is common elsewhere in pastoral Africa. Studies of livestock marketing behaviour as reported by the Boran suggested that many behave as "optimistic gamblers" (Coppock, 1992b). Far from being predisposed to sell cattle readily to buy food when a drought occurs, they struggle to endure considerable misery before they capitulate to a sale. Cattle thus appear to be held more as a lasting asset rather than an expendable resource. They hold out as long as they can and hope that the next rainy season will be adequate and thus allow them to avoid sales.

This explains drought-marketing dynamics in the southern rangelands. The attitude has negative implications for the stability of the system under drought perturbation because the collective effect of such behaviour can translate into disastrous herd losses for the community when more animals have to compete for less forage in drought grazing reserves. This behaviour of waiting to sell "until you have no choice" has negative implications also for seasonal strategies intended to improve terms of trade between livestock and grain. Although the post-harvest season is the best time to maximise favourable terms of trade, the Boran are reluctant to sell then because "they don't yet have a problem." Innovations such as grain storage and banking livestock capital thus face considerable cultural obstacles. Confronting these obstacles is the key to system transformation and development.

Adult male animals, followed distantly by cull cows, are preferably sold because a herd owner receives the greatest net return from their sale, given that production costs are minimal. Cash received is used to buy commodities plus replacement calves so that selling mature cattle can meet the two objectives of generating income and herd building. The Boran do not want to sell immatures except the poor because they have no choice.

Borana marketing behaviour and cultural values strongly suggest that the perverse supply rule (Sandford, 1983a) operates here, although this will vary with livestock species and household wealth. This is not to say that animals will not be drawn to markets that have higher prices, they will. It is to say, however, that households seek higher prices so they have to sell fewer cattle over the long term, and thus avoid herd depletion. Except for households actively trying to build their herd through trade by buying immatures, the majority of households have relatively fixed cash needs and that this is a disincentive for livestock commercialisation. Stimulating cash income among the Boran may be far easier using sheep rather than cattle markets; this is because the two species serve different economic functions in different households. Sheep are more of a cash crop while cattle are for milk production and a means to store wealth.

22) **Livestock commercialisation:** While it is expected that most households will engage in more livestock sales in the future, this will be essentially a coping reaction to pressure to secure more food grain. Unless markets are stable and offer grain at favourable terms of trade, such increased market dependence would be dangerous. Informants have, for example, expresed the fear that producers who are exclusively commercially oriented may gradually emerge from the ranks of the educated wealthy and/or from those with strong ties to the urban sector; some of these people may have been government export agents in the early 1980s and that is how they learned the business. If commercial herds ever have to compete with subsistence herds for water and forage, this could be a source of social conflict in the future. Overall, it is hypothesised that traditional producers are unlikely to be transformed into purely commercial operators.

23) **Evolution of agropastoralism:** Demographic preconditions could now force a widespread shift to agropastoralism in the Borana system. The extent of this shift will, however, be limitted by a landscape that offers relatively few opportunities for sustainable cultivation. Rainfall may be less of a drawback while the patches of valley bottoms, swales and vertisols, where cultivation is viable, may comprise less than 12% of the study area. It remains unclear the extent to which competition for these valuable sites is a problem for the production system (Scoones, 1991). In a few documented cases, the Boran appear to be attempting to accomodate both cultivation and forage production on these sites even though they seem to be aware of the negative implications that extensive cultivation could have for the grazing system overall in terms of competition for key resources and environmental degradation.

McIntire and Gryseels (1987) noted the uncertain nature of forging a working linkage between crops and livestock in the semi-arid zone. Our observations support this contention because, at least in respect to the recent past, cultivation seems to be pursued when the livestock sector fails, and vice versa. Integration of cultivation with livestock production would probably happen only when the ratio of cattle to people becomes low enough for cultivation to be attempted on yearly basis. This suggests that agropastoralism would emerge as a result of chronic negative pressures on the system. Agropastoralism thus does not necessarily equate with "progress" and improvement of human welfare here. Because of constraints of arable land it is expected crop-livestock mixed production possibilities will remain relatively tenuous for most households in the forseeable future. This is particularly true if development strategies advocated earlier in this chapter succeed in managing the system in such a way to release pressure. If this occurs, the most desirable situation, especially in terms of promotion of environmental sustainability, would be for cultivation to remain as an opportunistic activity only. The future strategies for the system should thus keep a primary focus on sustainable extensive livestock production.

24) **Evolution of dairy marketing:** Observations here suggest that peri-urban dairy marketing evolves in response to increasing poverty and food deficits. Dairy products are renewable sale items that provide a regular income and allow producers to avoid selling from a small supply of animals. In the past producers used to sell dairy products occasionally to buy some discretionary items; today more of them sell to buy grain for survival. Wealthy producers sell more products in absolute terms if they reside closer to a market; in relative terms, however, dairy marketing is more important for the poor because they have little else to sell. Hence dairy markets provide ample reason for the poor to migrate to peri-urban locations where the favourable terms of trade allow them to sell an otherwise inadequate food-energy source (milk) to be sold to purchase a survival ration of grain. Dairy marketing is expected to be strongly influenced by the long-term system trend and by the interdrought cycle. When the poor sell more milk, it is likely to be taken from the calf. Calves of poor households near towns are therefore expected to be at increased risk of morbidity and death due to malnutrition.

25) **Evolution of herd diversification:** Trends suggest that herd owners seek to diversify into small ruminants to take pressure off the need to sell more cattle to buy grain. Cattle represent a collective family asset for which the producer needs to obtain a concensus that a sale is in the best interest of the household. Small ruminants, by contrast, are truly "small change" and appear to be sold whenever a need arises. It is unclear whether men or women control small ruminant production and sales.

26) **Pastoral household diversity:** The Boran, like other African pastoralists, are a diverse society so that the idea of the "average household" has little use in understanding the dynamics of the system or in prescribing blanket intervention approaches today. Similarly, households exhibit great regional variability in their access to natural resources and local variability in their access to urban markets. The system should be appropriately segregated into peri-urban and rural sectors, with the former consisting of areas within a radius of 30 km of major towns. Compared to people far from towns, those in peri-urban areas are expected, on average, to be poorer in livestock holdings, more market-oriented, more aware of a changing world in general and more likely dominated by female heads of households. One interesting point is that the "average household" may have been a more relevant concept 30 years ago when the society was not as diverse as it is today. Trends towards greater wealth stratification and peri-urban economic dependence may be exacerbated by increased competition for resources and equilibrial system dyanmics. Greater wealth stratification is evident from statistics that suggest that the wealthy, which may comprise around 18% of the population, control 65% of the cattle while the poor with 51% of the population may control only around 10%.

27) **Urban-pastoral linkages:** Over the long term, it is proposed that promoting the development of towns such as Yabelo, Mega, Negele and Moyale holds potentially great benefits for the Boran in terms of providing local markets and job opportunities. It appears, by contrast, that only a very few Boran have ever emigrated to distant urban centres such as Addis Ababa. This difference means that urban development initiatives which focus on the smaller towns and cities in the countryside, rather than on the major metropolis, would offer many more associated benefits to livestock producers like the Boran.

It is also proposed that banking livestock capital could add considerable impetus for funding rural development initiatives in small towns by providing funding in addition to helping the Boran better manage their personal assets. Interest in stimulating urban development among international donors has been spurred, in part, by the current crisis of widespread migration of rural people to the cities (Winrock International, 1992). One important question involves where the capital will come from to facilitate the growth of small businesses and urban enterprises. It is argued here that some of this capital could come from livestock otherwise used as traditional stores of wealth. Policies and incentives which promote banking livestock capital could be useful in a pan-African context and could have the ancillary benefits of relieving pressure on grazing lands, stimulating animal production per head and stabilising system dynamics. Research is needed, however, to study the economic risks involved for livestock producers in the context of portfolio management of assets.

28) **Systems science, interdisciplinarity and education:** It may be argued that systems research is inherently site specific (Winrock International, 1992). It is contended, however, that the systems perspectives described in this volume are founded on basic principles that can be applied to any livestock production system in Africa. One implication of the extended chapter discussions and literature reviews is that, while pastoral systems appear diverse superficially, they are remarkably similar in many fundamental respects. The diversity, in part, results from any one system being at a different point along a more or less similar continuum of change. For example, the Maasai of Kenya are probably a couple of generations ahead of the Boran in terms of coping with system pressure. The effect of their proximity to Nairobi has led to system dynamics proceeding in some directions that will not hold for the Boran. The Boran, in turn, may be "ahead" of other pastoral groups in Ethiopia that remain more isolated from the outside world.

The key for getting at appropriate possibilities for development impact is knowing the status of any given system at any point in time. While commodity work can point to what to do in a given situation, systems work conducted in parallel can show us when to intervene and why. Systems analysis is thus appropriate to facilitate impact of technology and management innovations. It may also be argued that the long time frame and the expenses involved make the future of systems work uncertain in Africa. While in part this is true, it is offered that, rather than merely funding more long-term work, the challenge is to extract principles of system function from existing studies, compare these and boil them down to a series of key interactions. These hypotheses can then be tested in an economical fashion in a variety of situations so that systems science can make progress. Verified principles can then be used more widely in the diagnosis of local problems and for their solutions within the framework of rapid appraisal of rural communities (Chambers, 1992).

The intellectual source for the systems approach we have employed is diverse; it has called upon material in population ecology, theories of agrarian change (Boserup, 1965) and classical farming systems research. It has not been founded on concepts dealing with ecological community structure, energy flow or nutrient cycling as have been invoked in other pastoral research projects (Coughenour et al, 1985).

The most useful computer models in our approach were of the simple empirical variety that illustrated some consequences of population dynamics on a finite resource base. Cheap and easy to construct, these models were used sparingly but provided good general insights. In contrast, models involving projected herd performance or economic outcomes of various production strategies (Upton, 1986b; Cossins and Upton, 1988b; von Kaufmann et al, 1990) helped formulate ideas and organise thinking, but these were ultimately assessed to have limited utility in predicting real-world outcomes or prescribing best-bet innovations. It is speculated that these problems arise from several factors that include: (1) limited depiction of the true complexity of ecological dynamics and human behaviour; and more specifically (2) the difficulty in portraying risk as viewed by rural livestock producers. More data are needed on biological, ecological and sociological interactions for inclusion into computer models.

The framework outlined in Section 7.2: *A theory of local system dynamics* may be unusual compared to previous systems theories because: (1) it presents a very dynamic view of system interactions; and (2) the most important interactions can only be understood if one sees that system forces act across disciplines. For one simple example, stocking rate influences milk production per head and per hectare and milk production influences the social and economic behaviour of households. The suite of these interactions can shift from year to year, and also depend on rainfall and other external events.

All this implies that to understand system dynamics, analyses of cause and effect must be interdisciplinary. It is proposed that this represents a wide open field of scientific investigation. In contrast to viewing cause and effect as interdisciplinary, independent scientists who conduct multi-disciplinary work in parallel probably tend to examine issues of cause and effect as isolated and by confining them within their narrow world view. These situations offer little opportunity to advance systems science.

Another case in point is the intervention involving banking livestock capital. This is an interdisciplinary intervention in terms of what to do, when to do it and how to do it. Again, banking livestock capital is as much a nutritional intervention for cattle as it is an economic intervention for people. Knowledge of livestock production and ecological concepts of carrying capacity and competition allows one to understand variability in risk over time and see when the intervention should be implemented; knowledge of traditional, social and economic values allows one to see why the intervention could be resisted; and knowledge of economic forces operating in the commercial banking sector allows one to see other economic trade-offs involved, all pointing to the vital need for interdisciplinary and systems-oriented education for people involved in researching or developing systems and requiring capabilities to deal with problems concerning agriculture and natural resources.

Annex A

Table A1. *Rainfall[1] on a monthly and annual basis for 10 sites in the SORDU sub-project area for the period 1980–89.[2]*

Site[3]	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual (CV)[4]
1. Wachile[5] (1040 m)	10.4±7.8	4.9±1.8	48.3±16.2	175.5±33.3	58.3±21.2	4.3±1.9	7.9±3.3	5.9±3.1	27.5±10.7	40.1±6.8	42.1±16	6.4±3.3	436.8 (55.2)
2. Sarite[6] (1052 m)	3.2±1.4	10.7±4.9	79.5±20.4	144.8±28.3	48.4±15.2	11.3±5.2	4.2± 2.9	3.4±1.8	35.5±11.6	48.8±7.3	27.8±10.5	8.8±4.2	426 (49.8)
3. Moyale[5] (1200 m)	6.4±3.8	13.2±4.8	94.4±29.7	342.9±74.5	277.5±81.9	36.3±8.5	17.9±5.3	20.4±5.9	33.2±13.9	121.7±44	124±22.5	23.4±7.8	111.2 (52.4)
4. Hidi Lola[5] (1430 m)	10.8±3.8	16.7±3.3	67.9±15.9	142.4±23.4	196.5±45.1	36.1±8	22.4±7	17.8±8.3	42.5±13.8	76±20.1	51.5±12.5	19.2±6	696 (41.8)
5. Teltele[5] (1470 m)	9.1±3.7	17.9±6.6	82.3±22	164.2±29.8	79.3±16.6	31±11.7	13.6±6.3	16.4±9.3	62±11.3	61.3±12.7	55.8±115.8	21±9.4	614.2 (37.9)
6. Negele[5] (1530 m)	0.6±0.5	22±11.8	48.3±20.4	236.7±56.2	165.8±33	14±4.1	9.3± 3.2	8.1±3	47.5±12.2	146.1±19.4	41.1±10.3	4.1±1.5	757.2 (50.4)
7. Did Hara[7] (1535 m)	0.5±0.4	3.7±3.3	32.1±12.5	143.3±27.6	108.1±21.5	14.3±7.2	4.6± 2.7	15.2±9.3	17.4±7.2	34±11.7	18.6±6.5	14.5±12.4	406.8 (57.2)
8. Dubluk[8] (1550 m)	0.5±0.3	14.7±6.1	68.2±26.5	115.8±19.9	42.9±9.7	5.9±3.4	0.4±0.3	0.9±0.8	7.7±6.7	48.5±12.1	48.9±14.5	16.9±7.6	369.6 (51.7)
9. Arero[5] (1700 m)	28.5±24.1	15.7±7.5	131± 34.8	228.7±54.7	126.5±31.8	23.1±8.7	37.4±21.1	14.4±7.2	65.4±26.2	76± 24.3	89.5±62.3	18±10.7	858 (50.9)
10. Yabelo[5] (1750 m)	9±5.3	13.7±5.8	77.8±19.8	124.6±17	52.8±16.3	10.1±3.7	6.3± 4.4	13.6±6.5	42.6± 13.5	52.6±11.2	29.4±10.2	23.3±10.6	456 (40.1)

1 Tabular entries (mm) represent the mean ± 1 standard error (SE).

2 Averages are probably biased downwards because of the 1984–85 drought.

3 Sites are listed here from lowest to highest elevation (m.a.s.l.).

4 Coefficient of variation = standard deviation expressed as a percentage of the mean. It is a measure of variability.

5 1980–89.

6 1981–89.

7 1980–87.

8 1980–84; 1986–88.

Source: Raw data provided courtesy of the National Meteorological Service of Ethiopia.

Table A2. *Per cent probabilities of monthly rainfall exceeding 60 mm for six stations in southern Ethiopia as derived from data collected during 1957–1981.*[1]

Station	Elevation (m)	Month											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Gidole	—	20	60	90	100	90	50	60	60	90	100	60	30
Burji	—	15	10	60	100	90	15	10	20	50	95	50	25
Yabelo	1750	10	40	80	100	100	20	20	10	30	90	90	20
Negele	1530	5	10	30	100	80	5	0	0	30	95	60	5
Moyale	1200	5	5	20	100	90	0	0	5	10	80	60	20
Dolo	—	0	5	10	60	20	0	0	0	0	10	30	20
Average	—	9	22	48	93	78	15	15	16	35	78	58	20

1 Sixty millimeters per month is considered by Billé (1983) as the minimum required for herbaceous production in the southern rangelands. Gidole, Burji and Dolo are higher-elevation sites than Yabelo, Negele or Moyale. Exact elevations were not provided in Billé (1983).

Source: Billé (1983).

Table A3. *Number of rainy days and total rainfall[1] on a 10-day basis[2] during the long rainy season[3] for 10 sites in the SORDU sub-project area during 1980–89.*

Site[4]		Month[5]											
		March			April			May			June		
		1	2	3	1	2	3	1	2	3	1	2	3
1. Wachile (1040 m)	days	1.5±0.8	1.4±0.6	2.6± 0.5	3.9±0.8	3.2±0.8	3.3±0.7	3.4±0.9	1.3±0.5	0.5±0.3	1±0.3	0.2±0.2	0.2±0.2
	ppt	10.7±6	18.2±13.7	21.2±5.5	53.1±14.7	52.7±13.2	69.6±18.4	38±17.8	21.5±10.4	1.2±0.7	3.8±1.9	0.1±0.1	0.6±0.6
2. Sarite (1052 m)	days	1.2±0.5	2.4±0.5	2.4±0.9	5.2±0.8	4.7±1.2	3.4±1.1	2.1±0.6	2.3±0.6	1.2±0.7	1.1±0.7	0.7±0.4	0.3±0.2
	ppt	17.7±10.3	40.2±11.6	21.6±8.6	62.7±13.3	44±14.7	38.1±16	23.9±7.7	15.3±5.1	9.2±7	6.8±4.5	3.6±2.3	0.9±0.8
3. Moyale (1200 m)	days	1.2±0.4	1.5±0.8	4.7± 0.9	3.8±1	6.5±0.8	7.5±0.7	5±1	4.8±0.9	4.9±0.8	2.9±0.9	2.4±0.5	1.7±0.7
	ppt	6.5±3.2	14.4±10.9	73.5±24	63.3±17.5	114.6±30.1	164.9±37	133.9±53.7	88.7±34.7	54.9±21.3	14.7±4.8	12.5±4.8	9±5.6
4. Hidi Lola (1200 m)	days	1.6±0.7	2.8±0.6	3.1± 0.5	3.8±0.6	4.8±0.9	4.5±0.7	5.6±0.8	3.9±0.6	3.4±0.5	2±0.5	1.7±0.5	1.8±0.6
	ppt	16.3±10.9	24.1±7.1	27.5±6.2	35.3±7.3	52.4±13.5	54.7±17.8	120.9±35.9	58.5±18	35±11.2	16.5±5.3	13.2±6.1	6.4±2.4
5. Teltele (1470 m)	days	1.1±0.3	3.2±1.1	2.9± 0.6	4.3±0.7	3.2±0.6	3.8±0.9	2.6±0.6	3.3±0.8	1.2±0.4	0.9±0.5	1±0.5	0.9±0.4
	ppt	10.2±4.6	38.1±17.3	34.1±9.1	63.9±12.4	45.2±11.7	55.1±14.1	23.9±5.5	41.4±9.3	14±6.2	14.4±11.4	9.7± 7	6.8±3.2
6. Negele (1530 m)	days	0.9±0.4	1.6±0.6	1.8± 0.9	5.2±0.8	5.2±0.9	5.1±0.8	5.3±0.8	6.1±0.9	3.1±0.9	2±0.5	1.5±0.5	1±0.5
	ppt	10.1±5.5	14.1±6.6	24.2±15.4	79±21.5	83±22.3	74.7±20.5	47.9±8	81.5±18.7	36.4±14.4	8±3.4	4.1± 1.8	1.5±1
7. Did Hara (1535 m)	days	1.6±0.9	0.8±0.2	1.1± 0.4	4.5±0.8	5.4±1.3	3.7±0.8	3.5±0.7	3.2±0.7	2.7±0.9	0.6±0.5	1±0.5	0.5±0.3
	ppt	8.2±4.4	9±4.2	15±7.1	47.4±11.6	59.5±14.6	36.4±10.8	48.6±18	32.4±11	26.9±10.4	2.8±2.1	6.8± 3.9	4.7±4.4
8. . Dubluk (1550 m)	days	0.7±0.7	1.7±0.5	3.1± 1.1	3.6±0.6	2.4±0.6	3.9±0.8	2.6±1	1.4±0.5	0.9±0.5	0.3±0.2	0.2±0.2	0.1±0.1
	ppt	10.8±10.8	17.4±9.2	40±16.4	44.7±9.4	22.6±9.1	48.5±15.5	22.6± 8.1	12.6±5.1	7.7±4	3.7±2.5	1.5±1.5	0.8±0.8
9. Arero (1700 m)	days	1.4±0.5	2±0.6	3.4±1	3±0.6	4.2±1	3.9±0.5	3.7±0.5	2.3±0.7	2.2±0.9	1±0.4	0.7±0.2	1.2±0.5
	ppt	21.6±11	58.5±30.5	59±19.6	62 ±16.5	85.1±25.2	81.6±19.8	63.8±12.6	50.2±29.9	15.4±9.2	6.1±2.7	11.7±8.8	7.1±3.8
10. Yabelo (1750 m)	days	1.8±0.5	2.4±0.8	3.8± 0.8	4.5±0.7	4.6±0.9	4.3±0.6	3.3±0.7	3.5±0.6	1±0.4	1.1±0.4	0.8±0.4	0.9±0.3
	ppt	17.4±7.2	24.3±10.7	36.1±9.8	32.5±6.9	39.5±10.5	52.5±12.6	23.9±15.9	23.7±5.2	5.2±3.2	5.9±2.5	2± 1.1	2.2±1

1 Tabular entries (number in mm) represent means ±1 standard error (SE).

2 The data are organised by 10-day intervals per month (1, 2, 3 above).

3 The long rains (*ganna mesa* in the Borana/Oromigna vernacular) typically occur in late March, April and May.

4 Sites are listed here from the lowest to the highest elevation (m.a.s.l.); days = rainy days and ppt = rainfall.

5 Bordering months were also included to illustrate variability.

Source: Raw data of the National Meteorological Service of Ethiopia.

Table A4. *Number of rainy days and total rainfall[1] on a 10-day basis[2] during the short rainy season[3] for 10 sites in the SORDU sub-project area during 1980–89.*

Site[4]		Month[5]											
		September			October			November			December		
		1	2	3	1	2	3	1	2	3	1	2	3
1. Wachile (1040 m)	days	1±0.1	0.8±0.4	2.6± 0.7	2.3±0.5	1.8±0.5	2.3±0.5	1.6±0.3	1.6±0.5	1.2±0.6	0.8±0.3	0.6±0.4	0.3±0.2
	ppt	0.7±0.7	8.9±5.7	21.1±9.6	13.2±4.4	9.5±3.6	17.4±4.5	15.5±8.3	18.1±6.8	11.2±5.3	3.4±1.8	2.4±1.5	1±0.9
2. Sarite (1052 m)	days	0.6±0.4	1.8±0.7	1.7± 0.5	1.2±0.5	2.6±0.7	2.2±0.9	1.9±0.7	1.3±0.5	0.8±0.5	0.7±0.6	0.3±0.2	0.9±0.8
	ppt	3.4±2.4	12.6±6.9	19.4±9.2	15.1±6.8	20.3±5	13.4±5.4	13.1±6.2	8.3±4.6	6.4±5.5	4.2±2.9	1.4±1.1	3.2±2.5
3. Moyale (1200 m)	days	1.7±0.5	1.5±0.5	1.3± 0.7	2.1±0.8	3.6±0.9	4.4±0.8	3.9±0.6	3.3±0.6	3.4±0.9	2±0.7	0.7±0.3	0.1±0.1
	ppt	9.1±3.7	16.9±12.6	7.2±4.4	27.3±19	50.9±25.9	43.5±11.7	48.2±12.5	41.3±10.8	34.6±12	17.1±7.6	5± 3.4	1.4±1.4
4. Hidi Lola (1200 m)	days	1.2±0.6	2.2±0.4	2± 0.4	2.9±0.5	2.1±0.7	2.4±0.5	2.6±0.5	1.9±0.6	1.6±0.6	1.7±0.4	0.6±0.3	0.1±0.1
	ppt	2.5±1.3	28.1±13.5	11.9±6.9	23.5±7.2	22.2±7.4	30.3±11	22.1±4.3	14.6±4.8	14.7±6.7	15.6±6	3.3± 2.4	0.3±0.4
5. Teltele (1470 m)	days	1.2±0.4	2.1±0.4	2.3± 0.6	2.2±0.6	3.5±0.8	1.7±0.6	1.9±0.8	1.8±0.6	1±0.4	0.4±0.3	0.7±0.4	0.3±0.2
	ppt	18.9±6.6	18±6.5	25.2±10.7	15.1±4.8	36.1±8	10.1±4.9	16.5±7.2	26.9±7.9	12.4±6.4	10.2±7.8	8.8± 5.8	2.6±2.3
6. Negele (1530 m)	days	0.8±0.3	2.4±0.9	4± 0.8	6±0.8	5.5±0.7	4±0.6	3.7±0.8	1.4±0.4	0.8±0.4	0.4±0.2	0.4±0.3	0.2±0.1
	ppt	3.2±1.3	14.9±6.5	29.4±8.7	46.7±7.4	64.7±12.2	34.7±11.8	33.2±10.3	4.1±1.3	3.9±2.6	2±1	1.4±0.9	0.8±0.6
7. Did Hara (1535 m)	days	0.9±0.4	1.9±0.7	1.1± 0.5	2.6±1.3	2.4±0.8	1.8±0.8	1.6±1	1.6±0.6	0.9±0.6	1±0.6	0.6±0.3	0.4±0.4
	ppt	4.4±2.6	7.1±2.7	5.9±2.8	14±8	11.5±4	8.5±5.1	6±4	9.5±4.1	3.1±2.5	5.5±3.9	2.7±2.3	6.4±6.4
8. Dubluk (1550 m)	days	0.1±0.1	0.2±0.1	0.3± 0.2	2.9±0.6	2.6±0.6	1.1±0.6	1.7±0.6	1.3±0.6	1.8±0.6	1.1±0.5	0.6±0.4	0.7±0.4
	ppt	0.2±0.2	0.4±0.3	7.1±6.3	22.8±7.1	20.4±10	5.3±3.1	18.36±8.6	5.2±3	25.4±14.1	12.4±7.2	0.5± 0.4	4±2.7
9. Arero (1700 m)	days	1.2±0.5	1.1±0.6	2.8± 1	3.4±1.1	2.2±0.6	3.4±0.9	1.6±0.7	2.3±0.8	1.9±0.9	1±0.5	0.4±0.3	0.9±0.6
	ppt	24±15.8	15.7±14.8	29.6±12.6	27.5±11.7	23.6±8.7	30.7±11.4	13.1±5.7	32.7±24	43.6±35.2	12.6±9.7	2.6±1.9	3.4±2.7
10. Yabelo (1750 m)	days	2±0.7	2.7±0.9	2.1±0.5	2±0.6	3.9±0.8	2.1±0.8	2.6±0.9	1.5±0.7	1.5±0.7	1.1.±0.4	0.6±0.3	1±0.9
	ppt	15.6±7.7	17.3±7.3	9.7±3.2	13.9±4.3	25.4±6.9	13.3±7.5	12.6±6.4	7.8±3.6	9±4.2	13.2±9.8	6.4±4.2	3.8±3.6

1 Tabular entries (number in mm) represent means ± 1 standard error (SE).

2 The data are organised by 10-day intervals per month (1, 2, 3 above).

3 The short rains (*hagaya* in the Borana/Oromigna vernacular) typically occur in September, October and November.

4 Sites are listed here from the lowest to the highest elevation (m.a.s.l.); days = rainy days and ppt = rainfall.

5 Bordering months were also included to illustrate variability.

Source: Raw data provided courtesy of the National Meteorological Service of Ethiopia.

Table A5. *Air temperature[1] on a monthly and annual basis for seven sites in the SORDU sub-project area during 1980–89.*

Site		Month												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Sarite[2] (1052 m)	max	34.2±0.1	34.0±0.2	31.3±0.2	29.9±0.2	29.9±0.1	31.2±0.1	30.8±0.1	30.7±0.2	30.2±0.1	29.8±0.1	31.7±0.2	33.2±0.1	31.4±0.1
	mean	25.7±0.1	25.6±0.1	24.8±0.1	23.4±0.1	23.5±0.1	24.1±0.1	23.6±0.1	23.5±0.1	23.1±0.1	23.4±0.1	24.1±0.1	25.2±0.1	24.2±0.1
	min	17.1±0.1	17.1±0.1	18.3±0.1	17.1±0.2	17±0.2	17±0.1	16.5±0.1	16.4±0.2	16.1±0.2	16.9±0.2	16.4±0.2	17.2±0.2	16.9±0.1
Moyale[3] (1200 m)	max	31.6±0.1	31.9±0.1	31±0.1	27.2±0.2	26±0.1	25.5±0.1	25.3±0.1	25.6±0.1	20±0.1	26.8±0.1	26.4±0.1	28.3±0.1	27.6±0.1
	mean	24.1±0.1	24.9±0.1	24.5±0.1	22.1±0.1	21.2±0.1	20.9±0.1	20.6±0.1	20.7±0.1	21±0.1	21.7±0.1	21.6±0.1	22.4±0.1	22.1±0.1
	min	16.5±0.2	17.9±0.1	18±0.1	17.1±0.1	16.4±0.1	16.3±0.1	15.8±0.1	15.6±0.1	16.0±0.1	16.7±0.1	16.8±0.1	16.6±0.1	16.6±0.1
Hidi Lola[3] (1430 m)	max	29.1±0.2	28.9±0.1	27.5±0.2	25.9±0.2	24.4±0.1	23.7±0.1	23.5±0.1	24.5±0.1	25.9±0.1	26±0.1	25.8±0.1	27.3±0.2	26±0.1
	mean	22.8±0.1	22.5±0.1	21.8±0.1	21±0.1	20.1±0.1	19.5±0.1	19.5±0.1	19.6±0.1	20.5±0.1	20.9±0.1	20.3±0.1	21.6±0.1	20.6±0.1
	min	16.5±0.1	16.2±0.1	16.1±0.1	16±0.1	15.8±0.1	15.3±0.1	15±0.1	14.7±0.1	15.2±0.1	15.8±0.1	15.2±0.1	16.4±0.1	15.7±0.1
Teltele[3] (1470 m)	max	29.7±0.1	30.2±0.1	30±0.2	27.5±0.1	26.5±0.1	27±0.1	26.9±0.1	27.3±0.1	28±0.1	27.8±0.1	27.8±0.1	28.3±0.1	28.1±0.1
	mean	23.3±0.1	23.4±0.1	23.7±0.1	22.3±0.1	21.6±0.1	21.7±0.1	21.4±0.1	21.5±0.1	22±0.1	22.1±0.1	21.9±0.1	22.1±0.1	22.3±0.1
	min	16.9±0.1	16.6±1.2	17.5±0.1	17.2±0.1	16.7±0.1	16.4±0.1	16±0.1	15.8±0.1	16.1±0.1	16.3±0.1	18±0.2	15.8±0.2	16.5±0.1
Negele[2] (2530 m)	max	30.6±0.1	30.8±0.1	30.1±0.2	26.8±0.2	26.1±0.1	25.2±0.1	25.8±0.2	26.1±0.1	27.3±0.1	27.1±0.1	28±0.1	29.2±0.1	27.7±0.1
	mean	23.3±0.1	23.5±0.1	23.1±0.1	21.3±0.1	20.9±0.1	20.2±0.1	20.1±0.1	20.7±0.1	21.1±0.1	21±0.1	21.7±0.1	22.4±0.1	21.6±0.1
	min	16±0.1	16.1±0.1	16.1±0.1	15.8±0.1	15.8±0.1	15.3±0.1	14.6±0.1	15.2±0.1	15±0.1	14.9±0.1	15.4±0.1	15.6±0.1	15.5±0.1
Arero[4] (1700 m	max	29±0.1	29.6±0.2	28.9±0.2	27.4±0.2	25.9±0.1	25.8±0.1	25.7±0.1	26±0.2	26.8±0.1	26.7±0.1	27±0.2	27.9±0.1	27.2±0.1
	mean	19.2±0.1	19.8±0.1	20.6±0.1	20.9±0.1	19.6±0.1	19.2±0.1	19.4±0.1	19.4±0.1	20±0.1	19.5±0.1	19.5±0.1	19.4±0.1	19.7±0.1
	min	9.3±0.2	10±0.3	12.3±0.2	14.3±0.2	13.3±0.2	12.5±0.2	13.1±0.2	12.6±0.2	13.4±0.2	12.3±0.2	12±0.2	10.9±0.2	12.2±0.1
Yabelo[3] (1750 m)	max	28.4±0.1	28.8±0.1	27.8±0.1	26.3±0.1	25.6±0.1	24.9±0.1	24.6±0.2	25±0.1	25.7±0.1	26±0.1	26±0.1	27.4±0.1	26.4 ±0.1
	mean	20.6±0.1	21.3±0.1	21.3±0.1	20.2±0.1	19.7±0.1	19±0.1	19±0.1	18.9±0.1	19.4±0.1	19.9±0.1	20±0.1	20.1±0.1	19.9±0.1
	min	12.9±0.1	13.9±0.1	14.7±0.1	14±0.1	13.7±0.1	13.2±0.1	13.3±0.1	12.9±0.1	13±0.1	13.7±0.1	13.4±0.1	12.9±0.1	13.5±0.1

1 Tabular entries are means ± 1 SE.

2 1981--89.

3 1980–89.

4 1980–86.

Source: Raw data courtesy of the National Meteorological Service of Ethiopia.

Table A6. *Altitudinal distribution of 55 important plant species in the SORDU sub-project area.*[1]

Species	Growth form[2]	Altitude class (m)					
		950–1050	1050–1200	1200–1550	1550–1600	1600–1650	1650–2000
Delonix elata	T	———		- - -			
Adenium obesum	S	———		- - -			
Dobera glabra	T	———	———				
Acacia paolii	T	———	———	- - -			
Acacia horrida	T	———	———	- - -			
Sesamothamnus rivae	T	———	- - -	———			
Salvadora persica	T	———	———	- - -			
Cadaba glandulosa	S	———	———	- - -	- - -		
Sterculia rhynchocarpa	T	———		———			
Sorghum arundinaceum	G		———				
Acacia reficiens	T	———	———	———	- - -	- - -	
Acacia senegal	T	———	———	———			
Balanites orbicularis	T	———	———	———	- - -	- - -	
Lintonia nutans	G	———	———	- - -	- - -	- - -	
Aspilia mossambicensis	F	———	———	———	- - -	- - -	
Acacia seyal var *fistula*	T	———	———	- - -	- - -	- - -	
Cordia sinensis	T	———	———	———		- - -	- - -
Schoenfeldia transiens	G		———	———			- - -
Enteropogon macro–stachyus	G	- - -	———	———			- - -
Acacia mellifera	T	———	———	———	- - -	- - -	- - -
Sporobolus pyramidalis	G	- - -	———	———	- - -	- - -	
Panicum maximum	G			———			
Eleusine floccifolia	G			———			
Acacia nubica	S	———	———	———	———	- - -	- - -
Pennisetum mezianum	G	- - -	———	———	———	- - -	- - -
Cynodon dactylon	G	———	———	- - -	———	- - -	- - -
Balanites aegyptica	T	- - -	———	———	———	———	- - -
Cenchrus ciliaris	G	- - -	———	———	———	- - -	- - -
Acacia tortilis	T	———	- - -	———	———	———	- - -
Omocarpum trachycarpum	T		- - -	———	- - -	———	- - -
Boscia angustifolia	T	———	- - -	- - -	- - -	———	———
Dichrostachys cinera	T	- - -	- - -	———	- - -	- - -	———
Chloris roxburghiana	G	- - -	———	———	———	- - -	———
Rhus natalensis	T	- - -		———	- - -	- - -	———
Indigofera spinosa	D				———		
Aristida adscensionis	G	- - -	———	- - -	- - -	———	———
Acacia bussei	T		———	———	———	———	———
Dactyloctenium aegyptium	G			———		———	
Acacia seyal	T	- - -	- - -	- - -	———	———	- - -
Boswelia hildebrandtii	T	- - -	- - -	———	- - -	———	———
Acacia etbaica	T	- - -		———	- - -	———	———
Leptothrium senegalense	G			———	———	———	- - -
Acacia nilotica	T	- - -	- - -	———	———	———	———
Acacia drepanolobium	T		- - -	———	———	———	———
Acacia brevispica	S			———	- - -	- - -	———
Pappea capensis	T			———	———	———	———
Commiphora africana	T		- - -	- - -	———	———	———
Terminalia brownii	T			———	- - -	- - -	———
Combretum molle	T			———	- - -	———	———
Themeda triandra	G			- - -	———	———	———
Heteropogon contortus	G		- - -	- - -		———	———
Hyparrhenia hirta	G			- - -		———	———
Dodonea viscosa	S					———	———
Olea africana	T						———
Juniperus procera	T						———

1 Based on a survey of 134 sites. Solid lines indicate greater probability of occurrence in respective altitude classes. Species are arranged from those occurring more at lower elevations (top of table) to those occuring more at higher elevations (bottom of table).

2 Where T= tree, S = shrub, G = grass and D = dwarf shrub.

Source: Raw data from Corra (1986).

Table A7. *Soil colour distribution for sites containing 55 important plant species in the SORDU sub-project area.*[1]

Species	Growth form[3]	Soil colour class[2]: Light red to red	Soil colour class[2]: Dark red-gray; dark red-brown to yellow red	Soil colour class[2]: Brown; strong to dark brown	Soil colour class[2]: Dark gray to light brown-gray
Eleusine floccifolia	G	———	- - -		
Juniperus procera	T	———	———		
Acacia etbaica	T	———	———		
Heteropogon contortus	G	———	———		
Dodonea viscosa	S	———	———		
Acacia drepanolobium	T	———	- - -	- - -	
Pappea capensis	T	- - -	———		
Commiphora africana	T	———	- - -	- - -	
Terminalia brownii	T	- - -	———	- - -	
Chloris roxburghiana	G	———	- - -	- - -	
Lintonia nutans	G	- - -	———	- - -	
Boscia angustifolia	T	———	- - -	———	
Indigofera spinosa	D		———		
Sorghum arundinaceum	G		———		
Schoenfeldia transiens	G		———		
Panicum maximum	G		———		
Olea africana	T		———		
Dactyloctenium aegyptium	G		———		
Acacia paolii	T		———		
Acacia horrida	T		———		
Acacia seyal var *fistula*	T	- - -	———	- - -	
Balanites aegyptica	T	- - -	———	———	
Balanites orbicularis	T	- - -	———	———	
Sporobolus pyramidalis	G	- - -	———	———	
Acacia mellifera	T	- - -	———	———	
Delonix elata	T	———	- - -	———	
Cadaba glandulosa	S		———	- - -	
Omocarpum trachycarpum	T	———	- - -	———	
Acacia reficiens	T	- - -	———	———	
Cenchrus ciliaris	G	———	- - -	———	- - -
Acacia nilotica	T	———	- - -	———	———
Aristida adscensionis	G	- - -	———	- - -	- - -
Sesamothamnus rivae	T		———	———	
Enteropogon macrostachyus	G	- - -	- - -	———	
Acacia senegal	T		———	———	
Acacia tortilis	T	———	- - -	———	———
Aspilia mossambicensis	F	- - -	———	———	———
Salvadora persica	T		———	———	
Cynodon dactylon	G	- - -	- - -	———	———
Rhus natalensis	T	———	- - -	- - -	———
Pennisetum mezianum	G	- - -	- - -	———	- - -
Dobera glabra	T		———	———	
Themeda triandra	G	———	- - -		———
Acacia seyal	S	———	- - -	- - -	———
Cordia sinensis	T	- - -	- - -	———	———
Acacia brevispica	S	———	- - -	- - -	———
Dichrostachys cinerea	T	———	- - -	———	
Sterculia rhynchocarpa	T		- - -	———	
Adenium obesum	S		- - -	———	
Hyparrhenia hirta	G	———	———		———
Leptothrium senegalense	G	———	- - -		———
Combretum molle	T	———	- - -		———
Boswellia hildebrandtii	T	- - -	———		———
Acacia bussei	T	- - -	———	- - -	———
Acacia nubica	S	- - -	———	———	———

1 Based on a survey of 134 sites. Solid lines indicate greater probability of occurrence in respective soil-colour classes.

2 Categories determined by Corra (1986).

3 Where T = tree, S = shrub, G = grass and D = dwarf shrub.

Source: Raw data from Corra (1986).

Table A8. *Slope distribution of 55 important plant species in the SORDU sub-project area.*[1]

Species	Slope class				
	Growth form[2]	2%	≤ 3–10%	11–20%	≥21%
Sorghum arundinaceum	G	———			
Dobera glabra	T	———	———		- - - -
Acacia drepanolobium	T	———	———	- - - -	- - - -
Acacia seyal var *fistula*	T	———	- - - -	———	
Indigofera spinosa	D		———		
Dactyloctenium aegyptium	G	———		- - - -	
Lintonia nutans	G	- - - -	- - - -	- - - -	- - - -
Balanites orbicularis	T	———	———	———	- - - -
Dichrostachys cinerea	T	———	- - - -	- - - -	- - - -
Pennisetum mezianum	G	———	- - - -	———	- - - -
Salvadora persica	T	———	———	- - - -	- - - -
Aspilia mossambicensis	F	- - - -	———	———	- - - -
Acacia horrida	T	- - - -	———	———	- - - -
Acacia nilotica	T	———	- - - -	———	- - - -
Acacia seyal var *seyal*	T	———	———	- - - -	- - - -
Cordia sinensis	T	———	———	- - - -	- - - -
Acacia tortilis	T	———	———	———	- - - -
Acacia bussei	T	- - - -	———	———	- - - -
Themeda triandra	G	———	- - - -	- - - -	———
Balanites aegyptica	T	- - - -	- - - -	———	- - - -
Acacia paolii	T		———	———	
Acacia mellifera	T	- - - -	———	———	- - - -
Omocarpum trachycarpum	T	———	- - - -	- - - -	———
Boscia angustifolia	T	- - - -	———	- - - -	- - - -
Rhus natalensis	T	———	- - - -	———	———
Acacia brevispica	S	- - - -	- - - -	———	- - - -
Cadaba glandulosa	S	- - - -	———	- - - -	- - - -
Acacia reficiens	T	- - - -	———	———	- - - -
Leptothrium senegalense	G	- - - -	———	———	- - - -
Cynodon dactylon	G	- - - -	- - - -	———	- - - -
Combretum molle	T	———	- - - -	- - - -	———
Cenchrus ciliaris	G	- - - -	———	———	- - - -
Delonix elata	T	- - - -	———	- - - -	———
Chloris roxburghiana	G	- - - -	———	———	———
Acacia nubica	S	- - - -	- - - -	———	- - - -
Commiphora africana	T	- - - -	———	———	———
Sesamothamnus rivae	T		———	———	- - - -
Pappea capensis	T	- - - -	- - - -	———	———
Schoenfeldia transiens	G	———	———		———
Eleusine floccifolia	G	———	———		———
Adenium obesum	S	———	———	———	———
Terminalia brownii	T	———	———	———	———
Panicum maximum	G			———	
Aristida adscensionis	G	- - - -	- - - -	- - - -	———
Heteropogon contortus	G	- - - -	- - - -	- - - -	———
Boswelia hildebrandtii	T	- - - -	- - - -	———	———
Sporobolus pyramidalis	G	- - - -	- - - -	———	———
Hyparrhenia hirta	G	———	- - - -		———
Enteropogon macrostachyus	G		———	———	———
Acacia etbaica	T	- - - -	- - - -	- - - -	———
Acacia senegal	T		- - - -	———	———
Dodonea viscosa	S	- - - -	- - - -	- - - -	———
Sterculia rhynchocarpa	T			———	———
Juniperus procera	T			- - - -	———
Olea africana	T				———

1 Based on a survey of 134 sites. Solid lines indicate greater probability of occurrence in respective slope classes.

2 Where T = tree, S = shrub, G = grass and D = dwarf shrub.

Source: Raw data from Corra (1986).

Table A9. *Vegetation structure distribution for 55 important plant species in the SORDU sub-project area.*[1]

Species	Growth form[2]	Physiognomic class				
		Woodland	Bushland	Bush–grassland	Bush–thicket	Grassland
Juniperus procera	T	———		- - -		
Dodonea viscosa	S	———		- - -		
Hyparrhenia hirta	G	———		- - -		
Acacia seyal var *seyal*	T	———		- - -		
Sesamothamnus rivae	T	———	———	———		
Terminalia brownii	T	———		- - -	———	
Acacia reficiens	T	———		———	- - -	
Salvadora persica	T	- - -		———		
Combretum molle	T	———		- - -	———	
Aristida adscensionis	G	———	———	- - -	- - -	- - -
Acacia etbaica	T	———		- - -	———	
Boscia angustifolia	T	- - -	———	———	———	
Acacia bussei	T	———		———	———	
Rhus natalensis	T	———	———	- - -	———	
Enteropogon macrostachyus	G	———	———	- - -	———	———
Acacia brevispica	S	———	———	- - -	———	
Heteropogon contortus	G	———		- - -	———	———
Dactyloctenium aegyptium	G	———			———	
Leptothrium senegalense	G	———		- - -	———	
Dichrostachys cinera	T	———		- - -	———	
Pappea capensis	T	———		- - -	———	
Adenium obesum	S	———		- - -	———	
Cynodon dactylon	G	- - -	———	———	- - -	- - -
Acacia nilotica	T	———	———	- - -	———	- - -
Balanites orbicularis	T	- - -		———	- - -	
Omocarpum trachycarpum	T	———	———	- - -	———	———
Acacia mellifera	T	- - -	———	- - -	———	- - -
Acacia nubica	S	———		- - -	———	- - -
Cenchrus ciliaris	G	———	———	- - -	———	———
Indigofera spinosa	D			———		
Sorghum arundinaceum	G			———		
Schoenfeldia transiens	G			———		
Olea africana	T			———		
Eleusine floccifolia	G			———		
Dobera glabra	T			———		
Acacia tortilis	T	- - -	- - -	———	———	- - -
Commiphora africana	T	———		- - -	- - -	- - -
Acacia seyal var *fistula*	T	———		———		———
Themeda triandra	G	———		- - -		———
Chloris roxburghiana	G	———		- - -	———	———
Pennisetum mezianum	G	- - -		———	- - -	———
Balanites aegyptica	T	- - -	———	———	- - -	———
Boswellia hildebrandtii	T			———	———	
Cordia sinensis	T	- - -		———	- - -	- - -
Aspilia mossambicensis	F	- - -		———	———	- - -
Acacia senegal	T	———		- - -	———	———
Delonix elata	T			———	———	
Acacia horrida	S			———	- - -	———
Cadaba glandulosa	T			———	———	———
Sterculia rhynchocarpa	G				———	
Panicum maximum	T				———	
Acacia drepanolobium	G	- - -		- - -	- - -	———
Sporobolus pyramidalis	G	———		- - -	———	———
Lintonia nutans	T			———		———
Acacia paolii	T			———		———

1 Based on a survey of 134 sites. Solid lines indicate greater probability of occurrence in respective physiognomic classes.

2 Where T = tree, S = shrub, G = grass and D = dwarf shrub.

Source: Raw data from Corra (1986).

Table A10. *Soil reactivity for sites containing 55 important plant species in the SORDU sub-project area.*[1]

Species	Growth form[3]	Soil-reactivity class[2]	
		Negative	Positive
Indigofera spinosa	D	———————	
Themeda triandra	G	———————	
Terminalia brownii	T	———————	
Schoenfeldia transiens	G	———————	
Panicum maximum	G	———————	
Pappea capensis	T	———————	
Olea africana	T	———————	
Leptothrium senegalense	G	———————	
Juniperus procera	T	———————	
Eleusine floccifolia	G	———————	
Dodonea viscosa	S	———————	
Dactyloctenium aegyptium	G	———————	
Combretum molle	T	———————	
Acacia brevispica	S	———————	
Dichrostachys cinera	T	———————	- - - - - - - - - - -
Omocarpum trachycarpum	T	———————	- - - - - - - - - - -
Chloris roxburghiana	G	———————	- - - - - - - - - - -
Heteropogon contortus	G	———————	- - - - - - - - - - -
Acacia seyal var *seyal*	T	———————	- - - - - - - - - - -
Rhus natalensis	T	———————	- - - - - - - - - - -
Hyparrhenia hirta	G	———————	- - - - - - - - - - -
Acacia nilotica	T	———————	- - - - - - - - - - -
Aristida adscensionis	G	———————	- - - - - - - - - - -
Commiphora africana	T	———————	- - - - - - - - - - -
Sporobolus pyramidalis	G	———————	- - - - - - - - - - -
Acacia bussei	T	———————	- - - - - - - - - - -
Acacia etbaica	T	———————	- - - - - - - - - - -
Acacia drepanolobium	T	———————	- - - - - - - - - - -
Acacia senegal	T	———————	- - - - - - - - - - -
Boscia angustifolia	T	———————	- - - - - - - - - - -
Boswellia hildebrandtii	T	———————	- - - - - - - - - - -
Pennisetum mezianum	G	———————	- - - - - - - - - - -
Cenchrus ciliaris	G	———————	- - - - - - - - - - -
Acacia tortilis	T	- - - - - - - - - - -	———————
Enteropogon macrostachyus	G	- - - - - - - - - - -	———————
Acacia nubica	S	- - - - - - - - - - -	———————
Balanites aegyptica	T	- - - - - - - - - - -	———————
Cynodon dactylon	G	- - - - - - - - - - -	———————
Balanites orbicularis	T	- - - - - - - - - - -	———————
Aspilia mossambicensis	F	- - - - - - - - - - -	———————
Acacia mellifera	T	- - - - - - - - - - -	———————
Sterculia rhynchocarpa	T	- - - - - - - - - - -	———————
Acacia reficiens	T	- - - - - - - - - - -	———————
Sesamothamnus rivae	T	- - - - - - - - - - -	———————
Cordia sinensis	T	- - - - - - - - - - -	———————
Adenium obesum	S	- - - - - - - - - - -	———————
Acacia seyal var *fistula*	T	- - - - - - - - - - -	———————
Lintonia nutans	G	- - - - - - - - - - -	———————
Cadaba glandulosa	S	- - - - - - - - - - -	———————
Acacia horrida	T	- - - - - - - - - - -	———————
Salvadora persica	T	- - - - - - - - - - -	———————
Delonix elata	T	- - - - - - - - - - -	———————
Acacia paolii	T	- - - - - - - - - - -	———————
Dobera glabra	T	- - - - - - - - - - -	———————
Sorghum arundinaceum	G		———————

1 Based on a survey of 134 sites. Solid lines indicate greater probability of occurrence in respective soil reactivity classes.

2 Reactivity of top soil to 4 M HCl. Negative values for soil reactivity occurred more at higher elevations dominated by basement-complex formations. Positive values for soil reactivity occurred more at lower elevations dominated by volcanics and mixed soils.

3 Where T = tree, S = shrub, G = grass and D = dwarf shrub.

Source: Raw data from Corra (1986).

Annex B

Table B1. *Distribution of six agro-ecological zones within 29* madda *or* madda *groups in the southern rangelands.*[1]

Madda	Agro-ecological zones					
			Lower semi-arid			
	Subhumid	Upper semi-arid	Basement-complex soil	Mixed soils	Arid	Bottomlands[2]
Arbele	0	<1	4	56	40	0
Arero	41	43	4	0	0	12
Bidiru	0	0	0	84	8	8
Cheri Liche	0	37	0	35	28	0
Dibegayo	5	39	5	49	5	0
Did Hara	1	70	6	0	1	21
Did Yabelo	46	47	1	0	0	6
Dilo Goraye	<1	0	2	34	60	3
Dokole	38	10	10	42	0	0
Dubluk	<1	0	79	20	0	0
Elwaya	0	4	11	77	0	8
Gelchet	0	5	9	40	41	5
Gobso	22	6	16	50	3	3
Gololcha	52	11	12	16	9	0
Harwe-U/Deritu	20	6	23	46	3	1
Hidi Lola	0	65	10	20	0	4
Hobok	0	0	2	6	88	4
Kadim	0	0	1	23	76	0
Marmaro	0	8	0	87	<1	5
Medecho	0	14	54	19	2	11
Orbate Gedi	3	11	7	50	26	3
Orbate Oli	13	2	0	31	46	7
Roms/Mega	2	0	25	42	9	22
Saki/Megado	0	4	0	58	38	0
Sarite	5	7	0	32	15	41
Soda/Igo	0	7	72	3	1	17
Votalo	63	23	14	0	0	0
Web/Gayu/Melbana	0	25	54	0	<1	21

1 See text for description of agro-ecological zones. See Figure 2.10 and Figure B1 for map details.

2 Includes Vertisols.

Source: D. L. Coppock (ILCA, unpublished data based on results from Assefa Eshete et al (1986)).

Table B2. *Per cent average basal cover for herbaceous (grass, legume and forb) and small shrub vegetation on and off protected calf pastures* (kalo) *in the southern rangelands.*[1]

Local no.	*Kalo*	Per cent average basal cover				
		Grass	Forbs	Legume	Total herbaceous	Shrub
1	Off	40.4	2.0	0.0	42.5	57.5
	On	56.1	0.0	3.2	59.3	40.2
2	Off	39.7	0.2	3.8	43.7	55.8
	On	50.9	0.4	4.5	55.8	43.7
3	Off	37.0	0.2	10.8	51.6	48.0
	On	35.0	2.1	9.8	20.5	46.9
4	Off	31.1	3.5	28.4	63.1	28.4
	On	50.2	0.4	3.3	45.7	53.8
5	Off	67.4	0.3	9.5	77.2	22.3
	On	69.6	1.0	19.4	90.5	9.5
6	Off	40.8	0.2	5.6	46.6	53.4
	On	65.5	0.2	0.3	66.5	33.4
7	Off	30.7	0.1	0.2	31.3	68.7
	On	64.8	0.0	0.9	65.7	34.3
8	Off	39.3	3.4	28.2	70.8	29.2
	On	29.5	6.7	16.9	53.6	46.4

1 Where protected sites had been removed from continuous grazing pressure for at least seven years. Cover was determined using the method of Daubenmire (1959) with 60 plots/site.

Source: Menwyelet Atsedu (1990).

Table B3. *Average per cent feeding time (±SE) spent on various browse species by camels in the Beke Pond region of the southern rangelands during four seasons in 1985–86.*[1]

Species	Season[2]			
	Cool dry	Short rains	Warm dry	Long rains
Acacia brevispica	23±31	67±11	10±16	56±15
Rhus natalensis	32±5	10±10	3±10	4±14
Grewia tembensis	2±3	4±4	—	11±9
Commiphora africana	—	2±6	—	3±3
Acacia etbaica	—	3±6	—	3±2
Acacia tortilis	—	—	6±6	2±2
Cadaba farinosa	6±12	—	17±14	—
Dichrostachys cinerea	1±2	1±2	—	4±4
Ormocarpum mimosoides	1±2	—	—	1±1
Euclea shimperi	1±3	1±3	5±6	—
Balanites spp	—	1±2	17±9	—
Acacia seyal	—	—	1±2	2±1
Phyllanthus somalensis	4±5	—	—	—
Acacia nilotica	2±2	—	—	1±2
Acacia goetzii	4±5	—	—	—
Boscia angustifolia	—	3±3	4±5	—
Albizia amara	6±6	—	—	—
Acacia drepanolobium	3±3	4±4	—	—
Caucanthus auriculatus	1±2	—	—	2±4
Commiphora habessinica	—	—	—	2±2
Grewia bicolor	2±5	—	—	—
Vernonia cinerascens	—	—	—	4±5
Dahlbergia microphylla	—	—	—	2±2
Capparis tomentosa	5±11	—	—	—
Acacia bussei	—	—	—	2±4
Total per cent identified	93	96	63	99

1 See text for methodological details.

2 The cool dry season is from July to September, the short rains occur in October and November, the warm dry season is from December to March and the long rains occur in April to June.

Source: Woodward (1988).

Table B4. *Average per cent feeding time (±SE) spent on various browse species by goats at the Beke Pond region of the southern rangelands during four seasons in 1985–86.*[1]

Species	Season[2]			
	Cool dry	Short rains	Warm dry	Long rains
Acacia brevispica	27±15	40±12	16±15	34±8
Rhus natalensis	19±5	12±9	12±5	4±5
Grewia tembensis	—	10±9	1±2	9±5
Commiphora africana	—	2±3	1±3	3±2
Acacia etbaica	5±9	4±6	3±4	9±8
Acacia tortilis (leaf)	—	—	3±6	3±2
Acacia tortilis (flower)	—	—	36±37	—
Cadaba farinosa	2±3	—	5±7	—
Dichrostachys cinerea	—	2±3	2±2	3±3
Ormocarpum mimosoides	—	3±7	—	9±7
Euclea shimperi	2±2	—	6±7	—
Balanites spp.	2±2	1±2	—	—
Acacia seyal	—	—	2±3	3±2
Phyllanthus somalensis	4±5	2±3	—	—
Acacia nilotica	—	—	—	2±3
Acacia goetzii	4±5	—	2±5	—
Boscia angustifolia	—	—	2±4	—
Albizia amara	2±3	—	—	—
Acacia drepanolobium	3±4	—	—	—
Caucanthus auriculatus	5±8	—	—	—
Commiphora habessinica	2±4	—	—	—
Grewia bicolor	6±8	—	—	—
Vernonia cinerascens	—	2±3	—	4±5
Lannea floccossa	—	—	7±15	1±3
Plectranthus ctilongipes	—	2±3	—	—
Total per cent identified	80	80	98	84

1 See text for methodological details.

2 The cool dry season is from July to September, the short rains occur in October and November, the warm dry season is from December to March and the long rains occur in April to June.

Source: Woodward (1988).

Table B5. *Average per cent feeding time (±SE) spent on various browse species by sheep in the Beke Pond region of the southern rangelands during four seasons in 1985–86.*[1]

Species	Season[2]			
	Cool dry	Short rains	Warm dry	Long rains
Acacia brevispica	14±13	11±13	5±10	34±21
Rhus natalensis	14±9	9±14	7±11	—
Grewia tembensis	—	6±11	1±4	11±7
Commiphora africana	—	2±3	—	4±9
Acacia etbaica	—	—	—	1±2
Acacia tortilis (leaf)	—	—	4±10	—
Acacia tortilis (flower)	—	—	58±45	—
Cadaba farinosa	3±7	—	—	—
Dichrostachys cinerea	—	6±9	2±2	43±7
Ormocarpum mimosoides	—	—	—	9±16
Euclea shimperi	—	—	1±4	—
Acacia seyal	—	1±2	—	1±3
Phyllanthus somalensis	1±3	—	1±3	2±2
Albizia amara	1±2	—	—	—
Acacia drepanolobium	3±2	—	—	—
Caucanthus auriculatus	4±7	—	—	—
Grewia bicolor	3±4	—	—	—
Vernonia cinerascens	—	—	2±5	—
Lannea floccossa	—	—	1±1	—
Dahlbergia microphylla	1±4	—	—	—
Cordia gharaf	—	—	3±3	—
Capparis tomentosa	—	11±15	—	—
Combretum molle	—	—	—	2±4
Total per cent identified	44	46	85	68

1 See text for methodological details.

2 The cool dry season is from July to September, the short rains occur in October and November, the warm dry season is from December to March and the long rains occur in April to June.

Source: Woodward (1988).

Table B6. *Summary of population trend, diet preference for livestock and abundance of browse species in the Beke Pond area of the southern rangelands.*[1]

Plant species	Indicators: Trend		Preference				Abundance	
	Hill	Low	CD	SR	WD	LR	>10%V	>10%D
Acacia brevispica	S	—	N	S	S	S	X	X
Acacia drepanolobium	I	I	—	A	A	—	X	
Acacia etbaica	I	—	N	N	N	N		X
Acacia tortilis	I	—	—	—	N	N		X
Albizia amara	—	I	A	A	—	—	X	
Balanites spp	—	—	—	N	S	—		X
Cadaba farinosa	—	—	S	—	S	—		X
Capparis tomentosa	—	—	—	—	S	—		X
Commiphora africana	I	—	A	A	—	A	X	
Dichrostachys cinerea	I	—	A	—	N	N		X
Euclea shimperi	—	I	A	A	N	—	X	X
Grewia bicolor	—	—	S	—	—	—		X
Grewia tembensis	I	I	N	N	—	S		X
Lannea floccossa	I	—	A	A	N	A	X	
Ormocarpum mimosoides	—	—	—	N	—	N		X
Rhus natalensis	I	S	S	S	S	N		X

1 Where trend is segregated according to hillsides (Hill) or flats and depressions (Low) and S indicates a stable population, I indicates increasing populaition (larger percentage of smaller individuals); — indicates very low abundance such that trend could not be determined. Preference according to season (where CD = cool dry; SR = short rains; WD = warm dry; and LR= long rains) and ranked as N (neutral; no preference), S (selected for), A (avoided) or — (insufficient data). Abundance categorised as relative occurence in vegetation (V; greater than 10% of cover) or occurrence in diet (D; greater than 10% of diet); X indicates species equalled or exceeded 10% in the respective category.

Source: Woodward (1988).

Table B7. *Scientific and vernacular name[1], growth form, importance value and traditional household uses of native plants in the southern rangelands.*

Scientific name	Vernacular name	Growth form[2]	Value[3]	Traditional utilisation
Acacia brevispica[4]	*hamaresa*	S	VI	Wood for construction (termite resistant); root extracts have medicinal value.
Acacia bussei[4,5]	*halo*	T	VI	Extracts for tanning, pigments; hard wood for fencing, firewood and utensils; indicator of onset of wet seasons by green flush; bark strips for rope and matting.
Acacia drepanolobium[4]	*fulesa*	T	—	Edible gum during drought.
Acacia elatior	—	T	I	Firewood; fencing.
Acacia etbaica	*alkebesa*	T	I	Firewood; fencing; shade tree.
Acacia goetzei	*bura*	T	VI	Wood for fencing and incense; ceremonial and shade tree; bark extracts for red dyes; charcoal for fumigation of milk utensils and people (sauna).
Acacia mellifera	*sapansa*	T	I	Bark burned for fumigation; wood for fencing.
Acacia nilotica	*burquqe*	T	VI	Firewood; fencing; bark extract for red dyes; pod extract for black dyes.
Acacia nubica	*wanga*	T	—	Bark extract has medicinal value (boiled for colds); bark tied around fence at encampment for disease prevention (spiritual belief).
Acacia reficiens[4]	*sigirso*	T	I	Fencing; medicinal paste from bark; rope from bark and cortex; wood for corral doors.
Acacia senegal	*hidado*	T	VI	Gum Arabic; firewood; fencing.
Acacia seyal[5]	*wachu*	T	VI	Extracts for red pigments; bark extracts to make paint for wooden handicrafts; fencing; firewood; gum; root has medicinal value for camels.
Acacia tortilis	*tedecha*	T	VI	Shade tree; wood for axe handles.
Acacia tortilis	*urbu*	P	VI	Soup from boiled seeds and pods for people during drought.
Acacia fruticosa	*diri-boranto*	S	—	Ceremonial branches; construction wood for making weapons and traditional beds.
Albizia anthelmintica	*wachu*	S	—	Root extracts used for treatment of tape- worm and roundworm.
Aloe sp	*hargessa*	F	—	Pith chewed for snakebite cure; sap protects wounds; root extracts in milk as medicine for colds, flu; extracts for stomach ache, eye drops; when a son is born, a piece of Aloe will be placed on the top of the hut.

1 Borana Oromigna.

2 Where growth form is indicated as S (multi-stemmed shrub), T (single-stemmed tree), P (pods or dry, dehiscent fruits), F (herbaceous forb or dicot), and Su (succulent).

3 Where value is categorised as VI (very important) or I (important) according to Borana informants. Blanks suggest moderate or minor importance. Values are scored for use by people. Use by livestock as forage is reviewed in Section 3.3.5.1: *Livestock food habits.*

4 Considered as an encroaching species in the rangelands.

5 Economic value for handicrafts.

Source: Wilding (1984) and Tesfaye Wogayehu (CARE-Ethiopia, unpublished data).

Table B7 cont'd

Scientific name	Vernacular name	Growth form[2]	Value[3]	Traditional utilisation
Alysicarpus sp	*bobra*	F	—	Edible roots.
Amaranthus hybridus	*rafu*	F	—	Edible leaves.
Asparagus	*ergemsa*	F	VI	Root fibres for weaving milk containers; other ceremonial values.
Balanites aegyptica[5]	*badana okolo/luo*	T	VI	Leaves of new shoots chewed into paste for application for lesions; edible fruit; scent wood; gum; fumigation wood for milk containers; wood for utensils like butter whisk and butter spoons; construction wood; firewood.
Boscia angustifolia	*kalkacha*	T	VI	Carving wood for mortars and pestles for grinding grain and making coffee cups; twigs used as cleaning utensils.
Boscia coriacea	*kalkacha*	T	—	Carving wood; twigs used as cleaning utensils.
Boswellia hildebrantii	*dakara*	T	VI	Bark extracts for medicines, paste and dyes; edible root; incense; good firewood.
Cadaba heterotrichaduse	*duse*	T	—	Shade tree.
Calotropis procera	*boa*	S	—	Ceremonial grave marker; medicinal sap; leaves used in milk processing.
Canthium bogosensis	*ladan*	S	—	Edible fruit; incense; charcoal for fumigation of milk utensils and people (sauna); wood made into butter pots.
Canthium schimperianum	*galle*	S	—	Edible root and fruit; fibres for utensils, containers, binding and home construction.
Canthium setiflorum	*ladan*	S	—	Edible fruit; scent wood; fumigation wood.
Capparis tomentosa	*gora gel*	S	—	Fruit has medicinal value.
Carissa edulis	*dagamsa*	S	—	Edible fruit; spines for utensils and piercing ears; seed for dyes; medicine for toothaches.
Carissa schimperi	*quararu*	T	—	Cortex fibres for rope; edible fruit; bark extracts for emetics; firewood; poison sap for arrows from female fruit; male fruit is edible.
Carthamus tinctorius	*boria*	F	—	Medicinal sap for stomach problems.
Catha edulis	*chati*	S	—	Leaves chewed as a stimulant.
Caylusea abyssinica	*erenchi*	F	—	Edible leaves and stems.
Ceropegia sp	*kakalla*	S	—	Edible roots which contain water in dry seasons.
Coleus ignarius	*abune*	S	—	Dried leaves chewed as a tobacco-like stimulant; root extracts have medicinal value for children.
Combretum molle	*rukesa*	T	VI	Scent wood; shade tree.

Table B7 cont'd

Scientific name	Vernacular name	Growth form[2]	Value[3]	Traditional utilisation
Commiphora africana[4,5]	*hamessa*	T	—	Live fencing; wood for utensils like coffee cup, camel bell, milk pots and bowls.
Commiphora campestis[5]	—	T	—	Wood for carving milk pots.
Commiphora crenulata[4]	*siltacho*	T	I	Leaves for fumigation; wood for incense and fencing; charcoal for fumigation of people (*sauna*); sticks rubbed together can make sparks to start a fire.
Commiphora fluviflora[4]	*chaiaka*	T	I	Live fencing; sap used as soap; fibers to construct milk pots and coffee cups; spines are poisonous.
Commiphora paolii[4,5]	*agarsu*	T	VI	Branches to line well paths; bark extracts have medicinal value to accelerate delivery of human after-birth; diluted bark extracts as tick repellent; edible fruit; carving wood to make camel bell; sap as glue for arrows; edible gum; extracts for camel skin disorders; wood for fencing; fibres for weaving milk containers.
Commiphora rivae[4]	*agarsu*	T	I	Live fencing; wood for utensils.
Cordia africana	*kilta*	T	VI	Shade tree; edible fruit; wood for utensils; presence indicator of close water table; sticky gum for adhesive.
Cordia gharaf[4]	*medera*	S/T	VI	Edible fruit important in drought; gum is chewed; wood for fencing; carving wood for ceremonial sticks.
Cordia ovalis[5]	*medera* *hido*	S/T	VI	Carving wood; wood for sticks; edible fruit; wood for fencing.
Croton macrostachys	*mekanisa*	S	I	Extracts have medicinal value for venereal disease.
Cucumis sp	*burate*	F	—	Edible fruit.
Cyphostemma sp	*chobi loni*	F	—	Edible fruit and leaves; root extracts have medicinal value for cattle.
Datura stramonium	*qobo/sunki*	S	—	Extracts for poison; other extracts for wound healing.
Delonix baccal	*balanji*	T	VI	Fencing; wood for utensils like pestle; firewood; shade tree.
Delonix elata[5]	*sukeia*	T	VI	Wood carved into mortars used for pounding grain, household containers, camel bells, coffee bowls and milk jugs; shade tree.
Dichrostachys cinerea	*jirme*	T	—	Firewood; fencing; carved into utensils such as pestles; seed extracts for black dyes; extracts have medicinal value.
Dobera glabra	*gerse*	T	VI	Hard seed boiled for food; edible fruit; shade tree; wood for utensils such as stools; extracts have medicinal value.

Table B7 cont'd

Scientific name	Vernacular name	Growth form[2]	Value[3]	Traditional utilisation
Dombeya schimperania	*darissa*	T	—	Edible tuber.
Dracaena sp[5]	*ergamsa*	T	—	Root fibres woven into milk containers *(gorfa)*.
Ehretia cymosa	*ulaga*	S	—	Bark strips for construction.
Endostemen tereticaulis	*urgo*	F	—	Branches used for sweeping; fumigation wood.
Entada sp	*sokela*	T	—	Wood carved into household utensils.
Erythrina melanacantha[5]	*walensu*	T	VI	Wood carved into big stools, big milk jugs *(amuyou)*, coffee cups, butter pot *(dibe)*.
Euclea shimperi	*miesa*	S	I	Important ceremonial (*Jila)* plant, root extracts as medicine; edible fruit; wood for construction.
Euphorbia tirucalli	*ano*	Su		Live fencing; sap used to heal wounds.
Euphorbia candelabrum	*adama*	T	VI	Wood for troughs; sap for skin sores; wood beams used to split rocks for well construction.
Ficus glumosa	*kilta*	T	VI	Edible fruit; sap produces salivation response.
Ficus sycomorus	*oda*	T	VI	Edible fruit; wood for utensils; indicator of accessible water table; seed and root extracts have medicinal value for women after they have given birth.
Ficus thoningii	*dembi*	T	VI	Ceremonial grave marker; edible fruit; indicator for high water table; bark extracts for red dyes.
Gardenia volkensii	*gambeela*	S	—	Wood used for carving utensils; edible fruit; shade tree.
Gnidia stenophylloides	*arsa-arsita*	F	—	Extract added to milk as medicine for stomach ailments.
Grewia tembensis	*deeka*	S	VI	Edible fruit; branches used for arrows and construction.
Grewia tenax	*deeka*	S	VI	Similar to *Grewia tembensis.*
Grewia bicolor	*aroresa*	S	VI	Edible fruit; wood used for construction, spears and sticks; tea from boiled seeds; fibre for rope.
Grewia villosa	*ogomdi*	S	VI	Edible fruit; fibres used for weaving; edible root during drought.
Hibiscus micranthus	*bungala*	S	—	Edible fruit.
Indigofera suaveolens	*agagaro*	S	—	Twigs for toothbrush.
Ipomea sp	*baate*	S	—	Incense; fumigation charcoal for animal skins used for bedding.

Table B7 cont'd

Scientific name	Vernacular name	Growth form[2]	Value[3]	Traditional utilisation
Juniperus procera	*hindesa*	T	VI	Trunks for urban house posts (termite resistant); incense; fencing; shade tree; firewood.
Lannea floccosa	*handaraka*	T	VI	Edible fruit; wood carved into utensils; extracts as medicinal stomach anti-acid; ceremonial sticks.
Lantana viburnoides	*midan dubera*	S	—	Edible fruit.
Lawsonia inermis	*elam*	S	—	Extracts for hair dye.
Mariscus sp	*qundi*	—	—	Extracts for perfume used with butter for skin; scent wood; fibres for rope.
Maytenus senegalensis	*jimma*	T	—	Edible portions; extracts have medicinal value for eye infections.
Mimusops kummel	*bururi*	T	—	Edible fruit; shade tree.
Ocimum hadiense	*urgo dada*	S	I	Leaves added to butter to improve taste.
Ocimum suave	*anchabi*	S	—	Edible leaf extracts as a tobacco-like stimulant.
Olea africana	*ejersa*	T	—	Edible fruit; bark strips for construction; fumigation wood; firewood; strong construction wood; shade tree; sticks have ceremonial value.
Oncoba spinosa	*akoku*	S	—	Edible fruit.
Ormocarpum mimosoides	*butiye*	S	I	Wood for fencing; extracts have medicinal value.
Pappea capensis	*bika*	T	—	Edible fruit; firewood; shade tree.
Pennisetum mezianum	*ogondo*	G	—	Used for thatching roofs of huts.
Phyllanthus sepialis	*diri-werses*	S	—	Bark strips for fencing and bed construction; fibres for construction and weaving water containers.
Phyllanthus somalensis	*diri-wersesa*	S	I	Similar to *Phylanthus sepialis.*
Pittosporum viridifolium	*sole*	—	—	Leaf extracts have medicinal value for toothache.
Plectranthus sp	*baranbaressa*	S	I	Twig extracts have medicinal value for punctures and cuts.
Premna resinosa	*tateesa*	S	—	Edible fruit; fumigation wood.
Rhus natalensis	*debobesa*	S	I	Edible fruit. Extracts have medicinal value.
Ricinus communis	*qobbo*	S	—	Seed extracts have medicinal value for venereal disease.
Salvadora persica	*ade*	T	—	Twigs for toothbrush; extracts have medicinal value; fruit fermented for local alcoholic beverage.

Table B7 cont'd

Scientific name	Vernacular name	Growth form[2]	Value[3]	Traditional utilisation
Sansevieria abyssinica[5]	*alge/chake*	Su	VI	Sisal – like fibres woven into roofing mats for Gabra huts; bark strips for construction; source of water in dry seasons.
Sansevieria robusta[5]	*alge/chake*	Su	—	Similar to *Sanseviera abyssinica.*
Securinega virosa	*damela*	S	—	Edible fruit; wood carved into containers.
Solanum somalense	*hidi gaga*	S	—	Seed and root extracts have medicinal value.
Sterculia rhynchocarfa	*qarare*	T	VI	Edible fruit; fibres for woven containers; bark straps for well-ladder construction.
Tagetes minuta	*sunki*	F	—	Exotic poisonous weed in cultivated fields. Extracts can heal camel wounds.
Talinum portulacifolium	*tuma*	S	—	Root extracts have medicinal value for colds and for livestock.
Tamarindus indica	*rokha*	T	VI	Edible fruit; fruit extracts as a cleanser and laxative; wood carved for utensils; extracts have medicinal value for women after birth.
Terminalia brownii	*biresa*	T	VI	Incense; fumigation wood; bark extracts for yellow dyes; wood carved into pestles; bark extracts for medicine; shade tree.
Terminalia orbicularis	*bissiqa-i*	T	—	Wood burned to fumigate utensils; edible root (tuber).
Veronia amygdalina	*ebicha*	S	—	Pith used as soap; flowers source of carbohydrate for honey production.
Vigna vexillata	*singo*	F	—	Edible wild "onion" important in drought; extracts for medicine to cure foot-and-mouth disease in livestock.
Vigna sp	*chame*	F	—	Edible root.
Ximenia americana	*huda*	S/T	—	Edible.
Zaleya pentandra	*arado*	F	—	Edible leaves; medicine for calves and sheep to kill worms in nasal cavities.
Ziziphus mauritiana	*kukura*	T	—	Edible fruit; shade tree.

Table B8. *Occurrence of apparently encroaching woody species on the central Borana Plateau as recorded in a survey of 801 field sites in 1989.*[1]

Species	Number of observations	Frequency (%)
Commiphora spp	99	30.7
Acacia brevispica	63	19.5
Acacia nubica	29	9
Acacia nilotica	23	7.1
Acacia drepanolobium	18	5.6
Acacia seyal	17	5.3
Acacia horrida	17	5.3
Dicrostachyus cinera	15	4.6
Acacia mellifera	14	4.3
Lannea spp	10	3.1
Acacia bussei	8	2.5
Boswellia sp	5	1.5
Aspelia sp	5	1.5
Total	323	100

1 This list omits *A. horrida* which is an encroaching species on the western side of the study area (Solomon Kebede, 1989) and *A. reficiens* which occurs in more arid locations (Pratt, 1987a). It also omits *Albizia amara* which is regarded as an encroacher in wetter locations (Michel Corra, ILCA, personal communication).

Source: Hacker (1990).

Table B9. *Principal grass and shrub forages for hand-reared and grazing calves during dry seasons of average rainfall, dry and drought years in the southern rangelands as ranked by 32 Borana herd owners in 1988.*[1]

Species names		Seasons[2]					
Vernacular[3]	Scientific	WDA	WDD	WDDR	CDA	CDD	CDDR
Grasses							
– *ogondo*	*Pennisetum* spp	2.53w	1.97*w*	1.9*w*	2.37*w*	1.71*w*	2.23*w*
– *alelo*	*Chrysopogon* sp	4.13*x*	5.98*x*	6.18*x*	4.34*x*	6.03*x*	6.15*xy*
– *metagudessa*	*Cenchrus ciliaris*	5.16*xy*	6.34*y*	—	6.34*wx*	6.35*x*	6.5*yz*
– *hido*	*Cynodon* sp	5.94*xy*	5.95*xy*	6.18*x*	6.34*xy*	6.29*x*	6.15*xy*
Shrubs							
– *bika*	*Pappea capensis*	—	—	6.21*xy*	—	—	6.18*xy*
– *ogomdi*	*Grewia* spp	—	—	6.34*xy*	—	—	6.31*yz*

1 Herd owners were asked to rank forages from most important (1) to least important (6) for various dry seasons. Entries in each column accompanied by the same letter *(w, x, y, z)* were not ranked significantly different ($P>0.05$) according to Friedman's test (Steel and Torrie, 1980).

2 Where WDA = warm dry season (December to March) of a year having average rainfall; WDD = warm dry season of a lower-than-average rainfall year; WDDR = long dry season of a drought year; CDA = cool dry season (October to November) of a year having average rainfall; CDD = cool dry season of a dry year; and CDDR = cool dry season of a drought year.

3 Borana Oromigna.

Source: Menwyelet Atsedu (1990).

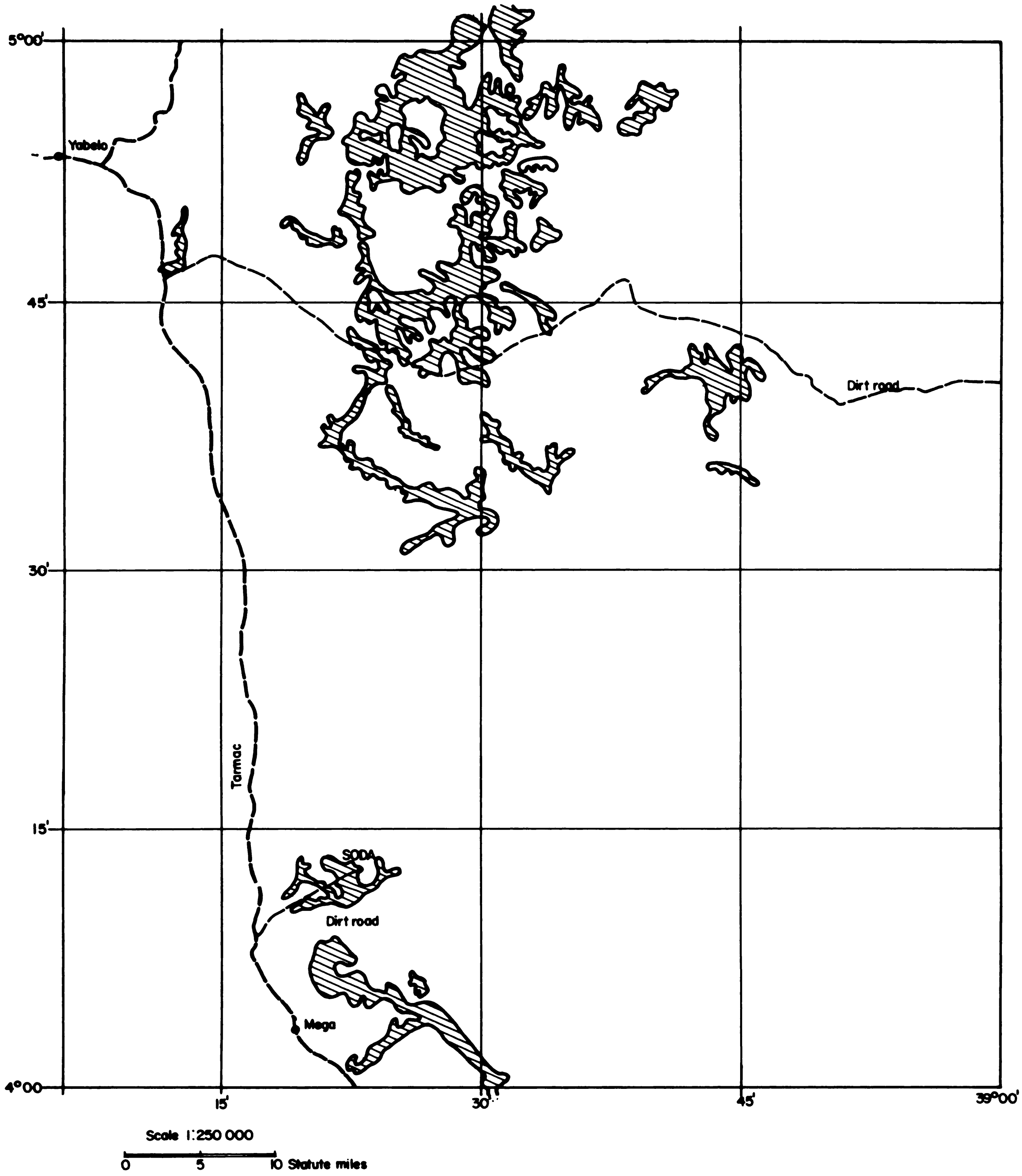
Figure B1. *Ecological map of the south-western Borana Plateau.*

Source: Assefa Eshete et al (1986).

See Annex C for the accompanying legen.

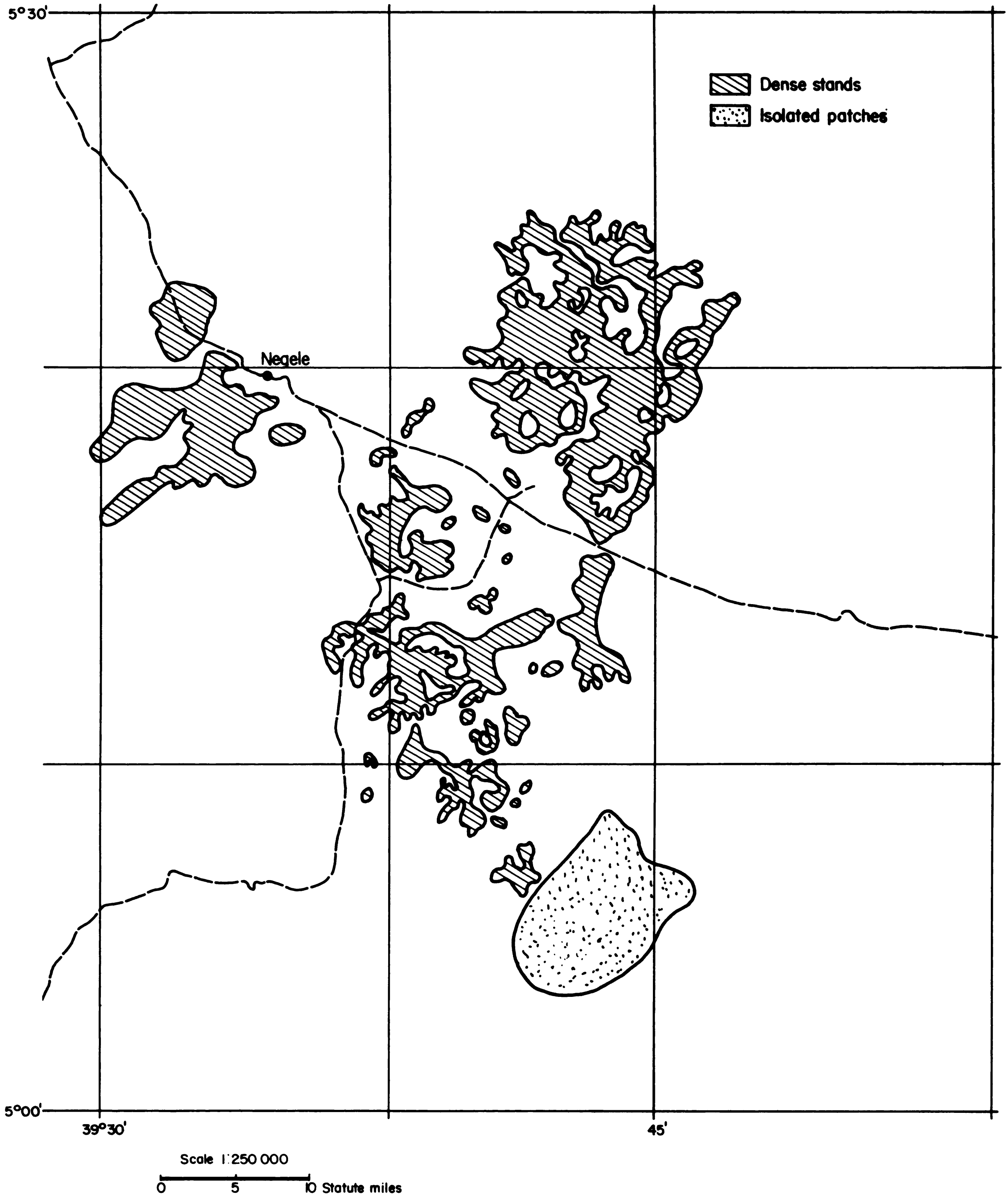
See fold-out map.

Figure B2a. *Aerial extent of stands of* Acacia drepanolobium *in the north of the study area on the central Borana Plateau.*



Source: Tamene Yigezu (TLDP/ILCA postgraduate researcher, unpublished data).

Figure B2b. *Aerial extent of stands of* Acacia drepanolobium *in the east of the study area on the central Borana Plateau.*



Source: Tamene Yigezu (TLDP/ILCA postgraduate researcher, unpublished data).

Annex C

Ecological map of south-western Borana[1]

Information gathered in the south-western portion of the Borana Plateau during 1982–86 by ILCA included details related to climate, soils and vegetation. This information has been used to produce an ecological map (see Figure B1, presented as a fold-out at the back of this volume). This annex covers two objectives: (1) to present the map legend; and (2) to provide some interpretation of the map to assist development planning. Readers interested in more interpretative details should consult Assefa Eshete et al (1986).

The map does not duplicate the AGROTEC/CRG/SEDES Associates map of Sidamo that was based on phyto-sociological concepts (AGROTEC/CRG/SEDES Associates, 1974d). The map presented here was based on satellite imagery as well as ground-truthing (see Section 3.2.1: *Ecology and land-use map*).

There were problems of interpretation of satellite imagery, however. Ecological subunits did not always have distinct boundaries and the quality of satellite images was not consistent. Scale distortions across images occurred and registration of images (i.e. transferring results to a topographic map) was difficult. Soil background also changed the apparent category of vegetation because of colour distortions. For example, trees varied from dark red to bright orange; shrubs were grey or blue on volcanics and yellowish on basement-derived soils; and grass appeared pale blue on volcanics and pale orange on basement-complex formations.

The first level of differentiation among mapping units is the combined influence of climate and soils on the environment. Subunits were primarily designated from variation in land form or vegetation physiognomy associated with soil features. The resulting legend is therefore not a simple one-axis presentation.

Map legend

The following material should be used in conjunction with Figure B1, Annex B.

1. Subhumid zone

The units in this zone are either densely wooded or previously wooded lands which have been exploited for fire wood and building materials or cleared for cultivation. The climate has favoured establishment of small towns (such as Arero, Yabelo and Mega) in the vicinity of these forests and this has traditionally put local pressure on resources. The present situation (i.e. 1986) seems to be stable and no changes in location or extent of remaining forest could be observed over the last 10 to 15 years from comparisons between the map of AGROTEC/CRG/SEDES Associates (1974d) and more recent satellite imagery.

1.A *Juniperus* forest

Intact forest can still be observed in two locations which are far from towns. The facets are:

1.A.1 = Group of valleys with steep walls within the Mega–Dokole massif. The site can be observed from the air. It is well protected and does not reveal significant human influence.

1.A.2 = Large area (150 km^2) north of Arero with human influences limited to the periphery.

1.B *Juniperus* woodland

Juniper trees are still abundant but there is evidence of moderate human exploitation. Shrubs have started to grow in interspaces between juniper trees. Plant associations also include elevational transition types. Facets include:

1.B.1 = This is the more open part of the Arero forest.

1.B.2 = Most of the higher ground of the Yabelo mountains have stands of juniper trees which are protected. The stands are separated by patches of shrubs.

1.C Mixed woodlands

Although woody cover is high, juniper trees are increasingly rare. Better indicator plants are *Olea*, *Euclea* and *Dodonea* spp. The most common shrub is often *Tarconanthus camphoratus*, usually considered an invader, which can be seen near the summit of the Mega range. Facets include:

1.C.1 = These communities cover the slopes of Gamedu and Gabela; juniper is present in small pockets.

1.C.2 = Rocky and steep slopes around Mega are covered with this very variable woodland; *Tarconanthus* sp is abundant.

1.C.3 = These facets correspond to slopes on the Yabelo range as well as those in the northwestern portion of the Teltele plateau. *Juniperus* and *Olea* spp are accompanied

1 This annex has been adapted from text in Assefa Eshete et al (1986: pp 3–18).

by *Tarconanthus* sp, *Acacia brevispica* and *Croton macrostachyus*.

1.C.4 = This unit has been differentiated from 1.C.2 because of the numerous campsites and settlements associated with small, cultivated fields. It occupies a large valley and covers rugged hills at the northern end of Mega Mountain.

1.D *Terminalia* sp woodlands

These sites are intermediate between the subhumid and upper semi-arid zones and are found on the lower slopes of mountains with occasional *Juniperus* sp, but more commonly *Terminalia* sp, *Combretum* sp and *A. brevispica*. The following facets are differentiated by land form:

1.D.1 = Very rocky slopes below Arero town, dissected by small river beds. Also occurs along the eastern fringe of the Arero massif.

1.D.2 = Previously cultivated slopes south of Yabelo town, now invaded by *A. brevispica* and *Commiphora* spp on shallow soils.

1.D.3 = Very rocky terrain south-east of Yabelo, isolated from the other woodlands. Occurs on Lithosols.

1.D.4 = Rugged terrain with granitic outcrops, possibly derived from unit 1.C.4 after cultivated fields have been abandoned.

1.E Cropped areas

These sites benefit from higher rainfall and cooler temperatures which allow regular cultivation. They are situated on top of mountain ranges, in valleys or at the base of mountains:

1.E.1 = Cropland around Yabelo town, presently expanding eastward along drainages into various acacia communities (especially *A. tortilis*, *A. nilotica* and *A. seyal*).

1.E.2 = Mosaic of fields and grasslands around Mega, with colluvial red soils from surrounding hills.

1.F High ground influenced by volcanism

The mountains described to this point are derived from basement-complex formations but volcanics have intruded into the Mega massif from two craters (at Medecho and Soda). The volcanics are often weathered and have contributed to building mixed soils. Volcanics also occur as scattered rocks. Facets include:

1.F.1 = Vegetation similar to that of 1.C.1 and 1.C.4 except for large volcanic rocks and granitic cliffs where basement-complex mountains were broken by volcanism to produce cuts oriented in a north-westerly or south-easterly direction.

1.F.2 = *Juniperus* and *Tarconanthus* spp on geology similar to that for 1.F.1 between Mega and Medecho.

1.F.3 = *Olea* and *Terminalia* trees on brown soils developed from volcanics along the valley where Mega town is located.

1.F.4 = Grasslands with temporary water logging and dominance of Vertisols.

2. Upper semi-arid zone

Broad-leaved trees occur in the most mesic sites of these units and mean annual rainfall is around 600 mm. Cultivation is practised on deeper soils but success of cultivation depends on annual rainfall. The zone includes most of the northeastern part of the mapped area (i.e. the teltele slopes and the top of the Moyale escarpment along the Kenyan border) where sudden changes in elevation (i.e. from 700 to 1200 m) results in an orthographic source of moisture.

2.A *Combretum* and *Acacia* spp woodlands

Combretum and *Terminalia* spp are usually accompanied by *A. etbaica* or *A. brevispica*. The latter may be replaced by *A. tortilis*, *A. nilotica* and *A. bussei*. Soils are mostly derived from granite parent materials. Facets include:

2.A.1 = Dense, heterogenous woodlands south of Hidi Lola. Large granite rocks are apparent within wooded valleys which correspond to deeper soils.

2.A.2 = Contiguous to 2.A.1, this unit differs in terms of steep cliffs and slopes that give rise to numerous small parallel drainages.

2.A.3 = This unit exists at elevations 1500 m in the same area as 2.A.2 on very rocky hills with red-yellow soils from nongranitic basement-complex substrates and extends to the east around Web town.

2.A.4 = A comparable unit to 2.A.3, but this occurs on a mixture of granites and schists from Das to Did Hara.

2.A.5 = Hills with deep reddish soils in Did Hara, very sandy with many pebbles and scattered termite mounds occur. Variations occur according to topography. Soils are slightly acidic.

2.B Acacia savannahs

These occur in Did Hara. *Acacia tortilis* and *A. nilotica* dominate the tree component as commonly observed for group 2.A. However, the units can often be considered as degraded and *A. brevispica* and *Commiphora* spp are substituted for broad-leaved trees. The following facets have been established on the basis of decreasing shrub density:

2.B.1 = Dense woody vegetation on eroded soils. Soils are sandy, fine grained and pale red in colour. The unit occupies both sides of a valley west of Arero and is heavily grazed. Grass cover has been greatly reduced and formation of gullies has occurred.

2.B.2 = Lower hills and small drainages east of Yabelo, with bare ground, sheet erosion and exposed bedrock. Attempts at cultivation have been made in the proximity of towns, but soils are acidic and poor for cultivation.

2.B.3 = Less eroded and bushy area in the same part of the zone as 2.B.2. Soils are yellow-red and similar to those in 2.B.2 except they are deeper. Vegetation is variable with dense woody vegetation occurring in small drainages.

2.B.4 = Facets are with those of units of 2.B.3 and occur on hill tops comprised of basement-complex materials (i.e. granites, gneisses and schists). Grass cover is moderate and young *Commiphora* spp trees are abundant.

2.B.5 = Occurs as one isolated patch in Did Hara region. Similar to 2.B.4 except this occurs on darker soils.

2.C *Euphorbia* spp woodlands

These units are scattered across the eastern portion of the upper semi-arid zone and may indicate very old examples of bush encroachment. Woody cover is dominated by *Acacia* spp but acacias are mixed with less competitive plants such as *Hibiscus* or *Euphorbia* spp. Facets include:

2.C.1 = Dense bushlands on rocky terrain having numerous outcrops.

2.C.2 = Same as units 2.C.1 but on eroded sites. Facets have been heavily grazed over a long period of time and are still heavily utilised.

2.C.3 = Same as unit 2.C.1 but on yellow sandy soils. Little grass cover.

2.C.4 = A southern variant of 2.C.3 in which soils are whitish or grey in colour.

2.C.5 = Lower slopes of the Yabelo mountains on the western-facing aspect. Colluvions have been cleared for settlement and crop cultivation.

2.D *Acacia* spp on volcanic substrates

These units occur along the Mega-Dokole range. They differ from 2.B or 2.C units because their soils are derived from, or influenced by, volcanics. They also show a more sparse and extensive grass cover. Dominant woody species are similar to those reported for 2.C units. Facets include:

2.D.1 = Isolated rocky volcanic hills in the Dokole area.

2.D.2 = Large volcanic outcrops within granitic formations surrounding Mega town.

2.D.3 = A facet specific to Mega town, where mixed colluvions and rocks are covered with a shrubby plant community.

2.D.4 = Equivalent to the 2.D.3 formation, but occurring in the Dokole region.

2.E *Acacia* spp on limestone

The Hidi Lola area occurs on a large gently undulating portion of the plateau where limestone was deposited and has been either partially eroded or covered by sandy deposits. Soils are darker than those derived from granites, vegetation is characteristic of the upper semi-arid zone and the region is suitable for cultivation. Scattered limestone formations are also found to the north in the Did Hara region. Facets include:

2.E.1 = Higher elevations dissected by erosion. Cultivation is often restricted to gentler slopes on deeper soils.

2.E.2 = This unit includes lower elevations having a reduced plant cover. There are numerous isolated cultivated fields and small settlements.

2.E.3 = Hilly landscape in Did Hara, close to a Vertisol valley. Soils are mixed with volcanics. Vegetation consists of grasslands with scattered *Acacia* spp trees.

3. Lower semi-arid zone on basement-complex substrates

Soils derived from granites have a more favourable water regime than soils derived from volcanic rocks and the eastern region of this zone (which coincides with the basement-complex as a geological formation) is more productive than the western region. It is typified by dry savannahs dominated by *Acacia and Commiphora* spp. It is rather homogenous in terms of flora. Subdivisions are largely based on vegetative physiognomy.

3.A Wooded and elevated sites

These rocky slopes and hills contain various mixtures of shrubs and grass which produce a high plant cover overall. The most common *Acacia* spp are *A. bussei*, *A. etbaica*, *A. senegal*, and *A. mellifera*. *Commiphora* spp are also abundant. Two facets occur on the central mountain ridge south of

Yabelo and two more occur in scattered locations on granitic rocks. Facets include:
3.A.1 = Granitic steep hills and hill tops.
3.A.2 = Lower slopes of granitic hills.
3.A.3 = Eastern, high-elevation area having rocky and shallow red soils.
3.A.4 = Isolated large rocks subtended by extensive bare ground at higher elevations.

3.B Wooded plateaus

At the periphery of units which comprise the 3.A group, this group covers most of the central part of the eastern zone, being generally similar in plant composition to that of the 3.A group. Facets are differentiated on the basis of location and plant cover:
3.B.1 = Colluvial plains associated with 3.A.2 or 2.C.5; the surface is slightly sloped and grass cover is low.
3.B.2 = Eastern woodlands with red soils and low grass cover, immediately below 3.A.3 or 3.B.5 sites in terms of elevation.
3.B.3 = Slightly elevated ground. Resembling 3.A.3 sites but flatter and more dissected. Grass cover is high in spite of heavy utilisation. Trees are less abundant than in other 3.B facets.
3.B.4 = A variant of 3.B.1, comprised of a mosaic of sloping plains and small drainages.
3.B.5 = This constitutes most of the central eastern plateau with a plant physiognomy that varies from dense bushland to open grasslands. Woody cover is usually less than in 3.B.2, but these sites appear to be regularly invaded by shrubs.

3.C Open savannah

The Dubluk area is remarkable in terms of the low density of trees and shrubs; this may have occurred because of pressure from small ruminants being taken to water at nearby wells. Four facets have been described:
3.C.1 = An open flat savannah south of Dubluk with small cultivated fields along the tarmac road.
3.C.2 = Similar to 3.C.1 but a high grazing pressure throughout the year has probably encouraged bush encroachment.
3.C.3 = Degradation is more pronounced here than in facets 3.C.1 or 3.C.2, although partial recovery of vegetation has occurred as a result of the creation of the Dembel Wachu Ranch.
3.C.4 = One small isolated hill used for settlement. It is currently heavily grazed.

3.D Grasslands

Grasslands are situated in the vicinity of the 3.C units. Soils are slightly acidic. Differentiation of units is based on landscape. Facets include:
3.D.1 = These flat grasslands lie close to 3.A or 3.B units, west of the main tarmac road.
3.D.2 = Terrain is gently undulating along the Mega range.
3.D.3 = Rolling landscape. Trees increase in abundance along small drainage lines.

4. Semi-arid zone on mixed soils

The geological formation described as Quaternary sediments (see Section 2.4.1.1: *Geology*) includes hydromorphic surfaces (Fluvisols and Vertisols in valleys) and more variable units on alluvial or colluvial material. This is a tentative classification of the latter group. Most facets appear to be more representative of the lower semi-arid zone, but soils are deeper and richer in nutrients that allow cultivation. Similarly, woody cover (at least at lower elevations) often appears higher than that expected based on annual rainfall.

The term "mixed" soils refers to material from granitic (or metamorphic) and volcanic origin. Soil variability is often very high and localised; this group of units articulates the transition between the eastern granitic plateau and the western volcanic depression which can be considered part of the Rift Valley, linking lakes Abaya and Chamo to the Chalbi desert and Lake Turkana. Subdivisions are established from the varied intensity of volcanic influence that increases from 4.A to 4.C and from vegetative physiognomy.

4.A Wooded savannahs

Acacia spp are the major component of the woody strata with *A. bussei*, *A. mellifera*, *A. nubica*, *A. tortilis*, *A. reficiens* and *A. horrida* common. Five facets occur:
4.A.1 = The south-eastern woodlands, on top of the Chalbi escarpment, correspond to a highly eroded landscape. Dense woodlands occur in small valleys and the facet is intermediate between 2.A.1 and 2.E.1 units in terms of vegetative cover. Cultivation could be attempted here.
4.A.2 = This is a similar unit to 4.A.1 that occurs on the Mega hills. Cropping is presently expanding.
4.A.3 = This degraded plateau borders the western hills and presents a mosaic of woody patches, dense bush and open savannahs on rocky terrain. Grass cover is highly variable. Erosion is common.

4.A.4 = Northern woodlands which border 2.A.4 units. They include grasslands where soil moisture is higher.

4.A.5 = These woodlands are aligned on the plateau from the Yabelo mountain range to Kancharo and border western volcanics. The volcanic influence is pronounced. Soils are of poor quality.

4.B Grasslands

Grasslands have established on either water-logged sites or shallow soils. The group on waterlogged sites includes four facets:

4.B.1 = Bordering the Vertisols in the Medecho area, these sites are slightly sloping and contain patches of dense bush.

4.B.2 = A bushy grassland, again adjacent to Vertisols near the Sarite Ranch.

4.B.3 = A unit near the 4.A.6 series. Volcanic rocks are common.

4.B.4 = This is a facet having a northern exposure. Soils are variable.

The group on shallow soils occurs on rocky hills adjacent to a large lava flow. There are two facets:

4.B.5 = Shallow soils on volcanic hills and slopes. Includes colluvial material, possibly due to proximity of hills representing the 3.A.4 type.

4.B.6 = This is an extension of unit 4.B.5, although this facet has higher grass cover and fewer rocks.

4.C Transition units

These units can be ranked based on vegetative physiognomy (from woodlands to grasslands). Physiognomy also reflects topography, as woodlands are closer to mountain slopes, and grasslands correspond to lower elevations nearer to lava flows. Seven facets have been mapped:

4.C.1 = Dense woodlands on lower slopes of the massif. Grass cover is very reduced except on old encampment sites. *Acacia* spp is the dominant genus for woody plants and invading forbs are abundant.

4.C.2 = These units occur along the edge of the granites. Woody plants are more scattered and bare patches of soil can be observed. The ground is often rocky.

4.C.3 = Open woodland close to volcanics, south of the Mega range. These also include volcanic outcrops, boulders and small cones.

4.C.4 = A similar physiographic unit to 4.C.3, but invaded by bush and still heavily grazed, especially near watering points (i.e. at Dilo Goraye or at mountain springs).

4.C.5 = Bushed grasslands associated with 4.C.2 that are not readily accessible to pastoralists. Further development of the tree layer would result in formations similar to those of 4.C.2.

4.C.6 = Large grassland plains, with vegetation physiognomy similar to 3.D.1 and subject to bush encroachment.

4.C.7 = Old lava flow with granitic outcrops. Vegetation is a mosaic of dense bushland and open grasslands.

5. Arid environments

The aridity of these sites is of a dual nature; partly climatic as related to reduced rainfall at lower elevations to the west but also edaphic as a consequence of shallow volcanic soils. *Acacia mellifera*, *A reficiens* and *A horrida* are dominant woody plants and differentiation of units considers density of trees and shrubs. In addition, lava flows have been grouped together because they exhibit low levels of grass production.

5.A Wooded plateaus

The central lava plateau is rocky and uniformly wooded. Subdivisions occur on the basis of landscape and soil features:

5.A.1 = This unit lies on deep soils and only scattered stones and boulders can be seen on the surface. Encampments have been established for wet-season grazing.

5.A.2 = A highly dissected and eroded terrain on both sides of the central valley and along the western drainage line. The unit is sloped with many lava boulders and sparse grass cover. Human occupation has occurred in the past.

5.A.3 = Woodland invaded by bush. Bare ground also common.

5.A.4 = The ultimate stage of degradation in this series; only observed in one location south of Sarite Ranch.

5.B Bushed savannahs

Poorer soils have been invaded by bush, and although the vegetation is not much different from that of 5.A units, the environment appears less resilient to heavy utilisation. Facets include:

5.B.1 = Volcanic hills and slopes have shallow loose soils with a dense cover of shrubs.

5.B.2 = This unit is a plateau covered by volcanic ash; soils are diverse because of occasional rock outcrops and moist swales.

5.B.3 = Similar to 5.B.2 but in a lower topographical situation where contact is made with

Vertisols, especially to the south of Sarite Ranch. Grass cover is higher than in other 5.B units.

5.C Grasslands

These grasslands contain some woody vegetation. Shrubs are patchy or localised in drainages. Soils are rocky and grass cover is moderate. Facets include:

5.C.1 = A large plain at the extreme south-western part of the zone occurs on very fine soils; some bush encroachment is evident.

5.C.2 = This unit is a mosaic of open and bushed grassland. Plant cover is variable.

5.C.3 = This corresponds to higher ground on volcanics and includes sloped and eroded sites. Except for drainages, soils are shallow and grass cover is low to moderate.

5.D Lava flows

Lava flows can be differentiated on the basis of their age: Older flows have more developed soils and a higher plant cover, while younger flows have a lower plant cover or are still bare. Lava flows are concentrated at lower elevations to the south of the study area. Facets include:

5.D.1 = This highly weathered lava is covered by a thin layer of ash, with exposed volcanic rocks. Vegetation consists of patches of scattered trees.

5.D.2 = Like unit 5.D.1, this is associated with the Mega hills complex. The terrain is undulating with sandy ripples. Bush cover is variable and grass cover is higher compared to that for 5.D.1.

5.D.3 = This grassland is a facet near 5.D.2 at lower elevations and having deeper soils.

5.D.4 = A large and rather recent flow that remains nearly bare. Volcanic vents and miniature craters occur.

5.D.5 = The latest lava flows are completely devoid of vegetation.

6. Bottomlands

Bottomlands cannot be classified on the basis of rainfall because the local water regime benefits from run-on moisture. All units in this group are temporarily waterlogged in rainy seasons. There are, however, differences among facets due to variation in soils.

6.A Vertisols

Vertisols (see Section 2.4.1.3: *Soils*) derived from volcanics have a fine texture and a poor water permeability. They produce impassable patches for vehicles when they are wet. They can be used to establish stock ponds. Vertisols are dark coloured and vegetation usually consists of *Pennisetum* spp grassland with *A. drepanolobium*. Other units, however, are better drained and consequently have a greater density of woody plants. Facets include:

6.A.1 = A mosaic of Vertisols and small hills covered by shrubs in the southern portion of Sarite.

6.A.2 = Plains consisting of bushed grassland with an occasional thin layer of sandy soil. The grass layer varies according to the seasonal flooding regime.

6.A.3 = Lower elevations of unit 6.A.2. These are temporarily flooded. Soils have been substantially leached.

6.A.4 = The most common land facet in Did Hara. This is a bushed grassland with *A. drepanolobium* and *A. seyal*.

6.A.5 = A south-eastern variant where *A. seyal* is dominant. Waterlogging is restricted to lower layers of the soil.

6.A.6 = Near to unit 6.A.4, but showing less compacted soils and lower production potential for vegetation.

6.B Riverine units

This group mainly includes plant communities on coarse Fluvisols that are well drained. Units have a moderate to high cover of trees and shrubs. Some woody plants have been cleared for cultivation. Differentiation of facets is based on density of woody plants:

6.B.1 = Forest on dark alluvium, corresponding to major drainages of the Did Hara region.

6.B.2 = Dense woodland in volcanic valleys. Valleys are oriented south wards and are sometimes discontinuous. Grasslands occur along banks of stream channels.

6.B.3 = Densely bushed grasslands that occur to the south-east; comparable to 6.B.1.

6.B.4 = One isolated patch where the valley is interrupted. Woody vegetation is variable.

6.B.5 = Grasslands with scattered trees and heavy grazing pressure. Units are intermediate with respect to 6.B and 6.C designations (i.e. soils in this unit are derived from limestone).

6.C Limestone valleys

Limestones are easily eroded and have produced alluvions in major valleys. Soils differ according to various parent materials, and most soils have developed on mixed alluvions. Soil colour ranges from whitish or light grey to red, and soil is usually fine textured. Differentiation among facets is based on vegetation physiognomy:

6.C.1 = Degraded forest in the vicinity of wells.

6.C.2 = Bushland on a mixture of limestone and quartz. Grassland occurs in strips in flood plains.

6.C.3 = Grassland on very white soils, probably subtended by volcanics (a few isolated volcanic rocks occur). Shrubs and *A. drepanolobium* are rare.

6.C.4 = Woodland on red soils. Sites less hydromorphic.

Annex D

Table D1. *Background information on 49 Borana households monitored in nine regions in the southern rangelands throughout the period July 1981 to July 1983.*

Household feature	*Madda*								
	Orbati	Dilo Goray	Web	Hobok	Dokole	Marmaro	Melbana	Did Hara	Beke
Number of households in sample	5	5	5	5	3	6	6	10	4
Average household size (AAME)	4	4.5	4	6.5	6.4	5.6	4.9	5.5	10
Average livestock holdings (LSU)	25.3	99.3	37.1	258.6	53.2	42.4	22.4	83.2	70.8
Cash income/household (EB)	419.2	818.6	1361.5	1872.9	217.1	954.6	1260.3	4061.5	445.3
Cash expenditure/household (EB)	372.5	547.4	826.25	324.9	200.9	430.7	361.7	2058.3	163.65
Percentage expenditure on food	25.6	25.6	51	23.8	33.6	51.4	25.7	41.4	67.8

Source: Negussie Tilahun (1984).

Table D2. *Reported importance rankings and total hours per week for various work activities of Borana women in Dubluk and Did Hara* madda *during the long rainy season.*[1]

Dubluk				Did Hara			
Activity	Mean rank[2]	Total h/wk	%	Activity	Mean rank[2]	Total h/wk	%
Milking	1.03*v*	14.12	18.8	Milking	1.13*v*	18.85	22.6
Fuel-wood collection	3.22*vw*	21.22	28.3	Fuel-wood collection	2.87*vw*	19.74	23.6
Milk churning	3.63*vw*	10.81	14.4	Milk churning	3.3*vwx*	12.55	15.0
Food preparation	3.83*vw*	8.75	11.7	Water collection	3.95*wxy*	3.06	3.7
Water collection	4.6*vwx*	3.63	4.8	Food preparation	4.7*xy*	7.6	9.1
Marketing	6.68*wxy*	6.71	8.9	Corral cleaning	6.5*y*	2.98	3.6
Corral cleaning	7.97*xyz*	2.9	3.9	Marketing	8.47*y*	6.86	8.2
Weaving milk container	8.93*yz*	2.64	3.5	Weaving milk container	8.55*y*	4.71	5.6
Cultivation	10.38*yz*	2.95	3.9	Cultivation	8.7*y*	2.68	3.2
Collect bush food	10.42*z*	0.82	1.1	Collecting bush food	9.63*y*	3.5	4.2
Herding cattle	10.95*z*	0.08	0.1	Pond construction	10.08*y*	1.0	1.2
Watering calves	11.12*z*	0.06	0.08				
Corral construction	11.12*z*	0.12	0.1				
Fence construction	11.12*z*	0.06	0.08				
Total hours per week		74.87		Total hours per week		83.53	

1 Based on independent interviews of 30 married women. See text for methodological details.

2 Entries for each *madda* accompanied by the same letter *(v, w, x, y, z)* were not ranked differently (P>0.05) according to Friedman's test (Steel and Torrie, 1980).

Source: Mulugeta Assefa (1990).

Table D3. *Reported importance rankings and total hours per week for various work activities of Borana women in Dubluk and Did Hara* madda *during the warm dry season.*[1]

Dubluk				Did Hara			
Activity	Mean rank[2]	Total h/wk	%	Activity	Mean rank[2]	Total h/wk	%
Milking	2.07*v*	5.63	5.2	Water collection	2.73*x*	26.03	23.1
Water collection	2.9*v*	22.73	21.0	Milking	3.13*x*	3.00	2.7
Food preparation	3.41*vw*	16.68	15.4	Forage collection	3.8*x*	11.58	10.3
Forage collection	4.12*vw*	14.13	13.1	Food preparation	3.83*xy*	15.10	13.4
Fuel-wood collection	4.45*vwx*	10.24	9.5	Fuel-wood collection	4.92*xy*	6.01	5.3
Marketing	7.91*wxy*	10.36	9.6	Corral cleaning	8.25*yz*	1.25	1.1
Corral cleaning	9.14*xyz*	1.18	1.0	Marketing	8.65*yz*	7.59	6.7
Watering calves	9.91*yz*	6.58	6.1	Pond repair	8.67*z*	5.00	4.4
Watering cattle	10.09*yz*	9.59	8.9	Watering cattle	8.92*z*	14.00	12.4
Weaving milk container	11.19*yz*	0.90	0.8	Watering calves	9.43*z*	7.01	6.2
Milk churning	11.97*yz*	0.53	0.5	Milk churning	10.28*z*	1.30	1.2
Pond repair	12.02*yz*	4.82	4.4	Weaving milk container	10.57*z*	1.00	0.8
Well work	12.57*yz*	2.80	2.6	Well work	10.9*z*	12.00	10.6
Corral repair	12.67*yz*	0.01	<0.01	Herding cattle	10.92*z*	2.00	1.7
Herding cattle	12.78*z*	0.37	0.3				
Calf hut construction	12.81*z*	1.59	1.5				
Kalo repair	13.0	0.07	0.06				
Total hours per week	—	108.21	—	Total hours per week		112.87	

1 Based on independent interviews of 30 married women. See text for methodological details.

2 Entries for each *madda* accompanied by the same letter (*v, w, x, y, z*) were not ranked differently (P>0.05) according to Friedman's test (Steel and Torrie, 1980).

Source: Mulugeta Assefa (1990).

Annex E

Table E1. *Purchase origin, mean entry and exit weights and average total live-weight gain for male cattle processed at Sarite ranch during 1980–81.*[1]

Purchase origin	*N*	Weight (kg)		Total gain (kg/head)
		Entry	Exit	
Did Hara	129	193	231	38
Hobok	122	170	214	44
Mega	177	173	201	28
Melbana	39	156	194	38
Gorille	39	160	203	43
Liche	22	169	208	39
Dubuluk	53	154	185	30
Hidi Lola	66	151	189	39
Dilo	95	159	204	45
Marmaro	175	180	231	50
Orbati	71	162	210	47
Gayu	24	137	177	40
Chewbet	25	141	175	34
Medecho	23	140	179	39
Megado	33	153	192	39
Dass	46	147	187	39
Dabayu	15	162	197	35

1 Based on a holding period of seven months at Sarite ranch. Effects of origin on total gain were highly significant ($P<0.001$).

Source: Nicholson (1983b).

Table E2. *Per cent incidence of major causes of mortality among adult cattle and calves in an average rainfall year in the southern rangelands during 1976–1987.*[1]

Mortality cause	Per cent incidence in	
	Adult cattle	Calves (<1 year old)
Calf scours	—	30
Black leg	12	10
Ascariasis	—	1
Pasteurolosis	30	3
Anthrax	14	2
External parasites	29	3
Strongylosis	—	5
Trypanosomiasis	2	—
Foot and mouth	5	15
Starvation	—	17
Other	8	14

1 Where an average year has around 600 mm of rainfall. Percentages are based on a sample of several thousand adult cattle and several hundred calves.

Source: Southern Rangelands Development Unit (unpublished data).

Table E3. *Per cent incidence of major causes of mortality among adult cattle and calves in a dry rainfall year in the southern rangelands during 1976–87.*[1]

Mortality cause	Per cent incidence in	
	Adult cattle	Calves (<1 year old)
Calf scours	—	10
Pasteurolosis	36	6
Strongylosis	28	4
Black leg	14	5
Anthrax	12	—
Ascariasis	—	—
Foot and mouth	—	20
Trypanosomiasis	2	—
Starvation	—	50
Others	8	5

1 Where a dry rainfall year has around 450 mm of rainfall. Percentages are based on a sample of several thousand adult cattle and several hundred calves.

Source: Southern Rangelands Development Unit (unpublished data).

Table E4. *Per cent incidence of major causes of mortality among adult cattle and calves in a drought year in the southern rangelands during 1983–84.*[1]

Mortality cause	Per cent incidence in	
	Adult cattle	Calves (<1 year old)
Calf scours	—	8
Pasteurolosis	31	—
Botulism	10	—
Trypanosomiasis	1	—
Ascariasis	—	—
Black leg	29	—
Foot and mouth	—	5
Anthrax	20	—
Starvation	—	80
Others	9	7

1 Where a drought year is a second consecutive dry year of 450 mm of rainfall or less. Percentages are based on a sample of several hundred adult cattle and several hundred calves.

Source: Southern Rangelands Development Unit (unpublished data).

Figure E1. *Equation used to predict calf growth based on milk intake. This equation includes the formula of Tyrrell and Reid (1965) and includes an empirical requirement of 13.6 MJ ME per kilogram of growth for pre-ruminant calves from Roy (1980).*

$$\frac{g_e = (g_o + (0.1454x)(0.93.10^{-3})\ 9.226(41.84F + 22.29SNF - 25.58)\ kg}{13.6}$$

where:

g_e = estimated total weight (kg) at time t

g_o = observed weight (kg) at time t

x = accumulated milk offtake

0.1454 = milk converted to dry matter at 14.54% solids

0.93 = proportion of metabolisable gross energy

10^{-3} = conversion of kJ to MJ

F = % fat in milk

SFN = % solids-not-fat in milk

9.226 (41.84 F + 22.29 SNF – 25.58) = gross energy content of milk (kJ kg^{-1}) (Tirrell and Reid, 1965)

13.6 = conversion factor for MJ to kg growth.

Source: Nicholson (1983a).

Annex F

Table F1. *Livestock census results from the SORDU sub-project area conducted during February and March, 1987.*[1]

Awraja	Woreda	*Madda*	PA	Water points	Mature cattle		Calves		Calf: cow	Total cattle	Goats	Sheep	Total small stock	Camel	Donkey	Horse	Mule
					Male	Female	Male	Female									
	Arero	0	29	117	34 247	94 579	19 981	28 619	0.51	177 426	51 163	18 724	69 887	22 006	2622	643	1255
	Dire	0	80	382	103 626	218 794	61 108	77 365	0.63	460 893	132 780	63 961	196 741	44 697	12 717	3331	2785
Arero	Moyale	20	0	226	29 962	72 834	11 382	16 765	0.39	130 943	49 615	17 771	67 386	59 760	3556	79	2366
	Teltele	0	34	253	44 537	92 198	15 735	18 844	0.37	171 314	68 195	39 384	107 579	940	3181	0	46
	Yabelo	0	25	80	53 197	103 216	28 382	34 265	0.61	219 060	65 993	15 660	81 653	11 036	3434	346	975
	Total	20	168	1058	265 569	581 621	136 588	175 858	0.54	1 159 636	367 746	155 500	523 246	138 439	25 510	4399	7427
	Dollo	0	36	121	12 164	56 324	7491	24 716	0.57	100 696	480 983	353 850	834 833	175 946	11 427	11	12
Borana	Liben	0	99	844	83 360	260 742	35 713	53 697	0.34	433 512	425 464	153 295	578 759	328 080	28 317	88	579
	Total	0	135	965	95 525	317 066	43 204	78 413	0.38	534 208	906 447	507 145	1 413 952	504 026	39 744	99	591
SORDU	Total	20	278	2023	361 091	898 687	179 792	254 271	0.48	1 693 844	1 274 193	662 645	1 936 838	642 465	65 254	4498	8018

1 Where awraja, woreda and PAs (Peasant Associations) were government administrative units and *madda* were traditional resource allocation units for Borana society. Government administrative boundaries have changed since 1987. Over 3000 water points were surveyed over a period of five weeks.

Source: Raw data from Solomon Desta (nd).

Annex G

Table G1. *Actual and projected cattle numbers, percentage and numbers of mature cows, annual milk production of the cattle herd and annual estimates of the human population and its energy requirements and milk-energy deficits, on the central Borana Plateau during 1959 and 1982–2006.*[1]

Year	Herd size	Per cent mature cows	Fraction of cows in milk	Fraction of maximum milk yield	Annual milk energy yield per cow (MJ GE)	Total milk cows (number)	Total milk yield (MJ GE)	Human population	Total human energy requirement (MJ GE)	Annual energy deficit (per cent)
1959	275 000	50	0.75	1	840	103 125	86 625 000	37 082	86 625 000	–
1982	325 000	45	0.75	1	840	109 687	92 137 080	66 423	155 164 128	40
1983[2]	256 034	40	0.53	0.84	705	54 279	38 266 841	67 087	156 715 232	76
1984[2]	262 349	39	0.31	0.68	571	31 717	18 110 407	67 757	158 280 352	89
1985	172 506	39	0.2	0.75	630	13 455	8 476 944	68 434	159 861 824	95
1986	250 000	44	0.75	1.00	840	82 500	69 300 000	70 145	163 858 720	58
1987	270 000	47	0.75	1.00	840	89 100	74 844 000	71 899	167 956 064	56
1988	291 600	50	0.75	1.00	840	109 350	91 854 000	73 696	172 153 856	47
1989	314 928	50	0.74	0.98	823	116 523	95 898 429	75 539	176 459 104	46
1990	333 823	50	0.73	0.96	806	121 845	98 207 070	74 427	180 869 472	46
1991	347 175	50	0.72	0.94	789	124 983	98 611 587	79 363	185 391 968	47
1992	357 590	50	0.71	0.92	773	126 944	98 127 712	81 347	190 026 592	49
1993	368 317	50	0.7	0.9	756	128 910	97 455 960	83 380	194 775 680	50
1994	375 683	50	0.69	0.88	739	129 610	95 781 790	85 465	199 646 240	52
1995[2]	300 546	40	0.53	0.84	705	63 715	44 919 605	89 790	209 749 440	78
1996[2]	120 000	38	0.09	0.5	420	4104	1 723 680	90 687	211 844 832	99
1997	226 000	41	0.31	1	840	28 724	24 128 160	91 593	213 963 280	89
1998	249 504	44	0.75	1	840	82 336	69 162 240	93 882	219 310 279	69
1999	269 464	47	0.75	1	840	94 986	79 788 240	96 229	224 791 061	65
2000	291 021	50	0.75	1	840	109 132	91 670 880	98 635	230 410 717	61
2001	314 302	50	0.74	0.98	823	116 291	95 707 493	101 100	236 171 644	60
2002	333 160	50	0.73	0.96	806	121 603	98 012 018	103 627	242 073 840	60
2003	346 486	50	0.72	0.94	789	124 735	98 415 915	106 217	248 124 489	61
2004	356 880	50	0.71	0.92	773	126 692	97 932 916	108 872	254 325 984	62
2005	367 586	50	0.7	0.90	756	128 655	97 263 180	111 594	260 683 584	63
2006	378 613	50	0.69	0.88	739	130 621	96 528 919	114 383	267 198 688	64

1 Herd sizes were collated from aerial surveys (during 1982–86; from Cossins and Upton (1985) and Assefa Eshete et al (1987)) with average subsequent growth in the first post-drought years (1987 and 1998) of 10.6% followed by 8% annual growth (Mulugeta Assefa, 1990) from 1988–89 and 1990–2001 until herd size exceeded 300 000 head. The 8% growth rate was then reduced by two percentage points/year to reflect density-dependent effects (see text). Drought effects on herd size in 1995–96 were assumed to be proportionally similar to those observed in 1983–85 (Cossins and Upton, 1985). Per cent mature cows in the herd were derived from Donaldson (1986) and Solomon Desta (nd). Fraction of cows in milk and maximum milk yields were from Donaldson (1986) and Cossins and Upton (1988b). Density-dependent effects on milk yields and fraction of cows in milk were assumed on the basis of unpublished interviews (D. L. Coppock, ILCA, unpublished data). The growth rate in the human population of 2.5% was from B. Lindtjørn (University of Bergen, unpublished data) and assumed to be 1% per year during drought (Coppock, 1988). The per capita annual energy requirement of 2336 MJ GE was from FAO/WHO (1973) cited in Upton (1989). Reduction in human food-energy demand is likely during drought (Webb et al, 1992), but was not included because of insufficient information.

2 Consecutive dry years (i.e. drought) observed in 1983–1984 (Cossins and Upton 1988a) and hypothetically projected for 1995–96.

Table G2. *Exotic and indigenous forage species and some possible establishment locations in the southern rangelands.*

Latin name	Cropped field	Range vegetation	Disturbed roadside	Encampment/Pond catchment
Acacia albida				x
Acacia tortilis				x
Azdarichta indica				x
Cajanus cajan	x			
Cassia rotundifolia	x	x	x	
Centrosema pascuorum	x	x		
Centrosema schottii	x	x		
Desmanthus virgatus		x	x	x
Gliricidia sepium				x
Lablab purpureus	x			x
Leucaena diversifolia				x
Leucaena leucocephala				x
Leucaena shannoni				x
Macroptilium atropurpureum	x	x	x	
Macrotyloma axillare		x	x	x
Moringa stenopetala				x
Phaseolus vulgaris	x			
Sesbania sesban				x
Stylosanthes hamata	x	x	x	x
Stylosanthes scabra		x	x	x
Vigna unguiculata	x			

Source: Hodgson (1990).

Table G3. *Effects of legume, harvest dates and standing crop or regrowth on crude-protein (CP) concentration[1] on a dry-matter basis for various plant parts at Dembel Wachu ranch in the southern rangelands during 1987.*

	Plant part[2]								
	Stem[3]			Leaf[4]			Whole plant[5]		
	Standing crop		Regrowth	Standing crop		Regrowth	Standing crop		Regrowth
Species/Cultivar[6]	July	December	December	July	December	December	July	December	December
Vigna unguiculata cv White Wonder Trailing	12.0	—	—	24.0	—	—	—	—	—
Lablab purpureus	12.8	—	—	29.1	—	—	—	—	—
Vigna unguiculata cv IT-82	8.8	—	—	22.4	—	—	—	—	
Cajanus cajan	8.3	8.1	8.5	27.1	19.3	23.5	—	—	—
Desmodium discolor	10.2	8.9	9.9	24.5	14.4	20.5	—	—	—
Cassia rotundifolia cv Wynn	—	—	—	—	—	—	18.6	8.6	12.4
Centrosema schottii	—	—	—	—	—	—	17.3	12.2	16.6

1 Percent kjeldahl nitrogen x 6.25.

2 Whole plant analyses were conducted on *C. rotundifolia* and *C. schottii* because of reduced morphological differentiation.

3 Entries that varied by ≥0.50 were different (P≤0.05) according to an LSD (least significant difference) test.

4 Entries that varied by ≥0.46 were different (P≤0.05) according to an LSD test.

5 Entries that varied by ≥0.19 were different (P≤0.05) according to an LSD test.

6 Where *V. unguiculata* and *L. purpureus* are annuals and the rest are perennials.

Source: Yohannes Alemseged (1989).

Table G4. *Effects of legume, harvest date and standing crop or regrowth on dry-matter digestibility[1] of various plant parts at Dembel Wachu ranch in the southern rangelands during 1987.*

	Plant part[2]								
	Stem[3]			Leaf[4]			Whole plant[5]		
	Standing crop		Regrowth	Standing crop		Regrowth	Standing crop		Regrowth
Species/Cultivar[6]	July	December	December	July	December	December	July	December	December
Vigna unguiculata cv White Wonder Trailing	61.3	—	—	78.7	—	—	—	—	—
Lablab purpureus	57.1	—	—	77.8	—	—	—	—	—
Vigna unguiculata cv IT-82	59.9	—	—	77.9	—	—	—	—	—
Cajanus cajan	48.2	39.8	44.1	66.1	56.9	63.5	—	—	—
Desmodium discolor	56.1	46.5	55.2	73.9	61.9	71.7	—	—	—
Cassia rotundifolia cv Wynn	—	—	—	—	—	—	64.8	38.9	48.5
Centrosema schottii	—	—	—	—	—	—	72.1	51.1	67.3

1 *In vitro* dry-matter digestibility (Goering and Van Soest, 1970).

2 Whole plant analyses were conducted on *C. rotundifolia* and *C. schottii* because of reduced morphological differentiation.

3 Entries that varied by ≥1.13 were different ($P \leq 0.05$) according to an LSD (least significant difference) test.

4 Entries that varied by ≥ 1.17 were different ($P \leq 0.05$) according to an LSD test.

5 Entries that varied by ≥ 5.88 were different ($P \leq 0.05$) according to an LSD test.

6 Where *V. unguiculata* and *L. purpureus* are annuals and the rest are perennials.

Source: Yohannes Alemseged (1989).

Table G5. *Hay-making statistics for Borana households in the southern rangelands during May and June 1990.*[1]

	Category									
	Cultivators (*N* = 30)				Non-cultivators (*N* = 32)				All (*N* = 62)	
Variable[2]	Mean	CV (%)	Max.	Min.	Mean	CV (%)	Max.	Min.	Mean	CV (%)
Work period (days)	11*x*	77	30	1	20*y*	37	31	3	16	59
Man-days worked (days)	7*x*	69	14	1	10*y*	51	20	3	8	61
Total time (hours)	12*x*	59	33	1	23*y*	50	46	7	18	63
Platform (hours)	2*x*	117	8	T	3*x*	153	18	T	2	145
Cutting (hours)	8*x*	52	15	1	12*y*	63	36	2	10	63
Drying (hours)	T*x*	–	–	–	4*y*	75	12	T	3	141
Transport (hours)	T*x*	–	–	–	2*y*	166	12	T	1	230
Stacking (hours)	2*x*	185	11	T	2*x*	127	8	T	2	154
Hay made (kg)	81*x*	74	276	20	159*y*	49	300	40	121	66

1 Means within a row accompanied by the same letter (*x*, *y*) were not significantly different ($P \geq 0.30$) in t-test comparisons. Other means were different ($P \leq 0.02$). Entries marked by a T indicate a trace amount of time invested (<0.5 hrs). CV is the coefficient of variation, the standard deviation expressed as a percentage of the mean. It is a measure of the variability in a given sample.

2 Where work period is the length of time between initiation and conclusion of hay-making. Man-days worked is the frequency of man-days within the work period which corresponds to any degree of work output on any given day.

Source: Coppock (1991).

Table G6. *Time budgets (%) of activities forgone for three priority persons observed in 62 Borana households involved in hay-making during May through June 1990.*

Activity[2]	Priority person[1]			Total
	1	2	3	
Firewood collection	10	16	–	11
Watering animals	9	25	18	12
Other livestock management	6	10	20	7
Child care	21	12	3	19
Social obligations	3	2	–	3
Leisure/hygiene	13	6	8	12
Milk processing	10	15	9	11
Household maintenance	18	11	17	16
Food preparation	10	3	25	9
Average hours per household	15	3	<1	18

1 Person 1 is a married woman, person 2 is usually a teenage female or older female relative of the wife, and person 3 is a teenage youth, older female relative, child or husband.

2 Where: (1) other livestock management is herding, health care etc. For women this commonly involves less important stock such as camels or equines while youths and children tend to be herders of calves and small ruminants; (2) child care includes playing, breast feeding, health care etc.; (3) hygiene includes hair braiding, washing etc; (4) milk processing includes preparation of containers for milk collection, butter-churning etc.; (5) household maintenance includes repair of house, clothing and miscellaneous containers; and (6) food preparation involves grinding grain, making tea and associated activities not involving milk.

Source: Coppock (1991).

Table G7. *Diet intake (dry-matter basis), water intake and growth for Boran calves under various feeding treatments at Dembel Wachu ranch in the southern rangelands during 1990.*

Diet	Diet intake (g/head/day)						Water intake (l/head/day)		Growth (g/head/day)	
	Dry matter		Organic matter		Nitrogen					
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Standing brown grass	2110	76.2	1930	69.1	13.4	0.74	4.6	0.21	-78	13.2
Grass hay	2259	66	2033	59.9	16.8	0.64	5.9	0.18	-7	11.5
Grass hay plus										
Acacia tortilis fruits	2327	66	2086	59.9	22.2	0.63	5.8	0.18	40	11.5
F-test probability[1]										
Overall	NS		NS		**		**		**	
Contrast 1	NS		NS		*		**		**	
Contrast 2	NS		NS		*		NS		*	

* and ** significant at P = 0.05 and P = 0.01 levels, respectively.

1 Overall *F*-tests based on 41 degrees of freedom. Contrast 1 = standing brown grass diet vs the grass hay diet and contrast 2 = the grass hay diet vs the grass hay plus *A. tortilis* fruit diet. Treatment observations ended up unbalanced because four calves on the grass diet were taken out of the trial after three weeks due to very poor performance.

Source: Coppock (1993a).

Table G8. *Comparative growth rates (g/head/day) and sample size per treatment (N) for livestock under supplementation with isonitrogenous amounts*[1] *of luceme hay (*Medicago sativa*), cowpea hay (*Vigna unguiculata*), or* Acacia *materials in feeding trials conducted at Dembel Wachu ranch and Debre Zeit during 1987–88.*[2]

Species	N	Control	Control conditions plus			
			Lucerne hay	Cowpea hay	*A. brevispica* leaves	*A. tortilis* fruits
Sheep[3]	6	31	53	57	53	53
Calves[4]	25	82	158	106	119	136

1 In the sheep trial animals received either 345 g luceme hay, 387 g cowpea hay, 302 g *A. bevispica* leaves or 368 g *A. tortilis* fruits daily on a dry-matter (DM) basis. In the calf trial animals received either 567 g luceme hay, 662 g cowpea hay, 473 g *A. brevispica* leaves or 616 g *A. tortilis* fruits daily on a DM basis. For the sheep, the control (base) diet was poor-quality grass hay (offered *ad libitum*) made near Debre Zeit (6.25% CP on a DM basis). Control (base) diets for calves were free grazing on *Pennisetum mezianum* rangeland (6.25% CP on a DM basis) and milk from restricted suckling. See text for details.

2 Linear contrasts revealed that growth rates and diet conversion efficiencies were significantly enhanced ($P<0.01$) in all supplemented sheep compared to controls. Supplementation also increased ($P<0.01$) calf growth rates compared to controls; the alfalfa diet was also superior to those based on native legumes. Milk intake ($ml/kg^{0.75}$) was used as a covariate in the analysis and milk intake was found to have been adequately standardised among treatments.

3 Conducted under an 84-day growth trial under confinement at Debre Zeit Station.

4 Conducted under simulated pastoral management during a 94-day grazing trial at Dembel Wachu ranch on the Borana Plateau.

Source: Coppock and Reed (1992).

Table G9. *Per cent mortality (and sample size) of* Acacia mellifera *and* Acacia bussei *from prescribed burning at two sites on Wollenso Ranch in the southern rangelands in 1989.*[1]

Height class[2]	Per cent mortality	
	Site 1	Site 2
(1) <0.5 m	40 (N = 52)	32 (N = 22)
(2) 0.6 to 1 m	51 (N = 35)	22 (N = 27)
(3) 1.1 to 2 m	30 (N = 53)	35 (N = 34)
(4) 2.1 to 4 m	9 (N = 51)	22 (N = 27)
(5) ≥ 4.1 m	11 (N = 44)	5 (N = 19)
(6) All	28 (N = 235)	32 (N = 129)

1 The two-way ANOVA (height class x species) for site 1 showed significant ($P<0.05$) interactions of height class x species and main effects of height class. The one-way ANOVA (height class) for site 2 (having *A. mellifera* only) was not significant ($P = 0.24$).

2 Height classes were arbitrarily designated for ease of classification. Classes represent height of trees from ground level.

Source: Coppock et al (1990).

Table G10. *Per cent* Acacia drepanolobium *trees in two size classes that were apparently killed due to various treatments in the southern rangelands during August 1989.*[1]

Site[3]	Treatment[2] (height class)									
	Control		Stumped[4]		Stumped+oil[4]		Stumped+Tordon[5]		Ring barking	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Did Tayura	0	0	0	2	0	5	100	100	45	0
Dembel Wachu	0	0	0	5	5	10	100	98	45	6
Average	0	0	0	3.5	2.5	7.5	100	99	45	3

1 An N = 60 was used per height class/treatment/site. Height class 1 was < 2 m, while height class 2 was ≥ 2 m. No statistics were employed for these results.

2 Where control = undisturbed trees; stumped = tree cut down completely at the base; stumped + oil = tree cut down with used motor oil applied to the cut surface (this was a treatment based on "local knowledge" of range managers); stumped + Tordon = tree cut down with 1 ml of Tordon 101 chemical applied to cut surface; and where ring barking = trimming off a 5-cm width ring of bark around the base of the tree.

3 Where Did Tayura is a Ministry of Agriculture ranch and Dembel Wachu is a TLDP ranch.

4 At least 97% of these stumps resprouted several new stems (N = 480).

5 Use of Tordon 101 does not imply formal endorsement.

Source: Coppock et al (1990).

Table G11. ***Maize grain yield (kg/ha) as affected by species of intercropped legume and maize planting density (no/ha) at Dembel Wachu ranch in the southern rangelands in 1987.***

Legume species	Maize-planting density				
	20 000	30 000	55 000	All	Overall per cent change[1]
None (maize only)	3025	4176	4271	3824	—
Vigna unguiculata cv White Wonder Trailing	2223	2605	3109	2646	-31%
Lablab purpureus	2362	2577	2982	2625	-32%
Cassia rotundifolia cv Wynn	2825	3653	4771	3750	-02%
Centrosema schottii	2984	3281	3967	3411	-11%

1 Relative change compared to monoculture of maize. Interspecific effects were highly significant in the three-way ANOVA ($P<0.05$). Any tabulated values that differ by at least 461 kg/ha were significantly different ($P\leq 0.001$) using an LSD (least significant difference) test.

Source: Yohannes Alemseged (1989).

Table G12. *Milk processing statistics for butter-making by Borana women using traditional methods.*[1]

Variable	Units	*N*	Mean	Minimum	Maximum
Whole milk:					
– quantity	ml	28	1046.6	500	1920
– temperature	°C	31	20.2	17	24
– acidity	%	31	1.06	0.68	1.5
– fat content	%	30	4.44	2	6.8
Buttermilk:					
– quantity	ml	27	916.7	460	1555
– fat content	%	31	0.75	0.4	2.3
– Churning time	min	31	40.2	20	64
	min/l	28	38.7	19.3	101.8
Fat recovery	%	26	84.6	54.8	93

1 See text for a description of analytical methods, milk components and variables used in calculations of milkfat recovery. Variables for whole milk were measured prior to churning; those for buttermilk were measured after churning.

Source: Coppock et al (in press).

Table G13. *Comparative household monetary income and food-energy yields for three feeding-management strategies for a Borana family managing an eight-cow breeding herd in the southern rangelands.*

Category	Management option[1]		
	Cow-feeding	Improved calf growth: A	Improved calf growth: B
Food energy (MJ GE):[3]			
Milk	6918 (+3)[2]	7970 (+19)	8813 (+31)
Fallen meat	726 (0)	1026 (+41)	1026 (+41)
Slaughtered meat	187 (0)	801 (+328)	801 (+328)
Total energy (MJ GE)[3]	7831 (+3)	9797 (+28)	10 640 (+39)
Total energy as a percentage of that required for average household	67.5	81.6	88.7
Sales offtake (kg LW)[4]	508 (0)	754 (+48)	754 (+48)
Gross cash income (EB)[5]	507 (0)	754 (+32)	754 (+32)
Cost of essential human food (EB)[5]	169 (-10)	95 (-46)	55 (-69)
Range forage required per herd (MJ GE x 10^3)	1481 (0)	1501 (+1.4)	1501 (+1.4)

1 Where cow feeding is when forage resources are given to milk cows with an increased milk offtake of 3%; calf-feeding option A is where forage resources are directed to calves and result in a reduction of mortality from 25 to 15% in calves and 13 to 10% in yearlings; weaning weights double from 47 to 94 kg/head, culling rates of immature females increase from 40 to 55%, and offtake of immature males is maximised; and calf feeding option B is similar to option A but milk offtake is also increased by 11%.

2 Per cent change over the traditional system is shown in brackets.

3 Mega-joules of gross energy. Food energy is that generated by the system for human consumption.

4 Kilograms live weight.

5 Where USD 1 = EB 2.05. Cost required to make up the food-energy deficit through grain purchases.

Source: Cossins and Upton (1988b).

Table G14. *Effects of treatments conducted on nursing calves on absolute weight gain (kg) from birth to weaning and on live weight (kg), shoulder height (cm) and weight-to-height ratio at weaning for heifers in the southern rangelands in 1986–87.*[1]

Treatment	N	Absolute gain		Live weight		Shoulder height		Weight/height	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Hay supplement:									
None	12	70	5	88.2	4.79	94.4	1.59	0.9	0.03
Medium level	16	81.2	4.41	99.7	4.16	95.7	1.38	1	0.03
High level	20	88.8	4.05	108	3.8	96.6	1.26	1.1	0.03
Water supplement:									
Traditional	25	67.5	3.65	86.2	3.44	92.8	1.14	0.9	0.02
Traditional plus five litres/day	23	92.5	3.69	111.0	3.49	98.4	1.15	1.1	0.02
F-test probabilities:									
Hay	—	$P = 0.02$		$P = 0.01$		$P = 0.5$		$P = 0.002$	
Water	—	$P = 0.0001$		$P = 0.0001$		$P = 0.001$		$P = 0.0001$	
Interaction	—	$P = 0.1$		$P = 0.09$		$P = 0.06$		$P = 0.1$	
Linear contrast (hay)	—	$P = 0.007$		$P = 0.0029$		—		$P = 0.0008$	

1 See text for methodological details.

Source: Sovani (1990).

Table G15. *Effects of treatments conducted on nursing calves on time to puberty (days), average daily gain (g/day), absolute gain (kg) from birth to puberty and on live weight (kg) and shoulder height (cm) at puberty for heifers in the southern rangelands, 1986–90.*[1]

Treatment	N	Time to puberty		Average daily gain		Absolute gain		Live weight		Shoulder height	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Hay supplement:											
None	12	1317	32.3	148.4	0.01	194.7	6.30	213	6.2	122.1	1.75
Medium level	16	1311	28.1	154.6	0.01	202	5.4	220	5.3	122.5	1.51
High level	20	1225	22.9	157.8	0.01	196.9	5.02	216	4.9	123.7	1.38
Water supplement:											
Traditional	25	1324	23.2	146.8	0.01	193.3	4.52	212	4.4	120.9	1.25
Traditional plus five litres/day	23	1265	23.5	160.4	0.01	202.4	4.58	220	4.5	124.6	1.26
F-test probabilities:											
Hay		$P = 0.2$		$P = 0.3$		$P = 0.6$		$P = 0.6$		$P = 0.7$	
Water		$P = 0.08$		$P = 0.01$		$P = 0.1$		$P = 0.1$		$P = 0.04$	
Interaction		$P = 0.05$		$P = 0.6$		$P = 0.3$		$P = 0.4$		$P = 0.09$	
Milk intake		$P = 0.2$		$P = 0.2$		$P = 0.02$		$P = 0.02$		$P = 0.04$	
Correlation coefficient		—		—		$r^2 = 0.26$		$r^2 = 0.29$		$r^2 = 0.31$	

1 See text for methodological details.

Source: Sovani (1990).

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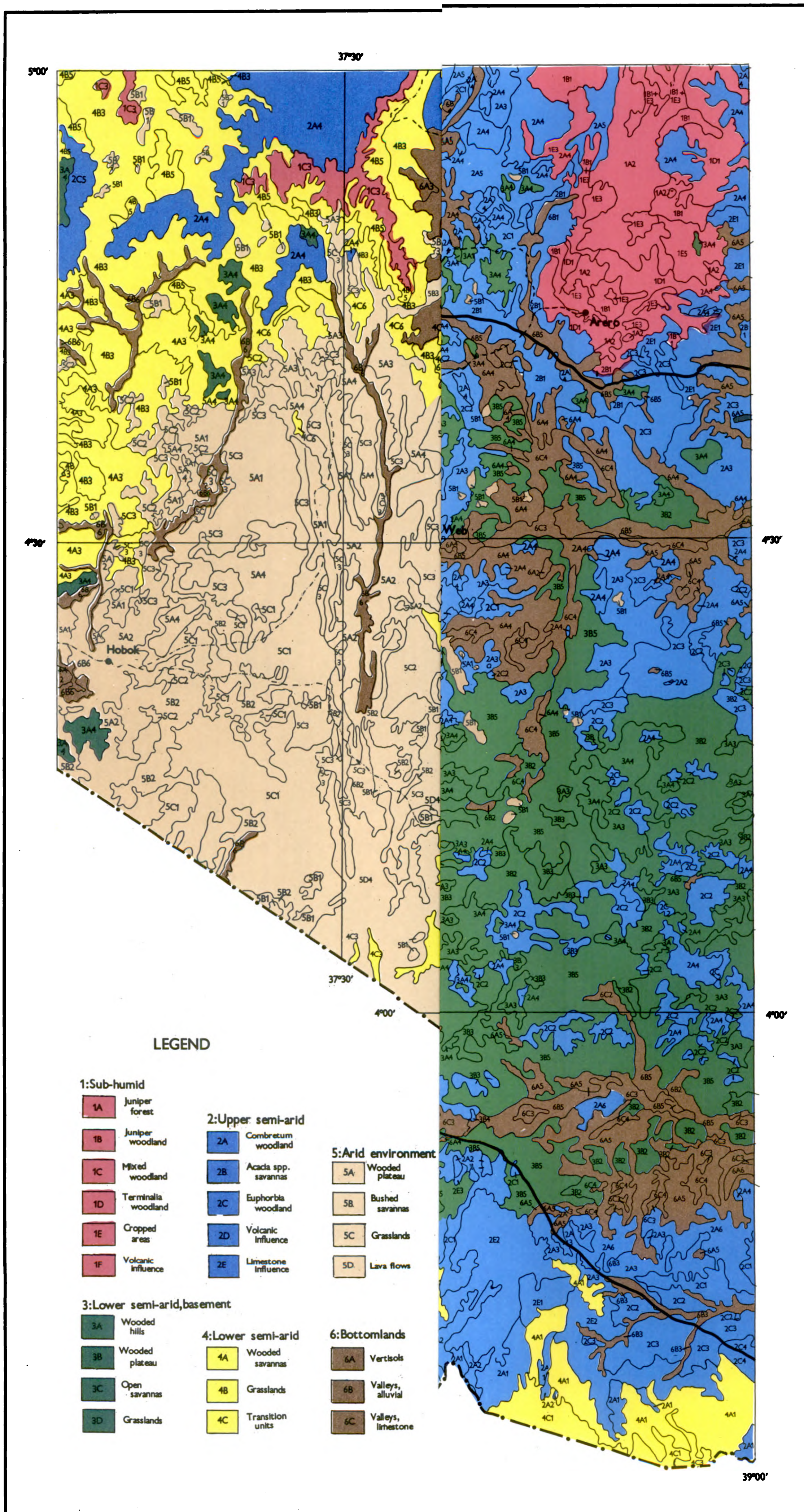
37°30'
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4°30'
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39°00'
Arero
Web
Hobok
LEGEND
1:Sub-humid
1A Juniper forest
1B Juniper woodland
1C Mixed woodland
1D Terminalia woodland
1E Cropped areas
1F Volcanic influence
2:Upper semi-arid
2A Combretum woodland
2B Acacia spp. savannas
2C Euphorbia woodland
2D Volcanic influence
2E Limestone influence
3:Lower semi-arid, basement
3A Wooded hills
3B Wooded plateau
3C Open savannas
3D Grasslands
4:Lower semi-arid
4A Wooded savannas
4B Grasslands
4C Transition units
5:Arid environment
5A Wooded plateau
5B Bushed savannas
5C Grasslands
5D Lava flows
6:Bottomlands
6A Vertisols
6B Valleys, alluvial
6C Valleys, limestone

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