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Georg-August University of Göttingen

Do smallholder farmers benefit more from crossbred (Somali x Anglo-Nubian) than from indigenous goats?

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Do smallholder farmers benefit more from crossbred (Somali x Anglo-Nubian) than from indigenous goats?

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DEDICATION

To my mother,

Agedech Hunegnaw,

who has had the courage to traverse
cultural, traditional as well as economic boundaries
to provide me with all the opportunities
to enable me to produce this contribution
to farmers like herself.

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LIST OF ABBREVIATIONS

BE	=	Breeding Efficiency
BW	=	Body Weight
CSA	=	Central Statistical Authority (of the Government of Ethiopia)
DoB	=	Date of birth
Dent.	=	Dentition
DM	=	Dry Matter
DP	=	Doe Productivity
DRI	=	Doe Reproduction Index
DSE	=	Deutsche Stiftung fuer Entwicklung (German Development Assistance)
FAO	=	Food and Agriculture Organization of the United Nations
FPI	=	Flock Productivity Index
GNP	=	Gross National Product
GoE	=	Government of Ethiopia
ID	=	Identification number
ILCA	=	International Livestock Centre for Africa
kg	=	kilogram
LDP	=	Livestock Development Project (of the Government of Ethiopia)
m.a.s.l	=	Meters above sea level
MoA	=	Ministry of Agriculture of the Ethiopian Government
Patt.	=	Pattern (coat color)
Trans.	=	Transfer
UNDP	=	United Nations Development Programme
Birr	=	Ethiopian currency,(in June 1999 1US$=Birr7.5)
Timad	=	Local measure of land area; about one eighth of a hectare

1. INTRODUCTION

Agriculture remains the mainstay of Ethiopia's economy. About 85% of the economically active population lives in rural areas, particularly in the central highlands (FAO, 1996). The majority of the population has a subsistence mode of crop and livestock production. This form of agriculture contributes a large share of the GNP. For instance, in 1997 the share of agriculture in the GNP was 55%, compared to 20% for the whole of Sub-Saharan Africa (UNDP, 1999). Direct and indirect taxes on agriculture are the most important source of government revenues.

The highlands of Ethiopia (>1500 m.a.s.l.) account from 40 to 50% of the land area, but they carry up to 88% of the total human population, over 95% of the regularly cropped lands, about two thirds of the livestock population and over 90% of the national economic activity (Jahnke, 1982; GoE, 1986; Getahun, 1991). The estimated 9.29 million smallholder farmers in this area had in the 1997/98 production year an average land holding of 0.98 ha. Three quarters of these households are mixed crop-livestock farmers with livestock holdings of both small and large ruminants and sometimes equines (CSA, 1998). Estimates of the contribution of livestock to total income of these households vary from a low of 6% to a high of 24 and even 30% when utilities like draught power and manure are taken into account (GoE, 1986; Webb and von Braun, 1994). The importance of small livestock holdings to the household economy becomes more apparent considering only the income contribution of sale of a goat which can fetch the equivalent of US$10 in the economy that generates an annual per capita GNP in 1997 of US$110 (UNDP, 1999).

While the human population is growing at about 3.2% per annum (CSA, 1999), the estimated total output of meat and milk from cattle, sheep and goats barely increased during the first half of the last decade, with the result that per capita livestock production in 1995 could reach only 88% of the level attained in 1989-91 (FAO, 1996). This disturbing trend has called for rapid improvements in livestock production and productivity to increase the per capita consumption of animal products, and more importantly, to increase the contribution of livestock to household income.

Production from the indigenous livestock under this traditional management of subsistence farmers is generally considered too low, and hence crossbreeding and improved level of care should be promoted as a quick way of attaining higher production and productivity under private commercial farms as well as smallholder management in selected sites in the highlands with a conducive climate for intensification. This is the basis for the policy of the Ethiopian government on livestock development in general (Gebremeskel and Tedla, 1995). This notion of genetic improvement through crossbreeding is challenged here to lay the ground for the thesis. Livestock education, research, and extension services generally favour intensification of livestock production through specialisation into e.g., dairy, beef and egg/broiler production. This approach does not go well with the low-input and risk-averse management style of majority of farmers who are smallholders and rear livestock mainly for their own consumption rather than for the market.

The fragmented and largely unsuccessful crossbreeding programmes supported so far by the extension services in the highlands (on cattle, sheep, goats, poultry) were based on the conviction that the indigenous livestock do not adequately respond to the improvements in the level of management. As elsewhere in the tropics (McDowell, 1972, 1988), a major reason for the failures of previous experiments on promoting crossbreeding in the tropical subsistence production system has been inadequate provision of the requirements for introducing and maintaining the crossbreds. Another reason appears to be lack of focus on the actual production objectives of the farmers for whom the technologies are promoted (Rischkowsky, 1996).

The majority of the farmers practice a low-input livestock management. They work in short time horizons and tend to minimize risk to the little capital holdings, and hence accept low production per animal (Jahnke, 1982). This led to the traditional production systems dependent on livestock breed types that can withstand environmental stress (von Kaufmann and Peters, 1990). Even in these highland communities biological survival and multiple production functions (biological, social) are more relevant than high productivity for specific products (Ørskov and Viglizzo, 1994). The livestock provide more avenues to generate income from feed resources of low opportunity costs and from common properties like grazing and wastelands. There is a consensus that increased production and productivity are imperative in the smallholder sector, but the relevant strategy to achieve these are open to debate. Crossbreeding entails intensification of livestock production by investing more resources, particularly capital, on the crossbreds, i.e. specialization. But the risk-averse poor farmers tend to increase production by way of diversifying and integrating farming activities to maximize use of particularly land and labour (Devendra, 1999). A recent on-farm study in the same area of the present study reported that farmers and development professionals varied widely in their views concerning problems limiting livestock production and the avenues for development (Kassa, 1999).

The increasing population density in the highlands exacerbates the competition for land between crop and livestock, leading inevitably to labour intensive livestock development (Birner, 1996). Specific action is needed to support these natural trends causing intensification of agriculture in general through further integration of mixed crop-livestock systems and improvement of productivity through appropriate technology and increased use of inputs (Winrock International, 1992).

The smallholder farmers have not been benefiting from the mainstream agricultural research and extension services. Systematic development intervention in the livestock sub-sector has been attempted only in the past several decades. Even these have thus far focused more on the benefits to consumers rather than on the development needs of the farmers themselves. For instance, the four major livestock development programmes of the country were based on specialised interventions in animal health, livestock marketing, pastoral development and dairy development, with major objectives of boosting export earnings and increasing supply of animal products to the urban consumer. The First Livestock Development Project (LDP) of the 1960s was targeted at supporting development of commercial dairy farming around the capital, Addis Ababa. The Second LDP focused on the establishment of slaughter facilities for major cities, and for the development of stock routes and markets in pastoral areas. The Third LDP in the 1970s focused on improvement of rangeland management and veterinary services in pastoral areas to support the expanding livestock export market. The Fourth LDP of the late 1980s was designed specifically for the highlands to improve fodder production of particularly smallholder and cooperative dairy farms (ILCA, 1993b; Gebremeskel and Tedla, 1995; Tilahun, 1995). It is only in the Fourth LDP, in a few area-specific pilot projects and in veterinary services that the highland mixed farming system received serious development assistance.

The Dairy Goat Development Programme (DGDP) is the latest donor-financed development assistance specifically designed for the densely populated agricultural highlands. The DGDP set out to test a more comprehensive approach to increase household welfare of smallholder farmers in which the goat plays a central role as a suitably small, multipurpose productive animal with scope for intensive improvement by way of management and crossbreeding. Crossbreeding (indigenous x Anglo-Nubian) was introduced as a means to improve the growth and milk production of goats. The DGDP was peculiar in a number of ways: it was designed to assist the poorest of households with a distinct women-focused goat credit and extension approach; it promoted collaborative joint on-farm undertakings between the livestock research and extension services; and it had strong supervision and evaluation components to facilitate technology adoption (Ayalew, 1996).

Some 1500 families in selected sites have taken part in the programme in eastern and southern Ethiopia. Over 2800 indigenous and 900 F1 crossbred goats have been distributed on credit. Furthermore, the DGDP supported 12 small (10 to 90 heads of goats) private commercial dairy goat producers with the view of establishing a less expensive source of the improved stock after it phases out. A total of 15 pure Anglo-Nubian buck stations were also set up in the villages as additional sources of crossbred goats (FARM-Africa, 1997b).

The DGDP was implemented between 1989 and 1997. Withdrawal of institutional support was effected gradually from March 1996 to its complete phasing out in June 1997, after having handed over full financial and supervisional responsibility to local collaborating institutions (FARM-Africa, 1997a,b). It was envisaged that experiences of the programme would be used to extrapolate the lessons learned to other areas of the country with similar socio-economic settings. FARM-Africa, the facilitator of the programme, also intended to use lessons learned in its regional dairy goat development programmes in Kenya, Tanzania and Uganda.

Against this background, the present study tests the overall objective of the DGDP, which is that crossbreeding and improved management are beneficial and sustainable in the highland subsistence goat production system.

2. REVIEW OF LITERATURE

2.1 Significance of the goat in Ethiopia

The goat is a very important livestock species in Ethiopia, and it is particularly useful in the dominant traditional subsistence mixed crop-livestock production system. At least 53% (CSA, 1995) or more realistically 71% (GoE 1986) of estimated 16.7 million indigenous goats of Ethiopia (FAO, 1996) are found in the highlands as part of the integrated crop livestock production system. Goats in Ethiopia are generally considered associated more with warm and dry areas of the lowlands. However, their broad feeding habits and multipurpose production functions appear to have well served the interests of highland farmers.

2.1.1 The place of goats in Ethiopian highlands

For all practical purposes the term “highlands” is generally understood to mean the landmass with altitudes of at least 1500 metres above sea level and the associated valleys as part of rugged landscapes. Most of this area lies above the 700 mm rainfall isohyte and has mean daily temperatures of about 20^{o}C. This area is rather large and comprises 40 to 50 per cent of the total central landmass of the country (GoE 1986; Getahun, 1991). The mild climate has provided, for centuries, a conducive environment for the mixed crop and livestock farming. It is home for approximately 88% of the total human population, over 95% of the regularly cropped lands, about two thirds of the livestock population and over 90% of the national economic activity of the country (GOE, 1986).

While the country’s national average population density stands around 46 persons per square kilometre, many highland districts in some of the most densely populated regions carry ten to twelve times more than the national average (CSA, 1998). Although both crop and livestock farming activities in this area are predominantly under subsistence mode of production, this form of agriculture is basically the mainstay of the country’s economy. The limited sales of agricultural produce is the major source of food for domestic consumption and raw materials for export. Direct and indirect taxes on agriculture are probably the most important source of government revenues (UNDP, 1999).

As is common with other developing countries with predominantly subsistence agriculture (Hayami, 1997), the low-input and subsistence agricultural practices so far have heavily depended on exploitation of the natural resources (soil, vegetation, water) and land of decreasing nutrient quality is increasingly put under crop and livestock production. With the traditional farming practices, the marginal productivity of labour gradually declines in both the extensive and intensive margins of production (Scoones and Toulmin, 1995). The low level of production of the rain-fed agriculture coupled with the alarming population growth has led to worsening food insecurity during the past decade (Habtewold and Worku, 1994).

In Ethiopia farmers do not own the land (because land cannot be sold or exchanged except by inheritance), and hence livestock are the most important asset with the capacity of self-renewal. Poor farmers view their smallholdings of cattle, sheep, goats and equines as uniquely productive asset that subsist on resources outside the control of the household (GOE, 1986).

Distribution of the goat in the highlands is uneven: an estimated 43 per cent of these are found in low potential cereal growing areas with higher rainfall variability, another 39 % in high potential cereal growing zones and the rest 18% in high potential perennial crop growing zones (GoE 1986).

The relative importance of the goat has increased because of declining land holdings and shrinkage of grazing land. The official estimate of goat populations barely increased between 1979 and 1998; but the human population increased by 54 per cent during the same period (FAO, 1989; 1999). Therefore the per capita holdings of goats must have decreased by half during this period. As a result the estimated per capita consumption of meat and milk in general has been decreasing (ILCA, 1993a). However, expansion of arable farms at the expense of grazing and fallow lands is expected to increase the comparative advantage of goats and sheep with respect to cattle, as was also observed in Kenya (de Haas, 1986), Malaysia (Neidhardt, *et al*, 1993), Malawi (Zerfas and Rischkowsky, 1993), and Nigeria (Bosman, 1995).

The small body size, broad feeding habits, adaptation to unfavourable environmental conditions and their short reproductive cycle provide for goats comparative advantage over cattle and sheep to suit the circumstances of especially the poorer mixed crop-livestock production environments of the highlands. These attributes make it easier to adjust goat flock size to match the available resources, facilitate the integration of livestock production into small scale production systems (low capital, low risk) and enable flexible production (Peters, 1987; Devendra, 1992).

2.1.2 Use of goat products

Utilities of the goat and its products in Ethiopia vary with the traditional farming practices across the agro-ecological zones. But in all cases, goats are raised under low input management and they serve multiple output and input functions (Ayalew, 1992; Reda, 1993; Alemayehu, 1994; FARM-Africa, 1996).

Goats represent only 5.32% of the total tropical livestock unit of the country, but they contribute an estimated 13.9% of meat and 10.5% of the milk production (FAO, 1999). These milk yield estimates appear to be understated considering the emphasis on goat milk in some pockets of the country (Ayalew and Peacock, 1993). All the known indigenous goat types of Ethiopia are milked. Particularly in the densely populated areas of the highlands in the east (Eastern and Western Hararghe), the north (Tigray, Gondar and Wollo) and south (Sidamo), goat milk is extensively used (FARM-Africa, 1996).

Comprehensive studies have not been done on use of manure as fertilizer in Ethiopia. Some farming systems studies (Wiebwaux, 1986; Bekele and Kassa, 1994; Storck *et al*, 1997) report that goat manure is a highly valued organic fertiliser in the intensively cultivated areas of the Eastern Hararghe highlands. Extensive use of goat manure as fertilizer was also reported elsewhere in the densely populated highlands of the country (FARM-Africa, 1996).

Goat manure, as is habitually applied to the soil, constitutes a low cost nutrient source. Its use becomes more relevant to the subsistence producers in view of the rising prices of inorganic fertilizers following the withdrawal of fertilizer subsidies since the 1980`s (Scoones and Toulmin 1995). Furthermore, as population pressure increases and fallow cycles are shortened, animal manure becomes one of the principal sources of nutrients for soil fertility maintenance and crop production (Williams *et al.*, 1995). Even when inorganic fertilizers are extensively used, results from long-term field experiments showed that their extended use leads in the long-run to decreasing base saturation, decreasing pH and increasing aluminium toxicity in soils (Bationo *et al.*, 1995). These problems are not associated with use of manure, and they provide another justification for proper use and valuation of manure in the densely populated highlands.

However, the utility of manure has not been seriously considered a useful addition to the total production from livestock. This is perhaps because manure is not widely marketed, or there has not been a practical quantitative procedure to estimate the value of manure. The available empirical evidence in the literature can be used for this purpose. Because the influence of manure on soil is both in augmenting its chemical composition as well as in improving its physical structure (Stangel, 1995), it is theoretically possible to develop a multi-stage valuation. First key soluble nutrients in manure are selected to relate with same nutrients in commonly applied inorganic fertilizers; then the composition and solubility of the same nutrients in manure is estimated from available empirical evidence (Jenkinson, 1982; Tisdale *et al*., 1985; Fernández-Rivera *et al*., 1995; Somda *et al*., 1995; Schlecht *et al*., 1997); this establishes the chemical equivalence of manure with the inorganic fertilizers with respect to the selected nutrients. Secondly the contribution of manure to soil physical properties is estimated from known residual effects that relate to improved water holding capacity, pH etc. as well as slower release of nutrients (Ikombo, 1989; Onim *et al*., 1990; Williams *et al*., 1995).

These estimates are crude because the type and amounts of nutrients that manure can supply to the soil, and consequently the crop response to manure, depend on the type of soil, season of the year, types of feeds available, manure storage and method of application (Williams *et al.*, 1995). Despite this, such an indirect valuation of manure makes it possible to estimate the benefits from manure along with meat and milk.

In Ethiopia, the key nutrients in common inorganic fertilizers are nitrogen and phosphorus. The chemical equivalence of goat manure with inorganic fertilisers can be estimated on these nutrients. The relatively high labour requirements of manure application are not relevant in the context of eastern Ethiopian highlands as manure is disposed of habitually as a routine barn cleaning exercise, and accumulated in small pits near the homestead as compost. In fact use of goat manure by the small farmers can be considered as having no direct costs. Composted manure is distributed in crop fields soon after ploughing and before final seedbed preparation and seeding. Rarely the manure is directly applied to crop fields during the planting season. Occasionally, manure is also applied to the roots of perennial crops, for instance *Chat* (*Khata edulis*).

Manure excreted during grazing in the daytime is effectively utilised (or not lost) as goats are often tethered and grazed around homestead, crop fields, borderlines and roadsides. Even when goats are allowed to graze freely in the limited communal pastures and wastelands, the manure gets recycled in these plots for the benefit of the whole community. The general tendency that defecation is commonly associated with (triggered by) certain physical activities such getting up after having laid down, walking and particularly watering (Fernández-Rivera et al, 1995; Schlecht et al, 1997) means that more manure is collected around homesteads where goats are tethered and supplied with water and supplementary feeds.

2.1.3 Functions of goats

Jahnke (1982) makes a clear distinction between goat products and functions. Product refers to the output of goat meat, milk, manure and offspring (as constituents of reproduction and growth). The functions, which are essentially tied to products, are output (products), input (resource use and integration), socio-economic (asset and security) and socio-cultural. In the context of the subsistence highland agriculture, and of this study, the perspective of functions is more relevant than that of the products. The reasons for raising goats, or the breeding objectives, go beyond the output functions (meat, milk, manure) and include benefits in resource use, socio-economic relevance and socio-cultural roles (Jahnke, 1982; Devendra, 1992; Bosman and Moll, 1995).

The conventional practice in evaluating subsistence goat production takes the perspective of products, as only outputs of milk, meat or both are used to measure improvements in benefits from goats. This approach is inadequate because these products alone do not constitute the benefits of goat keeping.

For analytical purposes, the benefits that accrue to subsistence goat farmers can be categorized from the perspective of functions into physical, socio-economic and socio-cultural (Table 1). Considering the subsistence mode of production, the inputs applied for goat production can also be divided into two: the household resources of goats (capital), land and labour, and those inputs purchased from outside the household. This framework provides a more realistic context to relate the benefits realised in the functions with the resources employed, to work out the net benefits of the operation.

Official estimates of national goat meat production measure only slaughters by farmer and consumer (FAO, 1999). This is a very narrow definition of meat considering its broad uses by the smallholder farmers. In the present study goat meat is hereafter taken to mean the net change in body weight of the flow and stock of goats in the small flocks. Meat is, therefore, more than the difference in weights between births and deaths during an observation period. Meat is produced as a net change in body weight of the stock of goats in a given time. Meat is produced through buying goats and selling them later at a higher body weight. Meat is also produced as a net change in body weight of animals transferred between related households. The meat so produced can be sold, consumed, maintained or transferred. Meat in these communities is, therefore, not only a product for home consumption or sale, but also a medium of frequent value transaction.

Table 1: Functions and inputs of subsistence goat production in the highlands of eastern Ethiopia

Functions	Input/Resources Used
PHYSICAL: ➢ 'Meat': monetary value of live animal ➢ Milk: value of off-take for sale or home consumption ➢ Manure: market value or monetary chemical equivalence with inorganic fertilizers SOCIO-ECONOMIC: ➢ Asset/financing: additional value of flock outflow ➢ Security/insurance: value embodied in average stock ➢ Employment ➢ Integration (resource use) SOCIO-CULTURAL	HOUSEHOLD RESOURCES: ➢ Goats (flock): in metabolic body weight ➢ Land: in hectare ➢ Labour: in hours EXTERNAL INPUTS ➢ All purchased inputs: in monetary value

Milk off-take can either go to home consumption or sales. In some areas, goat milk is preferred to cow and ewe's milk to feed to children, to prepare certain hot drinks and for medicinal purposes (FARM-Africa, 1996). For this reason goat milk sometimes fetches higher market prices than that of cow milk.

Even if manure is not marketed, its use as organic fertilizer constitutes a vital input function to the subsistence households. But use of manure is not unique to subsistence farmers. For centuries, animal manure was considered the only major external source of nutrients used to maintain the nutrient level of soils (Stangel, 1995).

Manure merely represents a transfer of nutrients from common grazing land to cropping land. Ruminant livestock speed up the recycling of crop residue, thereby adding value to them, and further integrating crop and livestock production for better use of the resources (Stangel, 1995).

In the face of declining average holdings of cultivated land, the highland farmers were reported to be increasingly dependent on livestock sales for cash income to cover incidental expenses (GoE, 1986). The smallholder goat production is not market-oriented, and it is driven by the immediate and future subsistence needs of resource-poor households. Transfers of goats between the households in the form of temporary transfer, gift and lease are as important as marketing transactions. Goats are temporarily transferred to related households in cases of shortages of feed or labour, and to share milk off-take from lactating goats. Goats are handed over in the form of gift during marriage, obituary, or accident (Ayalew *et al*, unpublished observation). These forms of resource sharing and support services strengthen social bonds that provide security during times of difficulty.

These socio-economic functions of goats effectively increase a household's income and improve its purchasing power. Goats help to adjust the consumption and savings of the household's income over time, by balancing the current cash needs against anticipated or unexpected cash needs of the future (Jahnke, 1982; Winrock, 1992; Sansoucy *et al*, 1995).

As Bosman and Moll (1995) have pointed out on a study of smallholder goat husbandry in southwestern Nigeria, physical production of meat alone (the sole product) does not explain the widespread keeping of goats in the area. Under the circumstances where the formal markets to manage finances or to deal with risk and uncertainty are very weak or do not exist at all, smallholder goat flocks have significant roles to play in providing financing and insurance functions. These households instead use informal arrangements, self-financing and capital accumulation. The value embodied in goat flocks provides asset (financing) benefits, as they are a low-cost and inflation-proof alternative of saving. Besides goats provide important security (insurance) benefits at times of difficulty. These benefits provide further economic stability to the household economy.

The concept of quantitatively assessing benefits from smallholder goat flocks from the perspective of functions was first proposed and applied by Bosman and Moll (1995) for a goat production system where meat is the only output. This paradigm allows to estimate the financing and security benefits from the total off-take (outflow) and average stock, respectively, of smallholder goat flocks. It can be extended to accommodate utility of milk as well as manure as in the case of the smallholder flocks of Ethiopian highland.

There are also other significant socio-economic and socio-cultural roles of goat, which under the current state of knowledge do not lend themselves to modelling and empirical value estimation. These benefits include provision of employment opportunities for otherwise low-opportunity cost household labour, integration and resource use (land, labour, feeds) and fulfilment of various socio-cultural obligations of their owners (Jahnke, 1982; Steinfeld, 1988).

2.2 Measurement of benefits from subsistence goat production

Given that the DGDP aimed at increasing the contribution of goats to the **welfare of poor farming families**, how can improved welfare be measured as an indicator on the success of the package? The term “family welfare” is generally defined as the physical and mental health and happiness (Procter, 1995), and this is too broad to apply in the context of the research questions of this study because it can take different forms depending on the subject in question. It is, therefore, essential to establish the theoretical/conceptual link with goat production.

2.2.1 Improved family welfare as an indicator

Subsistence (or semi-subsistence) producers are understood to be engaged in growing crops and raising animals primarily to satisfy the needs of the family rather than to meet the demands of a market. The limited sales of agricultural produce are conducted out of the necessity of fulfilling non-food essential commodities (supplies) for the household (Doppler, 1991). Welfare in this context is, therefore, more appropriately taken to mean achieving food security and alleviation of poverty. At the household level food security is defined in its most basic form as access by all people at all times to the food needed for a healthy life (von Braun *et al*, 1992). Increased income, apart from securing other non-food basic needs of the household, is essential to overcome scarcity of food supply during the lean season.

The small goat flocks in these households contribute to food security directly as a source of food and indirectly as a source of disposable income. Goats also have important socio-economic and socio-cultural functions that provide economic stability to the household. Needless to say that these diverse benefits ultimately translate into increased production and sale of goat products, but not necessarily improved food security. This is because the increased production and income are also influenced by the other pillars of food security namely, access and utilization. Access could be in the form of economic or physical access to adequate food for the whole household, and utilization refers to ensuring that the food consumed contributes to both physical and cognitive development (von Braun *et al*, 1992). Increased food production is only the first step to attain food security, and improved food utilization and nutrient availability are equally important.

A comparative study of nutritional impact of the DGDP during the last three years of implementation also indicated that the apparent benefits in increased production of milk and meat did not necessarily translate into improved nutritional status of the household. This study was based on the conceptual framework that the ultimate indicator of the improvement of family welfare was betterment of nutritional status of the most vulnerable members of the household (women and children of ages under five years). Level of vitamin A deficiency and protein-energy malnutrition were taken as key indicator variables. The study found out that increased production of milk and meat did not lead to significant improvements in the levels of vitamin A deficiency and anthropometric measurements on women and children of the DGDP participant households. It was then established that, because of the poor level of awareness in the community on the link between food consumption and health, further interventions were necessary in nutrition education to encourage increased consumption of milk and meat by children and mothers (Woldegebriel *et al.*, 1997).

Subsequent trial interventions comprising specific nutrition education, improved food preparation and vegetable gardening were implemented with the view of improving the nutritional outcome of the DGDP. The latter have significantly increased the consumption of produced and purchased nutritious foods by mothers and children, and resulted in significant improvements in the vitamin A status of the households. However, the levels vitamin A deficiency and generalized protein-energy malnutrition were so high that these nutritional deficiencies still remained of public health significance. Ownership of goats and the increased production of milk as well as meat were, therefore, not sufficient to resolve these nutritional problems (Ayalew *et al.*, 1999). In effect, indicators of food security only provide partial evaluation of the benefits accrued from subsistence goat production.

Clearly, improvements in family welfare of the DGDP participant households cannot be adequately measured using indicators of food security alone. Attempts to evaluate subsistence goat production need to apply broader criteria that reflect the actual utilities of goat flocks, in other words the working production objectives of the households. The quest for such broad criteria leads to the existing measurements of flock performance, or indices of productivity.

2.2.2 Conventional indicators of goat productivity

The conventional criteria that have been commonly applied to evaluate goat production focus on meat or milk or both and provide only a partial evaluation of how well subsistence goat production functions. The common measures of animal productivity were reviewed by Peacock (1987), Amir and Knipscheer, (1989) and later by Bosman and Udo (1995). Most of the productivity indices for subsistence production were developed and applied in the context of larger and more homogenous pastoralist goat flocks. Otherwise other indicators of progress were borrowed from concepts of commercial operations, namely performance on a selected trait with respect to a selected animal. Usually the quantified output is expressed with reference to an individual animal unit, notably the breeding doe.

Where meat is considered the major product, and when other benefits are not significant or non-quantifiable as in the case of extensive pastoralist or sedentary production systems, measurements on reproductive performance of does have been used to indicate overall flock performance as, for instance, in the Flock Productivity Index (FPI) (Wilson *et al.*, 1981; Fall *et al.*, 1982; Peacock, 1982; Wilson, 1982) (Table 2).

This index is not related to input, for instance to doe weight or metabolic body size, which is the primary input to the output. Besides, it does not relate to growth or body weight gain of the kids born. This index was later modified, by using the Breeding Efficiency (BE) of Singh

(1982), into the Doe Reproduction Index (DRI) (Knipscheer, *et al*., 1984). Use of the BE would require measurement of the kidding interval as a percentage of a full year. The DRI is a measure of the number of viable kids produced per doe per year. When the DRI is multiplied by the average weight of weaner kids, it gives an index combining reproduction with kid growth performance, or the Doe Productivity (DP) (Knipscheer *et al*., 1984). This value can be averaged out per unit of live weight of the doe, or preferably per unit metabolic body weight of the doe. The use of metabolic body weight gives a more accurate measure of the input-output relationship, as the main input required (feed) is better correlated with the metabolic weight than with the live weight (Morand-Fehr, 1981). This index measures productivity of the doe, and not of the flock, which has to be maintained anyway.

Table 2: Conventional indicators of goat productivity.

Productivity Index	Description	Source
Flock Productivity Index (FPI)	FPI = (Litter size x Kid survival x birth weight) x (1/Kidding interval)	Wilson *et al.* (1981); Fall *et al*. (1982); Peacock (1982); Wilson (1982)
Breeding Efficiency (BE) and Doe Reproduction Index (DRI)	BE =[365 (n-1)]/D; n= number of parturitions; D= days between first and last parturition; DRI = BE x litter size x kid survival rate	Singh (1982); Knipscheer, *et al*. (1984)
Doe Productivity (DP)	DP = DRI x average weight of weaner kids	Knipscheer *et al*., 1984
Physical off-take rate	Physical off-take = outflow / average stock	Wilson (1982); Knipscheer *et al*. (1984)
Flock Productivity Index (FPI), redefined as rate of increase or decrease per unit of flock; units are numbers, weight or monetary value;	$FPI = [E_S + E_{SL} + E_{SI} + C_{NI}] / F_{IS}$ E_S = Exits from the flock in the form of sales; E_{SL} = Exits from the flock in the form of slaughter; E_{SI} = Exits from flock through social transactions; C_{NI} = Change in net inventory; F_{IS} = Initial flock size.	Peacock (1987)
Production, modified FPI	$P_{kg} = [[O - I - C_{NI}] / (FW_m)] \times [365/period]$ P_{kg} = production; O = all outflow; I = all inflow; C_{NI} = Net change in inventory; FW_m= weighted average stock (all expressed in kilo gram live weight).	Bosman and Udo (1995)

First Wilson (1982) and later Knipscheer *et al*. (1984) have introduced an overall herd productivity index, known as off-take rate, which was defined as kilogram live weight produced per unit of the average kilogram live weight of total flock maintained over some specific time period. Multiplying off-take by dressing percentage gives an estimate of total meat production for a given population. But it is a measure of only one product of the flock:

meat. It is difficult to aggregate this average with similar averages of other physical products (milk and manure). The non-biological functions also remain unaccounted for.

Multiplying the physical off-take by the market value of the off-take can lead to assessment of economic efficiency, if inputs can as well be quantified in monetary value. However, as most of the inputs of subsistence goat enterprises are non-cash inputs, their valuation is difficult.

Modified versions of these indices were also suggested to assess overall reproductive performance at flock level by Peacock (1987), who went further to redefine the Flock Productivity Index (FPI) (Table 2). This index expresses the overall change in flock with reference to the initial flock size, which becomes a serious limitation in small and more dynamic flocks, such as those of the highland subsistence flocks. Furthermore, increments of flock size due to purchase and inward transfer are not taken into account.

Peacock (1987) also showed that setting the index from the perspective of the owners, as in the case of her traditional index, could better reflect the production objectives or priorities of the producers. She also highlighted a common difficulty that different indices lead to different ranking of the same production systems. This emphasises the need for the care in choosing an index appropriate to the purpose of the analysis. She then suggested that productivity indices should possess the following characteristics: (1) the output should include all relevant components; (2) the input should be the most limiting resource or the one which most urgently requires improvements; (3) the time period should be one year; and (4) the units of the index should be associated with the type of output and the purpose of the analysis. Besides, in order to interpret the productivity index correctly, an adequate description of the physical, economic and social environment of production should be added. These suggestions are valid even when broader aggregations are done at herd or flock level.

Bosman and Udo (1995) suggested an improvement of this index by including all flock entries in the numerator and replacing the initial flock size in the denominator by the average flock size, and standardised to one year (Table 2). Then entering monetary values instead of live weights produces what can be called the return to capital (in this case the average flock). Furthermore, if the weighted average flock is converted into metabolic weight of the average flock, the resulting index expresses productivity in the biological sense.

Attempts were made to incorporate milk off-take into such an index by applying biological product equivalents, of for instance 9 kg of milk for one kg meat. FAO/ILCA/UNEP (1980) proposed combined productivity indices for breed comparison on the basis of the dam (in this case cow) that combined reproductive rate, viability of dam and offspring, milk yield, growth of offspring and dam weights. A conversion factor of 9 kg cow milk for a kilogram of calf weight was applied. Similar ratio of milk to meat was also applied later for goats (Peters, 1987) and cattle (de Leeuw, 1990). This method of aggregation has the following limitations; first, it does not take into account that part of the herd/flock other than the dam and offspring born during the observation period; second, it cannot accommodate the seasonal fluctuations in the relative prices of milk and meat; third, it cannot be equally applied in areas where manure is also a valuable product.

Ideally the aggregation of outputs should be done at the level of whole flock/herd to take account differences in flock/herd structure. Productivity indices calculated by herd models, that accommodate all classes and age groups, take herd structure into account. Such indices are particularly relevant when feed input is considered a limiting factor, and especially when metabolic weights of the livestock units are used to determine the indices (Upton, 1989).

Indicators of economic performance like gross margin or return to capital presuppose that both outputs and inputs are widely marketed, which does not hold true for subsistence producers. In reference to commercial dairy farms, where milk, veal and other meat are sold, Kahi *et al*., (2000) developed a sophisticated procedure to determine the profit per day of productive life of a cow. The rationale behind this procedure is economic viability of the farms in a market-oriented system, which, again, is not necessarily the case for subsistence producers.

In conclusion, productivity indices based on a selected set of output, and profitability on marketable products fit better to the production objectives of commercial producers than to subsistence farmers. To the subsistence smallholder, improved sustainability, risk minimisation and diversity of production are more relevant than profit maximisation or productivity (Ørskov and Viglizzo, 1994). Furthermore, traditional livestock production systems are usually so dynamic and diverse that these productivity and efficiency parameters cannot consider all aspects, but instead focus on selected parameters depending on the aim of the assessment (Bosman and Udo, 1995). The available conventional productivity indices can provide only partial evaluation of subsistence flocks. Indices related to reproduction indicate, at best, the biological reproductive potential of flocks. Other indices on overall flock performance measure production in the form of meat, and possibly combining meat and milk.

A wider aggregation of production is required to capture the benefits realised in milk and manure as well, if these are also the reasons for keeping the animals. The aggregate production then needs to be related to the relevant inputs that went into the outputs. In the context of the smallholder flocks of subsistence producers this aggregation is further complicated by the important socio-economic roles of livestock and the low opportunity cost as well as multiple utility of the resources used. It is, therefore, necessary to establish the theoretical background of the process of aggregation from the concept of productivity.

2.2.3 The concept of productivity as applied to subsistence goat production

The term “productivity” generally embodies a connotation of rate of production in which the scale of the rate can be set in terms of the resources utilized, including time. The concept is commonly applied in animal agriculture in defining production operations, comparing or ranking alternative options of production and even measuring improvements (de Leeuw, 1990). The rationale behind determining an index of productivity appears to have emerged out of the need to making fairer comparison of production, and in recognition of the fact that volume of production alone cannot show how well a production operation functions. Outputs become more informative when expressed in relation to the inputs involved.

Productivity is used interchangeably with efficiency of resource use, and defined as a ratio of output to input, with output and input given a variety of biological, physical or financial units (Spedding *et al.*, 1981). The quantity so produced can be used as a guide for choosing between alternative systems if the numerator reflects a desired objective and the denominator a limiting constraint (Upton, 1989).

Such numerical output-input ratios provide a quick and handy tool to compare widely different entities: individuals or groups of animals, production systems, agro-ecological zones or geographical regions. Understandably care should be taken in interpreting the results of the comparisons. De Ridder and Wagenaar (1984,1986) showed that in Botswana ranching appears to be more efficient than traditional systems in terms of gross energy produced per unit of gross energy used for maintenance. Traditional systems, on the other hand, appear to be more efficient in terms of all the energy used in the whole production operation. Because some inputs, which spread the economic risk in intensive agriculture, are a potential source of risk for subsistence economies (Ørskov and Viglizzo, 1994), valid comparisons of productivity cannot be made between the intensive and the traditional systems when these inputs are used in the production process.

Productivity indices, once determined, lend themselves to easy extrapolation to higher abstract level, and as such can be used to measure complex development phenomena, to monitor change of a phenomenon over time, and to determine policy planning and preparation of political decisions. The indices relate to the range of measurements from which they were developed, and the physical as well as socio-economic circumstances where the observations were made (Spedding *et al*., 1981).

Cossins (1985) and Cossins and Upton (1987) have applied productivity indices to evaluate pastoral production systems and to compare different production strategies of a system. Similarly, Kaufmann (1998) has demonstrated in a study of pastoral camel husbandry in northern Kenya that elaborate productivity indices can effectively be used to evaluate different management techniques that exist among pastoral communities. She argues that single production parameters are insufficient for comparing different husbandry systems, and they must be aggregated and related to inputs in order to determine the efficiency of each system, and to identify feasible improvement measures. She further noted that comparative evaluations based on productivity indices seem to depend less on the actual system properties, but much more on how the evaluation is performed. Partial productivity indices fail to reflect the actual production objectives of the systems and the circumstances under which animals produce (in terms of resource base, climate, socio-economic characteristics).

Unlike in commercial settings with clear objectives of maximum profitability or economic efficiency, it is practically difficult in subsistence smallholder production to quantify production objectives as such, because of the multiple output and input functions of the resources (goats) used and because of the low opportunity costs of the major inputs: labour and land. Devendra and McLeroy (1982) argue that it is not easy to conceptualise a situation in which net production by the smallholder is zero or negative (body weight loss), and hence efficiency is zero. While such a value often portrays a negative image of the smallholder producers, the fact that animals gradually lose part of the weight gained during the lush season to survive the long dry season is actually a biologically useful attribute that helps the smallholders to cope up with times of scarcity (Ørskov and Viglizzo, 1994). This is usually the case in subsistence households during the lean season when no body weight is gained, or even weight is actually lost.

In reference to the subsistence African livestock keepers, Jahnke (1982) argues that from the producers' perspective the low productivity figures are less disturbing; the low productivity figures are real enough but they do not imply that livestock have a low value in the eyes of the owners. Furthermore, he remarks that when such comparisons are made across production systems using productivity on milk and meat, the two most readily quantifiable products, the products may not be equally important in systems under comparison, and other limiting factors are not taken into account. Multipurpose production objectives and hidden costs (disease risk, environmental side-effects) make it misleading to estimate profitability (or productivity as such) only in terms of a single output and input (Schiere, 1995).

Because goats in smallholder flocks have multiple production functions, it is logical to determine **aggregate productivity of all the major outputs at the flock level**, and not at the level of the individual animal. As Kaufmann (1998) pointed out, focusing only on production levels of a selected trait without doing aggregation of relevant outputs and inputs often leads to misuse of the term productivity. In the case of the subsistence mixed farms of eastern Ethiopian highlands, manure is a valuable output as are meat and milk. These constitute only the biological or physical functions of goats. Socio-economic and socio-cultural functions of livestock are also important to the producers.

Bosman and Moll (1995) have proposed one way of estimating the asset and security functions of goats under subsistence production where goats also serve financing and security functions in the absence of formal markets for credit and insurance. Although they are difficult to quantify, even values such as bride prices or slaughters in initiation ceremonies cannot be ignored in pastoral communities (Scoones, 1992).

Aggregation of all the quantifiable benefits into a common unit then yields what can be called the total benefits from the goat flock.

Choice of unit of measurement depends on the purpose of the evaluation, and aggregated output can be expressed either in monetary value (Behnke, 1985), in dietary energy equivalents (Upton, 1985), or in a combination of monetary value for traded items and protein and energy values for subsistence produce (Cossins and Upton, 1987). Most of the experimental evidence is from studies in pastoral production systems. Upton (1985) argues that in a pastoral system energy is likely to be most critical and protein deficiency is unlikely to occur; hence output is best measured in terms of dietary energy. However, the seasonal scarcity of either protein or energy leads to a trade-off between the values that cannot be captured when only energy is measured (Behnke, 1985). When nutritional units are to be used, even consumption preferences have to be considered and a higher value might be attributed to protein-rich food.

However, for the subsistence producers who use manure as well as meat and milk from their goats, using energy or protein as an aggregate unit of measurement is incompatible. It is difficult to make a clear distinction between marketable and consumption products in the household. Aggregation of socio-economic functions with physical products also makes it difficult to attach energetic or protein equivalents of the benefits.

Upton (1989) further suggested that a feasible alternative is to use both measures of productivity: cash and energy, which again may lead to undue complexity. For practical purposes, it is reasonable under the circumstances of subsistence production to accept Behnke's (1985) proposition of assigning monetary values to both subsistence and marketable products. Actual prices are taken for marketed products, and estimated prices are applied to subsistence transactions. It follows, therefore, that the relevant market price to attach to home consumption is the price that farmers would have to pay if the produce were to be purchased. The farmer correctly attaches a higher price to production for home consumption than to production for sale because he would have to pay the retail price for what he buys and receives the farm gate price for what he sells (Kaufmann, 1998). It is also important to note the seasonal fluctuation of market prices. Realistically, the current market prices of all the outputs and inputs are applied.

The denominator of the productivity index reflects the most limiting input, as the numerator quantifies the production objective. Essentially three different input factors are recognized: land, labour and animals. A limiting input factor is selected to emphasise the efficiency of its utilization in the system. However, under subsistence production of Ethiopian highlands, it is not realistic to select one limiting input when all the major factors of production (land, labour, goats) are commonly used for several production functions. The small land holdings are used throughout the year to produce successive crops. Crop thinnings and weeds provide a large part of the supplementary feed available to the goats. Use of household labour is also fluid, as children, housewives, householders and casual visitors are involved in accomplishing the daily chores of goat husbandry. As already stated, total flock output should be weighed against the whole flocks, and not only to animals that actually produced the output.

Land is a critical resource in the highlands; but there is no evidence to show that it is any more limiting to the total flock output than the total labour available at the disposal of the households or the biomass of goats. Under pastoral production land is the most limiting constraint of production where mobility is the principal strategy for overcoming drought and other environmental constraints and where the overriding goal is human survival. In contrast, the animal is the most limiting factor for the economic viability of commercial ranching (Ruthenberg, 1980; Ørskov and Viglizzo, 1994). Pastoral systems rank higher when compared with ranch systems on the basis of land and not per animal. From a certain stocking rate onwards productivity per animal decreases, while the productivity per land still increases (Behnke, 1985). Therefore, the use of land as denominator is more appropriate for the evaluation of pastoral systems (Kaufmann, 1998). Labour is a more limiting factor to ranches than to pastoral systems, thus productivity for labour is better in ranches. Such relationships are more complex under the circumstances of subsistence highland farmers for whom land appears as limiting to production as is labour. A logical approach should therefore be to take up land as one of the limiting factors.

The reasoning behind using the animal itself as the limiting input is its consumption of feed and other inputs. Feed is the major cost of livestock production. The difficulty is that there is no cost-effective way of quantifying total feed input under extensive production, and especially when a combination of grazing, browsing, scavenging and supplementary feeding are applied, as in the case of mixed farms in Ethiopian highlands. However, for all practical purposes, the total maintenance energy requirement can be indirectly estimated from the metabolic body size of the animals (Morand-Fehr, 1981).

Consumption of food, and especially food energy, increases with body size, but not necessarily in proportion to body size of the animal. The total turnover of this energy, also known as metabolic rate, is more proportional to the metabolic body size of the animal. It has been widely accepted to apply the same slope of the metabolic regression line for all mammals of 0.75 (Schmidt-Nielson, 1984). In fact, energy requirements of goats for maintenance are expressed per unit of metabolic body weight that uses this coefficient of 0.75 (NRC, 1981). Therefore, it is logical to express the size of the animals or flocks in the denominator in terms of aggregate metabolic body weight. Here again, there is no evidence to suggest that feed can be taken as the only limiting input in determining a productivity index in the highlands.

Availability of labour in extensive production systems determines the provision of feed to the animals, which in turn determines the level of production that can be achieved by the flock. Although the opportunity costs of labour of especially children and those who are unable to help in other farm operations may be low or zero (Ørskov and Viglizzo, 1994), the labour input of women and elderly children is shared with other habitual duties. Labour is, therefore, another important production factor, which needs to be accounted for in determining productivity indices. The lack of a formal labour market in subsistence and pastoral production systems means that it is difficult to attach a market value to the labour input. But the indices can be calculated on the estimated absolute amount of labour time.

This argument then leads to the simultaneous **application of multiple indices** in determining aggregate productivity indices that relate to the three factors of production (land, goats and labour). The three productivity indices based on land (cultivated area of land), metabolic body weight of the average flock, and labour input are then applied simultaneously and independently. This approach also allows capturing the interaction between the inputs without limiting depth of analysis on each of the factors of production. The common use of household inputs to the different branches of agricultural production for the overall goal of secured subsistence (Ruthenberg, 1980) also justifies that the three factors of production be evaluated together to see their linkages with operations outside goat production.

The simultaneous and independent expression of the total benefits in terms of the three quantified inputs over an observation period then produces what can be referred to as the **Unit Net Benefits** from the flocks for the resources used.

2.3 Crossbreeding and improvement of traditional goat production

Very little systematic attempt has been made to improve the traditional goat production system in Ethiopia. The fragmented pilot projects undertaken so far by research institutions and non-governmental organizations involved importation and testing of high-producer temperate goat breeds and their crosses. These included the Saanen, Toggenburg, Brown Alpine and Nera Verzasca breeds from Europe, and were reviewed elsewhere (Ayalew, 1992). The basis for each of these attempts was a prejudgment that indigenous livestock generally have lesser overall performance than their crossbreds with the standardized commercial breeds. All those initiatives were later discontinued. The reasons for failures should be sought in the inadequate evaluation of the worth of indigenous goats, poor appreciation of the owners' working objectives of raising the goats and understatement of the traditional husbandry systems in which the flocks are maintained.

Whether the introduction of the exotic breeds should be part of the limited development initiatives to the smallholder subsistence production system is open to debate. There is no empirical evidence to establish the comparative advantage of introducing crossbred animals in a modified management environment vis-à-vis gradually improving the traditional husbandry practices for the indigenous animals. Levels of production of meat and milk from the dominant smallholder goat flocks in Ethiopia are generally very low (FAO, 1999). There is lack of direct evidence to show attainable levels of improvement through genetic or management (environment) interventions. The necessary baseline information on the diversity, distribution, common uses and preliminary performance data of the indigenous goat types has only recently been made available (FARM-Africa, 1996). Too often reference is made to levels attained in other countries, or else to results of on-station tests, which can only be indicative and cannot serve the purpose of introducing suitable improvement strategies (Peters, 1987).

In theory the expressed phenotype is the function of the genetic constitution of the animal, the effect of its surrounding environment and the interaction between the two, the relative magnitudes of which determine the pathways of improvement in performance (Falconer, 1989). In the tropics in general, performance of smallholder goat flocks is highly influenced by a large number of environmental factors that the owners are unlikely to control. This makes adaptation of the animals to the prevailing environment very important. On this basis, Horst (1983) has introduced the concept of 'productive adaptability', which implies that phenotypic performance is the result of an animal's true genetic performance ability (referred to as specific performance ability) plus its specific ability to cope with environmental stresses, including the burden of common diseases and heat load (referred to as specific adaptation ability).

Along this line, Peters (1987) has outlined a systematic procedure for evaluation of goat performance in the tropics and subtropics under controlled (on-station) and actual (on-field) management environments. The procedure allows stepwise identification of location specific as well as general breed improvement possibilities that lead to introduction of suitable breed improvement strategies. Even if this procedure takes a long time, considerable resources and continuous professional commitment, it is essential for long-term genetic improvement and conservation of the indigenous genetic resources. There is no alternative to it under the current state of knowledge.

Leaving the issue of genetic limitations aside, which remain largely unexplored, other major reasons for the relatively low levels of production are the low levels of input provided, the multiple objectives for which goats are raised, and the limitations imposed by the environment. The multiplicity of objectives (production goals) of smallholder farmers under risk averse and low-input production regime is a critical constraint, but it is poorly appreciated (de Leeuw, 1990; von Kaufmann and Peters, 1990). Often technical experts tend to prescribe what needs to be improved from their own incomplete point of view rather than counting on the realities of the poor farmers, who ultimately make the routine management decisions (Chambers, 1997). In situations where environmental constraints (climatic limitation, feed supply, disease challenge) are pronounced, survival of the animals becomes more important than mere production to fulfil subsistence needs of the poor farmers (Ørskov and Viglizzo, 1994).

Nevertheless, there is a widely held belief in Ethiopia that, in the more conducive climate of the highlands, where the prevailing mild tropical climate is not expected to impose limitations in adaptation (Johnson, 1992; Vercoe, 1999), modification of the traditional husbandry practices alone cannot bring about satisfactory increases in production, given the present scarcity of animal products and the fast growing demand for them. As has been the case in other developing countries with large livestock populations, genetic improvement of indigenous livestock breeds in Ethiopia by way of selection is also considered too slow and complicated to achieve desired levels of production (McDowell, 1972, 1988). Consequently crossbreeding of some native breeds with selected exotic breeds has generally been accepted in principle and practised as a shortcut to genetic improvement of indigenous livestock under smallholder farmer management. These moves implicitly involved simultaneous improvement of the level of feeding and health care, without setting the minimum requirements for introducing the crossbreds.

This is probably the main reason why in recent years major livestock development programmes in the subsistence smallholder sub-sector of Ethiopia almost always involved introduction of improver exotic breeds for crossbreeding. These include dairy type cattle, wool and meat type sheep, egg and broiler type chicken and dairy type goats. The economic and biological viability of these options have not so far been tested under the smallholder management; but the general tendency has been towards introducing crossbred animals in a slightly modified management environment. Although crossbreeding is often regarded as an alternative to selection, it needs to be stressed that they are not mutually exclusive strategies, and that any crossbreeding options require a supporting selection programme, either in contributing pure breeds, or in the resulting crossbred offspring (Cunningham and Syrstad, 1987). In other words, control over the breeding process and selective breeding are part of genetic improvement through crossbreeding.

The aim of crossbreeding is to combine high yielding capacity of the exotic breed with the adaptation attributes of the indigenous breed, but not all crossbreds equally combine both. Intense selection is therefore needed to find the few animals combining the desired set of traits to maintain the level of improvement in succeeding generations (Cunningham and Syrstad, 1987). Crossbreeding strategies can be broadly classified into three categories, namely, breed replacement strategies, formation of synthetic populations, and establishment of stable crossbreeding systems (Mason and Buvanendran, 1982).

Crossbreeding as a method of improving productivity of small ruminants in the tropical smallholder sub-sector is often considered erroneous (Ademosun, 1990). The major concern is that introduced crossbred animals, because of their higher level of output and larger body weight, and lack of adaptation to the new environment, generally require more inputs in terms of feed and health care than is usually possible to achieve.

There is also concern on the potential danger in the long term in loose dissemination of the introduced genetic material as it could threaten the genetic identity of indigenous breed types. However, this argument is not strong in the context of the far larger scale local introgression between adjacent populations. Hall (2000) cited studies in west Africa that provided evidence of large scale and deliberate breed replacement of the more adapted indigenous humpless short-horned cattle through crossbreeding with the less adapted zebu type cattle, because the latter have greater market value. There are also developments in husbandry and environmental changes that provided more conducive environment for the introduced genotype. In Ethiopia, particularly the recurrent droughts and stock losses in the pastoralist areas and the subsequent gradual restocking appear to have produced increasingly mosaic herds and flocks in transition zones. Furthermore, the effect of market forces, which transcend traditional livestock movement zones, cannot be underestimated.

Local breeds that have adapted through time to environmental stress, disease challenge and seasonal fluctuations of feed supply provide better stability to the production system. As these animals can have the potential for significant performance improvement in more favourable environments, their gradual deterioration would mean increased vulnerability of the households to difficulties in subsistence (Ørskov, 1993; Ørskov and Viglizzo, 1994).

Some on-farm studies of the performance of crossbred and pure exotic goats report significant socio-economic problems after the introduction of the improved goats. A survey of crossbreeding projects in Burundi, Malawi and Kenya (Tropenzentrum, 1993) has also revealed some planning and managerial constraints that contributed to slow progress. These included: poor appreciation of farmers' priorities, little attention to women (when they have a significant traditional role to play in goat rearing), disregard for socio-cultural interests of target groups, and poor supervision. As was noted in another case study in Malawi, successful technical implementation of programme activities for introducing crossbreds into subsistence households does not guarantee long-term sustainability of the newly introduced technology. Socio-economic factors such as marketing and traditional practices in product use can have stronger influence on sustainability (Rischkowsky, 1996).

Apart from the common problems of parasitic and infectious diseases, adaptation of the introduced animals to the new climatic variables of warm ambient temperature and high relative humidity of the tropical environment can be critical (Johnson, 1992; Vercoe, 1999). In a comparative study in northern Tunisia (Steinbach, 1986), the local Tunisian goat was observed to be superior in biological productivity per unit metabolic body weight than the high-producer temperate goats, and the imported temperate goats suffered from low fertility and low viability in the arid Mediterranean climate.

In a developing economy, growing market incentives can provide the economic justification for introduction of crossbreds. In view of the recent rapid developments in the livestock sector of Brazil (Ferras, 2000), it is unrealistic to assume that evolution of commercial livestock breeds in developing countries will follow the same routes of long-term selection within and between indigenous breeds as have been observed in developed countries. Market incentives favour some at the expense of others; and crossbreeding among the indigenous and with imported breeds gradually gains momentum. With due regard to the comparative advantage of the local animals in having adapted to the local environment, the possibility of introducing suitable exotic breeds could be worth considering. There are situations where the ideal producing animal is some intermediate between a tropical adapted and an improved temperate breed. Hybrid vigour (heterosis) for most traits appears to be greater in sub-optimal environments, with the notable exception of growth, which is enhanced by favourable nutrition (Barlow, 1981). Devendra (1991, 1993) also noted from the experience in southeast Asia that the economic incentives are hard to resist when an important trait like milk yield can be increased very quickly through crossbreeding. Similarly, it took ten years of intense selection in the local cattle in Australia to improve tick resistance to a level attainable in just one generation of crossbreeding (Utech *et al*., 1978).

However, the environment by genotype interaction can be a very significant factor depending on the response of the introduced genotype in the new environment. For instance, in a comparative study of response to selection for growth in Australia, animals selected in the high plane of nutrition were found to be unsuitable for a regime with a low level of nutrition, and vice versa, because on the low plane of nutrition the response to selection was mediated mainly through reduction in maintenance requirements while selection on high plane of nutrition was mediated by increased appetite (Frisch and Vercoe, 1978). Similarly, Chagunda (2000) reported that the performance ranking of Holestein Friesian bulls imported from

Canada was different when they were evaluated in Malawi. Therefore, there is a need to incorporate a local programme to select even among the introduced genotype.

Even when the environment remains unchanged, crossbreeding between indigenous (but genetically distant) and complementary breeds may be justified. For instance, the Barbados Black Belly has been used in this regard to improve prolificacy with some success in the Caribbean and central America (Fitzhugh and Bradford, 1983). Cattle owners in central and west Africa have increasingly crossbred the native humpless short-horned cattle with the less adaptable but more marketable zebu types (Jabbar *et al.*, 1997**).**

Based on these observations, it can be argued that as long as breeding objectives of such a smallholder livestock production system are clearly understood, and as long as minimum requirements of introducing crossbred animals are within reach of the potential beneficiary households, crossbreeding can provide one option of intensification to the subsistence livestock sub-sector. There is also the argument that a large part of the community needs urgent biological and technical development assistance to overcome the difficulties of poverty. Market forces among subsistence farmers are not strong enough (Doppler, 1991) to demand market-induced modernisation of the traditional husbandry practices. Inevitably, alleviation of poverty involves use of natural resources; the challenge is how to make these small farms more sustainable and profitable through appropriate technology interventions and policy adjustments (Devendra, 1993).

The real operational difficulty is in precisely defining what constitutes ‘improvement’ to intensify the traditional husbandry practice to make the introduction of crossbreds worthwhile. It is essential to precisely define the production objectives even if they are broad and multiple (von Kaufmann and Peters, 1990). This is crucial because, to the subsistence smallholder producer under the traditional low-input, risk-averse production environment, improved sustainability, risk minimisation and diversity of production are more relevant than production *per se* (Ørskov and Viglizzo, 1994). In the worst scenario, failure to provide the necessary additional inputs to the animals could negatively affect stability of the small household economy.

The pilot programme of crossbreeding of indigenous goats with the Anglo-Nubian goats imported from England as part of the DGDP was the latest attempt to assist poor and marginalized subsistence farmers in Ethiopia through crossbreeding. The design and implementation of the DGDP took advantage of the experiences with previous crossbreeding experiments. It was promoted with a systems perspective as a comprehensive package of technologies designed to gradually upgrade the level of management to allow the crossbreds to express their supposedly greater genetic potential under smallholder management. It also differs from others of its kind in the longer timeframe it was promoted, in its rather strong supervision and continued institutional support (Peacock *et al.*, 1990; Ayalew, 1996).

The whole purpose of the DGDP was to test a package of technologies that were assumed to increase the contribution of goats to the welfare of poor farming families in the highlands, and build up experiences for extension at a larger scale. The improvements in goat production and productivity were envisaged to come through two complementary routes: gradual intensification of the level of management, and genetic improvement through selective breeding of the indigenous goats and crossbreeding with a selected exotic breed, in this case the Anglo-Nubian breed imported from England. The goat was selected because of its multipurpose production function, and its suitability for both management and genetic improvements.

The specific components of the DGDP package are discussed in section 3.1.3. The rationale behind developing the package was to bring about measurable changes in the traditional goat production system through interventions in feeding practice, basic health care, rearing and breeding. Introduction of the crossbred goats was the final step in the process. To make these changes more sustainable, the programme was also actively involved in training and information dissemination in order to encourage positive developments in policy and public awareness (FARM-Africa, 1998).

Apart from these activities, the DGDP was also involved, between 1991 and 1996 in extensive survey of the indigenous goat types and husbandry practices of Ethiopia and Eritrea to document the essential baseline information for the genetic improvement of the indigenous goats (Ayalew, 1992; Reda, 1993; Alemayehu, 1994;). The survey identified 14 indigenous goat (breed) types belonging to four district taxonomic families, but generated limited quantitative and qualitative data on the phenotypic characteristics of the goat types (FARM-Africa, 1996). To develop rational breed improvement strategies (within or between breeds), the next step is to identify the centre of distribution of the goat types and define typical homogenous populations for further studies. These include on-farm characterization of the physical descriptors and population structure, detailed on-farm performance description to allow breed comparisons and on-station characterization studies to allow estimation of genetic parameters on the most promising breeds (Baker, 1992). However, no systematic attempt has been made at the national level along this line.

The DGDP also provided support for basic and applied research on goat health (Bekele, 1993, Demeke, 1994), nutrition (Berhanu, 1997), reproduction (1996) and product use (Ayalew and Peacock, 1993; Abebe, 1996).

As the name also implies, the DGDP was designed as a dairy project. The main reasons for adopting crossbreeding as the quicker way of improving milk production from goats were (FARM-Africa, 1990):

1. there was (and still is) little quantitative information on milk production characteristics of Ethiopian indigenous breeds of goats and so there was no way of knowing if any of the indigenous breeds would reward selection, and
2. anyway, as has been the case in Kenya, it is likely that the variability of milk production within indigenous breeds when combined with the likely heritabilities of milk traits is not sufficient to achieve the level of desired improvement within a reasonable time.

The heavy thrust on milk was later relaxed and meat was also given as much emphasis after recognizing that the subsistence farmers realize considerable benefits from sale of goats as well.

The long-eared Somali breed type was selected to be the dam breed on account of experiences in similar programmes in Kenya. This goat type is a good milker and has a large frame. It is predominantly maintained in pastoralist communities in the lowlands of Ogaden (for the eastern wing of the DGDP) and Borana (for the southern wing). The relatively large size of flocks in these areas made it possible for the DGDP to select and purchase for the crossbreeding stations a large number of breeding females relatively quickly. The assumption that this breed type is a better milker was later supported by the preliminary indications from the national indigenous goat breed survey (Ayalew, 1992; Reda, 1993; FARM-Africa, 1996).

The initial plan of the DGDP included testing a number of exotic breeds for their suitability for one-way (simple) crossbreeding. However, delays in implementation with the first exotic breed, the Anglo-Nubian, as well as the long time it took to resolve policy issues related with crossbreeding did not encourage importing other exotic breeds. Therefore the DGDP worked with only the Anglo-Nubian breed throughout the three phases of operation between 1989 and 1997. This breed was selected for crossbreeding on the ground that it has been proved to be well suited to tropical climates and has been used widely for the same purpose in other tropical countries like India, West Indies, Mauritius, Malaysia and the Philippines (Devendra and Burns, 1983) as well as Thailand (Saithanoo *et al*., 1988) and Kenya (Ruvuna *et al*., 1988, 1995). It also has a tropical ancestry (Peacock, 1996). These attributes made the Anglo-Nubian a safer choice than the more productive but less well adapted Swiss dairy breeds such as Toggenburg and Saanen, or the very intensively managed Red Damascus breed (FARM-Africa, 1990).

The DGDP was set to test (on-station and on-farm) two exotic blood levels in the crossbreds: F1, F2 and 75% Anglo-Nubian crosses, and effectively develop a gene pool of crossbreds around 50% Anglo-Nubian blood. However, the small capacity to produce the first generation crosses and ambiguities on the right level of exotic blood level to maintain in the crossbreds limited the scope for any performance comparison between the crossbreds. As a result all the available F1 crosses were distributed to selected participant farmers (Ayalew, 1996).

The crossbred goats under farmers' management were observed to produce more milk and meat, in absolute terms, than the indigenous goats. For instance, in an on-farm observation of complete lactations of 77 indigenous and 31 crossbred goats, the F1 crossbreds had 43% longer lactation length, and produced 70% higher milk off-take on morning lactation and 97% higher milk off-take on evening lactation. In a similar on-farm fattening trial of 15 F1 and 18 indigenous castrated bucklings, the crossbreds gained twice as much as the indigenous goats during a three-month observation period (Ayalew *et al*., unpublished observation) (Table 3). F1 crossbred kids were also observed to weigh 19% heavier at birth and 59% heavier at 9 months of age than the indigenous goats (FARM-Africa, 1997b).

However, given the low-input nature of the predominantly subsistence production system of the area, this increased production should also be viewed from the perspective of resource use. The most direct indicator in this regard is the production per unit of body weight, and even better per unit of metabolic body weight of the animals involved as feed is considered the major cost of production (Morand-Fehr, 1981). The overall average body weights of the F1 crossbreds has been significantly larger than the indigenous goats (Table 4).

A mid-term socio-economic study commissioned by the DGDP (Wagayehu and Kassa, 1994) found out that the ownership of milking crossbred goats has increased per capita income by about 18%; consumption and sale of goat milk has increased; and the DGDP package has encouraged saving and credit activities among participant women. However, the study noted that more effort was needed to sustain the improvements and extend the technology at a wider scale.

Table 3: Performance of crossbred and indigenous goats under farmers' management in Gursum and Kombolcha in 1995.

Traits	Breeds group	Sample size	Performance: Means (standard error)
Lactation length (days)	Indigenous	77	127.0 (5.6)
	F1 crosses	31	182.0 (14.3)
	F2 crosses	4	140.0 (40.2)
Morning milk off-take (ml)	Indigenous	77	213.8 (8.8)
	F1	31	362.5 (21.8)
	F2	4	247.7 (62.3)
Evening milk-off-take (ml)	Indigenous	77	147.1 (9.9)
	F1	31	289.8 (23.6)
	F2	4	205.3 (70.6)
Litter size	Indigenous	76	1.15 (0.05)
	F1	31	1.36 (0.10)
	F2	4	1.25 (0.25)
Weight gain in 3 months of castrated bucklings	Indigenous	18	4.4 (0.5)
	F1	15	10.2 (0.6)

Source: W. Ayalew and co-workers (Unpublished Observation).

Table 4: Average body weights of weaned* goats in smallholder flocks in Gursum and Kombolcha between 1994 and 1997.

Breed	N	Mean	Standard error
Local	2233	23.5	0.1
F1	387	34.9	0.5
F2	193	24.9	0.6
25% Anglo-Nubian cross	160	20.3	0.4

* Weaning weight of 14 kg body weight.

Source: W. Ayalew and co-workers (Unpublished Observation)

Through its evaluation exercise the DGDP had also recognized that progress indicators alone could not provide effective tools for evaluation and impact assessment. As stated earlier, a selected set of key nutritional indicators of levels of vitamin A deficiency and protein-energy malnutrition in the DGDP participant households did not improve because of the technology

(Woldegebriel *et al*, 1997). The additional production must have gone also to fulfilling other needs of the subsistence households, such as the procurement of supplies. It was then deduced that nutritional indicators alone were not sufficient to measure the extent to which the super-goal of improved welfare was met. The additional gains in income and asset were not captured.

2.4 Sustainability of crossbreeding programmes

Although the whole concept and applicability of **sustainability** has its roots in agriculture with a notion of long-term maintenance of productivity, recent scientific discourse has expanded the depth and breadth of its analysis to include issues of environmental protection, socio-economic well-being and cultural values (Becker, 1997). The various issues surrounding this concept become interrelated and complex when time horizon and unit as well as scale of measurement of development are considered (de Wit *et al.*, 1996). In the context of productivity, Conway (1983) defined the term sustainability as the ability of a system to maintain productivity in spite of a major disturbance. But this was gradually expanded to cover direct and indirect effects of productivity on the environment in general. The commonest definition of sustainable development is one adopted by the World Commission on Environment and Development (WCED, 1987) which states as economic development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs.

Analysis of the effects of introduced technologies even on the immediate agro-ecosystem is beyond the scope of this study, and the narrower context of technology adoption is considered. In reality acceptance of one technology by a subset of the community can lead to marginalisation of the rest, and interests of the whole society may be affected. Increased productivity of the animal component of integrated crop-livestock systems can negatively affect the output of the crop component, or even of another animal component, requiring that stability of the overall system at a higher level of hierarchy be assessed (Schiere, 1995).

The ADB (1993) study on policies and strategies for livestock development in developing countries of Asia concluded that the primary failure was promotion of inappropriate technology, which often target levels of technology, such as, imported dairy cattle or rapid upgrading of local breeds, which cannot be supported by other necessary inputs, such as feed and animal health care. The study pointed out that to draw on the better capital and market available to them, private commercial producers provide venues for more intensive care of imported stock to provide breeding stock to smallholders and village breeding (bull or buck) stations.

In their extensive review of crossbreeding of *Bos indicus* and *Bos Taurus* cattle for milk production in the tropics, Cunningham and Syrstad (1987) found out consistent outcomes that crossing up to 50% level of exotic blood brings about improvement in almost all traits, but further grading towards the *Bos taurus* breed has given variable and often disappointing results. Particularly milk yield of the F2 has been observed to be much lower than would be expected. One explanation for this decline is the reduction in heterozygosity or loss of heterosis. Another common reason is deterioration of management over time, the F2 being born later than F1. They went further by saying that the continuous production of F1 crosses is either operationally difficult to set up and economically difficult to justify. The cost of maintaining their parental populations increases the complexity of the breeding management. Certainly there is a danger that if the initial crossing is not done on a large scale then problems of inbreeding may be encountered. The artificial insemination technology provides an effective tool to continuously deliver the sire breed, but again, the receiver farmers will have to keep pure indigenous females to continue to benefit from F1 offspring. Furthermore, the necessary infrastructure has to be in place, which is not the case in Ethiopia.

Genetic improvement programmes similar to those used in developed countries are suitable in the tropics if the herds are large and facilities for performance recording are available. However, in most cases, either herd sizes are too small or where they are large, recording may be impossible (Mason and Buvanendran, 1982).

The number of livestock maintained in the densely populated highlands of Ethiopia already defies predictions of carrying capacity; for instance, a socio-economic survey in 1996 of rural households in the same area as the present study showed that although grazing plots are very scarce and multiple crops are grown on the average holdings of less than half a hectare of cultivated land, the livestock density is equivalent to 44 heads of goats per hectare (Ayalew, *et al*., 1998). This density is very high when compared with the reported carrying capacities of pastures for adult goats in various parts of the tropics that range from 37 to 102 goats per hectare Devendra (1990). Reynolds and de Leeuw (1995) argue that the debate on sustainable livestock production should go beyond the concept of carrying capacity and focus on the net flow of nutrients taking the households as a unit of reference. This concept leads to the emphasis of overall benefits gained rather than how well or badly animals are maintained in the households.

2.5 Development of the general hypothesis

The rational behind introducing the crossbred goats along with improved management was that farmers would adopt the package of technologies and achieve higher level of overall productivity from crossbred goats than is possible from indigenous goats under traditional management. The additional benefit they realise from using the technology package was expected to help improve overall family welfare. This benefit expressed in terms of the three indices established in section previous 2.2.3 can be explicitly applied to measure and compare the unit net benefits that the farmers have realised from the two breed groups of goats. It is against this background that the general hypothesis of this study was formulated to test the basic tenet of the DGDP, which states that:

> **The benefits that accrue to households from raising crossbred goats under improved management are greater than those from indigenous flocks under traditional management**.

3. MATERIALS AND METHODS OF STUDY

3.1 The Research environment

3.1.1 The study region

The study population of goats and farmers came from Gursum and Kombolcha districts in Eastern Hararghe zone of Oromia Regional State where the DGDP operated the eastern wing of its field programmes.

Gursum and Kombolcha represent the densely populated, mixed highland farming zone of eastern Ethiopian highlands (Figure 1). They are located adjacent to each other. There is a slightly higher human population density and a more frequent production of vegetables as a supplementary source of income in Kombolcha than in Gursum. The rural population in the two districts, and particularly in the study villages, is over 99% Muslim and belongs to the Oromo ethnic group (CSA, 1999).

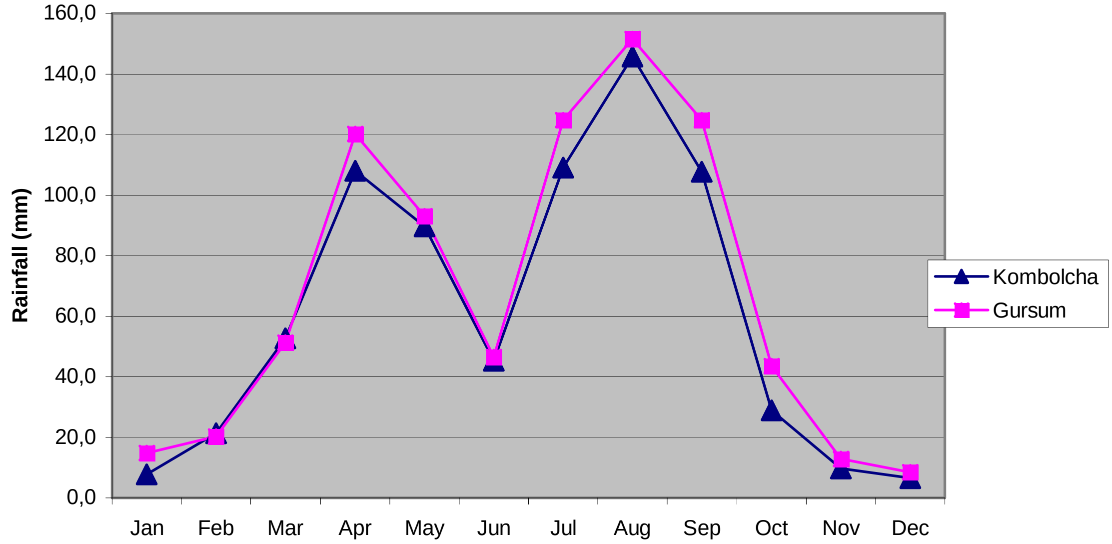
The area has a wet tropical climate and receives annual rainfall of about 600 to 900 mm in a fairly predictable bimodal pattern (Figure 2). The short rain usually falls in March and April, followed by the main rains between July and September. Cropping activities are the main source of subsistence. Several annual and perennial crops are grown, mainly in a mixture of two or more crops at the same time and in the same plot, or consecutively within a cropping season. The commonest of annual crops are maize, sorghum, sweet potato, beans and vegetables. *Chat* (*Khata edulis*) is the major perennial and cash crop in the area. Some farmers use a few vegetables and fruits as supplementary cash crop. Livestock rearing is also common with farmers keeping a small number of cattle, goats, sheep, donkeys and chicken.

3.1.2 The production system

Based on the way in which land is used and the extent of scarcity of land and animals, the households are classified as crop-livestock mixed production system (Jahnke, 1982). In terms of market relations, they are called subsistence to market-oriented subsistence producers (Doppler, 1991). Based on the relative access to key resources and the level of external input procured, the system is characterized as low external input agriculture, with shortage of capital and relative abundance of labour. The relatively abundant labour is used to increase or sustain output of crops and livestock from the land (Schiere, 1995).

Source: Adapted from Poschen (1986) and GoE (1986).

Figure 1: Location of the study area



Source: National Meteorological Services Agency, Addis Ababa.
(The data for 1984, 1992, 1993 and 1994 is incomplete, and hence excluded.)

Figure 2: Average monthly rainfall in the highlands of Kombolcha and Gursum between 1983 and 1998.

In 1996 a baseline survey of 830 farmers in the highland villages around the DGDP extension sites revealed that the average family size was about 5.7 persons, with total work force of 3.67 adult equivalents. The majority of farmers cultivate about half a hectare or less, with 1.6% of them being landless (Table 5).

Mixed farming on multiple crops and species of livestock is practiced to secure subsistence from the small holdings of cultivated land. There appears no alternative to integrated mixed farming for these farmers, and the diversity of activities are not only a means of yield and income, but also an effective strategy to spread risks of loss from disease, disrupted rains or unfavourable market (Wibaux, 1986). Assuming that the average person would require the energy equivalent of 300kg of cereals (Jahnke, 1982), even the most productive plots of maize or sorghum yielding 3000 kg per hectare can barely provide the minimum grain needs of a five-member household. The diversity also helps to better spread harvests over the year.

Table 5: Socio-economic characteristics of smallholder farmers in Gursum and Kombolcha in February 1996

Descriptors	Kombolcha	Gursum	Total/Average
Sample households	265	565	830
Average family size (se)	5.61 (0.11)	5.77 (0.08)	5.72
Livestock holdings - means(se)			
No. cattle	2.03 (0.08)	1.66 (0.07)	1.77
No. goats	1.41 (0.11)	2.11 (0.09)	1.88
No. sheep	0.88 (0.08)	0.47 (0.05)	1.45
No. donkeys	0.35 (0.03)	0.17 (0.02)	0.23
Aggregate (TLU*)	1.82 (0.06)	1.51 (0.05)	1.62
Households with no cattle (%)	13.3	31.3	25.4
Households with no goats	48.0	26.3	33.5
Households with no sheep	60.1	78.5	72.5
Households with no donkeys	66.9	85.7	79.6
Households with no ruminants	3.0	7.2	5.9
Households with no livestock	2.3	6.9	5.4
Distribution of holdings of cultivated land (%)			
Landless	0.4	2.2	1.6
< 0.5 ha	71.6	55.5	60.8
0.5 – 1.0 ha	20.3	21.6	21.2
1.0 – 1.5 ha	6.5	17.8	14.1
> 1.5 ha	1.2	2.8	2.2

* 1 TLU is a 250 kg tropical cow: cattle = 0.7TLU; sheep or goats = 0.1TLU; donkey = 0.5TLU(Jahnke, 1982).

Source: Adapted from Ayalew *et al.* (1998).

A mix of goats, cattle, sheep, donkeys and chicken are reared, with an average holding of 1.6 TLU. Goats are widely milked. During the survey in the dry season, of those households who had goats, 70 % of them in Kombolcha and 81% of them in Gursum had at least one lactating goat in their flocks. Not all farmers own livestock: a quarter of them had no cattle, one third had no goats, almost three quarters had no sheep and about 5% had no livestock at all. The proportion of households who keep the equivalent of 1 TLU accounted for 38% of the total. By all accounts the growth and milk performances of the animals are low.

Milk produced from the cows and goats is used as a source of nourishment as well as cash. During the study period, one quarter of them had no milk at home and procured from the market, and half of them reported to have used milk of home origin as well as milk from the village markets. Voluntary slaughter of animals for home consumption is rare. Up to 93 % of the households reported that, for home consumption of meat, they habitually purchase other animals or meat from the market, than to slaughter animals from their flocks just for home consumption.

A study of the nutritional status of 273 sample households around the DGDP extension sites during the peak dry (lean) season of 1996 also revealed that, at the level of the household, the average intakes of energy, protein, vitamin A, vitamin C and calcium were far below the optimal levels in many of the households (Table 6), which indicate high levels of food insecurity during the lean season.

Table 6:.Total daily requirements, intake, adequacy rate of households and per capita consumption of nutrients

Nutrients	Per capita daily intake	Adequacy rate (%)	Adequacy rates below 50%
Energy (Kcal)	1234	58.5	31.7
Protein (g)	27.9	79.3	23.3
Calcium (mg)	374.4	93.6	32.2
Iron (mg)	122.3	977.7	1.3
Vitamin A (µg)	75.4	30.3	74.4
Thiamine (mg)	0.92	102.3	-
Riboflavin (mg)	0.71	53.1	-
Niacin (mg)	8.9	58.7	-
Vitamin C (mg)	42.0	168.0	23.3

Source: Wolde-Gebriel *et al.* (1997)

Traditionally men have better positions in making major family decisions and property sharing. They are head of the household and effectively claim title for the land, although the wives are also said to have joint ownership. Men are generally responsible for fieldwork of farming, any construction work and marketing of large livestock and major crop sales. The women work at home preparing food, nursing children, marketing daily supplies, fetching water and fuel wood, marketing Chat (Khata edulis) and vegetables. Women and grown-up children are engaged in income generating off-farm activities.

Maize and sorghum provide the basis of the staple diet. Chat is an important tree crop in the area, and literally every farmer cultivates some for both home consumption and for sale. The young leaves and twigs are chewed for their stimulating effect. It is also the most important cash crop in eastern Ethiopia as a whole (Storck et al., 1997), which appears to have expanded in recent years with the liberalization of the economy. The leftover Chat provides a large amount of browse supplement for livestock, especially goats.

The DGDP had operated two adjacent extension sites in each of the districts under similar management and organizational structure. The total number of DGDP households reached 205 in Gursum and 90 in Kombolcha. The only difference between the two was that crossbred goat distribution in Kombolcha was implemented about 10 months later than in Gursum.

3.1.3 The Dairy Goat Development Programme (DGDP)

The DGDP was one of the agricultural development projects which FARM-Africa[1] designed and implemented in Ethiopia in collaboration with local institutions, including the Ministry of Agriculture (MoA), the Alemaya University of Agriculture, the Awassa College of Agriculture and several other government institutions as well as non-governmental organizations. It was launched in 1989 and its implementation continued in three successive phases until June 1997 when it was handed over, as planned, to local collaborating institutions. From a countrywide perspective, the DGDP was a pilot project set out to test a package of technologies and build up experiences for extension at a larger scale (Peacock *et al.*, 1990; Ayalew, 1996).

The DGDP was designed to improve family welfare of poor farming households in selected densely populated and marginalized areas of the Ethiopian highlands by way of improved goat production in areas where the goat is already a common livestock species and its products are extensively used (FARM-Africa, 1997b). The specific objectives of the project were: 1) to increase the milk and meat productivity of goats in selected areas, and 2) to stimulate increased interest and activity in goat production in Ethiopia.

Output from the smallholder goat flocks was conceptualised to be a function of a combination of factors, which can be modified through specific interventions (better feeding, genetic improvement, husbandry practices, basic health care, and increased income), and those factors, which are beyond the scope of village economy (climate, government policy, land tenure). Patterns of use of the products and services are also influenced, among others, by know-how and socio-cultural habits of the communities. As a result of these interrelationships in the production and utilisation of products, holistic or systemic approaches were recommended for development interventions (Fitzhugh, 1987).

[1] Address: FARM-Africa, 9-10 Southampton Place, London, WC1A 2EA, UK, and FARM-Africa (Ethiopia), PO Box 5746, Addis Ababa, Ethiopia.

The specific components of this package were the following, in their order of implementation:

1. organization of participating women into self-help credit and extension groups, as a means to facilitate delivery of the technologies and to prepare the groups as care takers of the technology package for its continuity after the project phases out;
2. improved forage development, tethered management, strategic supplementation and use of feeding racks or nets to reduce wastage of fodder;
3. indigenous goat restocking on revolving credit;
4. community based animal health services, including the training and deployment of community animal health workers (paravets) and setting up of private drug shops in the vicinity of paravets;
5. training of extension staff and participating women in improved goat management;
6. genetic improvement of goats through selective breeding of indigenous goats and crossbreeding them with exotic bucks at crossbreeding stations as well as through buck stations, and
7. close follow up and monitoring of activities.

The project followed a step-wise implementation plan (development path) to ensure gradual improvement of the traditional goat production system. Selected participants were first provided with indigenous goats on credit after having organised themselves into voluntary self-help groups, started developing some improved forage and participated in extension training. Those who maintained continued interest in the programme then received F1 crossbred goats on credit upon repayment of at least 50% of the credit for local goats.

The aim of the DGDP had been to enable the farmers to maintain the crossbred (Somali x Anglo-Nubian) and indigenous (Somali, Hararghe-Highland) goats managed under improved level of care in terms of feeding, health care and housing and produce better than the local flocks in traditional management. It was assumed that farmers would adopt the package of technologies and achieve higher level of flock productivity. Farmers were closely supervised and non-adopters of particularly improved forage and housing were not encouraged to receive crossbreds.

The project made a strategic decision to have a women-focused approach with revolving credit and self-help women groups on the premise that:

1. traditionally goats are reared and milked predominantly by women and children, and

2. women are naturally close to the core of household livelihood, and resources made available to them are better placed to help improve nutritional status of the family.

Once location of the project extension site was decided in consultation with the extension services, participant women were selected from among the poorest of households in a meeting in the presence of local extension staff, delegates from the local farmers' association and invited elders of the village. The main criteria for selection include lack of livestock ownership, good farming practice and interest in goat keeping. Selected women were then assisted to organize themselves into self-help women groups to ease the handling of revolving credit funds provided by the DGDP, to facilitate its implementation, and ultimately to prepare the group as care taker of the introduced technologies for their continuity after the DGDP phases out. During the previous socialist government these groups fall under the auspices of local cooperatives. But in the liberal policy of the current government these groups were neither required nor encouraged to affiliate themselves with any association or organization. They are not embraced by any active government policy on farmers' cooperatives.

Improved feeding practices were included based on the experiences of an earlier country-wide forage development project, Fourth Livestock Development Project of the Ministry of Agriculture (MoA, ND), the DGDP prepared a list of suitable forage development strategies and appropriate species for farmers to choose and try. The major forage development strategies promoted by the DGDP were: (1) backyard forage around homestead in the form of live fences or lines of forage trees; (2) forage strips (as bunds, shelter belts or hedges), (3) under-sowing of selected annual forage legumes in crop fields, and (4) inter-cropping of suitable forage legumes in crop fields. All of these have been tried in different places. The species promoted for the various strategies include:

- Grasses: Elephant/Napier grass (*Pennisetum purpureum*), Setaria (*Setaria sphacelata*), Guinea grass (*Panicum maximum*), Phalaris (*Phalaris aquatica*)
- Herbaceous legumes: Lablab (*Lablab purpureus*), vetch (*Vicia dasycarpa*), alfalfa (*Medicago sativa*), Desmodium (*Desmodium uncinatum* and *D. intotrum*), cow pea (*Vigna unguiculata*),
- Tree legumes: Leucaena (*Leucaena leucocephala*), Sesbania (*Sesbania sesban*), Tree Lucerne (*Chamaecytisus prolifer*), Pigeon pea (*Cajanus cajan*).

Improved feeding also included strategic supplementation of available high energy feeds to goats that are more in need, specifically pregnant, lactating and sick goats. To reduce the wastage of fodder offered to goats, the DGDP promoted suitable feeding structures such as tying the fodder in a bundle hanging down to allow goats to feed with their heads up; nets made of rope or strings are filled up with fodder, and forage racks made of wood on walls.

The DGDP itself supplied most of seeds and planting materials, the rest came from the agricultural extension services. Preparation of seedlings was undertaken in forage nurseries of the extension services. To make the farmers relatively independent of the supply, all the farmers were encouraged at later stages to set up their own backyard nurseries.

The interventions on health care were built upon the concept of **community based animal health services (CAHS)**, including the training and deployment of community animal health workers (CAHW or paravets) and, at a later stage, the setting up of private veterinary drug shops in the vicinity of these workers (FARM-Africa, 1998). FARM-Africa (1998) stated that the potential long-term advantages of the CAHS were:

1. CAHS is oriented to address routine primary animal health problems. Government veterinarians would have more time to address diseases of wider public health significance and can focus more on the qualitative improvement of veterinary services. It will relieve them of the routine workload.
2. CAHS workers can help government veterinary officers as contact persons for reporting animal health problems and outbreaks of infectious diseases in their areas.

CAHS activity in the eastern wing of the DGDP began in Gursum in 1992 through the training of 14 paravets by trained veterinarians, followed by 6 others in Kombolcha during the following year. Refreshment training had been conducted almost every year. The training constituted a one-week participatory diagnosis and treatment of the commonest goat diseases that participants identify, including deworming, wound dressing, castration, acaricide application and measurement of rectal temperatures to check whether diseased goats require higher level treatment from veterinarians.

In line with the liberalized government economic policy, the DGDP initiated the idea of setting up suitable local veterinary drug shops towards the end of the project lifetime, but not enough support was provided to establish the shops as planned. The DGDP provided the credit funds to a government-owned commercial bank to administer the credit. However, the policy guidelines for setting up private veterinary drug shops were very difficult to meet: in terms of qualifications of the applicant, the credit guarantees (collaterals) and the long time it took to finalize the formalities. In the end one shop was opened in Gursum in 1998.

The **crossbreeding** policy environment for the appropriate level of exotic blood to maintain in the crossbreds being ambiguous as it was, the following guidelines for distribution of improved stock were adopted as proposed by the DGDP:

- maintain 50% exotic blood level in crossbreds for the prevailing level of management (i.e. F1 does together with F1 bucks);
- the F1 does are distributed with 50% kid in-utero;
- establish pure Anglo-Nubian buck stations as an alternative source of crossbred goat production, i.e. to produce F1 crossbred goats from indigenous does in the farmers' hands.

The following criteria were drawn up and agreed upon for participating women to receive crossbred goats:

- adequate forage establishment in the field and around the house in the views of the local extension agent;
- repayment of at least 50% of the previous credit on local goats, and
- successful rearing of the indigenous goats and their offspring.

At the start of the programme there were three options for crossbred goat production: breeding stations, on-farm buck stations and contractual production. The first option was soon implemented with the establishment of the Alemaya Dairy Goat Crossbreeding station (and another at Awassa a year later). But later, it proved to have required strong technical and financial support, and made the cost of crossbreds too high (Bekele and Kassa, 1994). Subsequently pure Anglo-Nubian buck stations were set up in the villages. Contract production of crossbreds was possible until 1991 only with farmers' service and producers' cooperatives, which did not materialize at all. With the liberalization of the economy in the new government policy following fall of the previous government (May, 1993), private contract producers came into picture.

Up until the end of 1994 when the first crossbreds were procured from private producers, the only source of crossbreds in the east was the crossbreeding station at Alemaya, which operated at only half of its planned capacity. As a result practically all the crossbreds were meant for distribution to farmers, which, at the time, could reach only one third of the participants (Ayalew, 1996).

The first Anglo-Nubian buck station in Eastern Hararghe was established at Awbere in June 1994, which was soon followed by two other stations at Diferes (Gursum), and Egu (Kombolcha) in the same year. Two others were set up at Onaya in 1995, which brought the total number of buck stations established in the study area to five. Within a year of testing the buck stations had proved to be a cheaper and quicker way of producing and delivering F1 crossbreds than the crossbreeding stations. However, there had always been a high health risk for the bucks, and buck stations required central management for rotating them in order to control inbreeding. Mention should however be made of the marked differences in output between the buck stations, which were mainly because of disparities in level of care provided to the buck and in farmers' enthusiasm to use the bucks (Ayalew, 1996).

In line with the new economic policy of the government, which favours private investment, the DGDP encouraged and supported interested individuals to start commercial goat farms to get into contract production of crossbred and pure exotic goats. In the eastern wing of the DGDP alone, seven small farms were started in Gursum, Kombolcha, Alemaya, Dire Dawa and Harar. Two of them in Harar town decided to quit before the DGDP phased out, for reasons of high management costs and shortage of feed. Five others continued to operate after the DGDP. Each of them has acquired the initial exotic stock of three to four female and one male Anglo-Nubian goats on credit. At a later stage they procured indigenous does for crossbreeding. The DGDP entered contractual agreement with each of these private producers for them to supply the DGDP with F1 crossbred and pure Anglo-Nubian goats at fixed prices. By the time the DGDP phased out, the DGDP arranged that the largest of the farms entered similar contracts with the Eastern Hararghe Zone Department of Agriculture for the latter to use some credit fund set aside by the DGDP for this purpose. The idea was the revolving credit funds with the women groups could gradually be used in the same manner to procure improved stock through the extension services.

Progress of the DGDP was evaluated twice in 1991 and 1993 and reviewed in 1994 and 1997 (FARM-Africa, 1997b).

3.2 Sampling and data collection

The field study was conducted between April 1998 and July 1999. An initial survey of the study sites and selection of the sample households was undertaken in April. Purposive sampling was applied to select two villages from each district where the complete DGDP technology package was implemented. These were Gende-Hurso and Gende-Shanko in Kombolcha and Awbere and Onaya in Gursum. Random sampling was used to select study households within the villages.

For the purposes of this study, **improved management** of the DGDP participant households was taken to mean that:

1. The households have received at least indigenous goats on credit from the DGDP.
2. This means that the households have been members of one of the self-help women groups operating revolving small credit funds provided by the DGDP.
3. This also means that the households have demonstrated enough in producing improved forage in the backyard and/or crop fields using any of the forage development strategies.
4. Besides, the households have been accustomed to using the CAHS set up in the villages, and are well aware of the need for getting their goats vaccinated when the services are provided.
5. This also means that the households have taken part in farmer extension training sessions as provided by the DGDP extension training packages.

Only those DGDP-participant households which fulfil these criteria were included in the study. Similarly, the control households were selected if they own goats and their flock sizes during the initial survey were within the range as those of the DGDP participant households. Outlier study households in terms of family size, size of land holding and livestock holdings were dropped out in both groups. The control households were selected from the peripheries of the villages far off from the centres of DGDP group activities.

Four experienced enumerators were locally recruited, trained and deployed in the four study villages. All of them had taken part in the earlier on-farm flock monitoring study of the DGDP in which the author was also involved. The training of enumerators and pre-testing of formats was done simultaneously for two days in one of the villages. These were followed by the initial survey of 180 DGDP participant and control households, out of which 110 were selected based on the above criteria. Another set of 60 households were similarly surveyed and included to arrive at the final of set of 166 study households.

The actual data collection was conducted for one production year from July 1998 to June 1999. In the end, complete information was collected from 158 of the 166 study households. Out of these, 65 were from Kombolcha and the rest 93 were from Gursum districts. Thirty-seven of these were control households, and the remaining 121 households were DGDP-participant households. The latter fall into three groups based on the breed composition of their flocks, namely mixed (crossbred and indigenous) flocks, flocks with only crossbred and flocks with only indigenous goats.

The given names of goats as reported by owners were used to identify the goats. The coat colour of goats (type and pattern) as well as ear tag numbers (when available) were used to confirm identity when necessary. Each of the goats was then given identification numbers that relate to flock number and serial number of the goats within its flock.

All goats in sample flocks were weighed at the start and end of the study. Enumerators made a regular weekly visit to each of the study households to record changes in flocks (entries and disposals) and to weigh newly introduced animals. Events in flock dynamics in the form of acquisition (birth, purchase and inward transfer) and disposal (slaughter, death, outward transfer, loss) were updated and the reasons reported by owner recorded on standard forms.

Regular monthly body weights were recorded from all goats in sample flocks throughout the study period. All goats were weighed using bathroom type scales to the nearest half-kilo gram, whereby the enumerator first weighs himself and then holding the goat. The scales were checked for accuracy on a monthly basis.

Actual prices of all goats sold and purchased were recorded, along with the reasons for sale or purchase. Data on all purchased external inputs, namely feeds, veterinary services and other direct expenses were collected during these visits. Wherever appropriate, the use of these inputs was identified by breed group of the goat (crossbred or indigenous).

One member of the household was trained to take volume measurement of all milk off-take from lactating goats using graduated cylinders on a specific day of each week, and record it on the standard form, together with the approximate proportion of how the milk was used (home consumption, sales). The data was collected during the weekly visits by enumerators. Data on manure use was collected during monthly body weight checks. The data collection forms are attached in Appendix 2.

A selected list of 10 activities in improved management of goats were put into a checklist and filled out by the enumerators three times during the study period for all households. Management scores calculated from the checklist at the end of the study were used to stratify the households on level of management as weak, medium and strong. This stratum of management was included in all the statistical models applied for data analysis.

A representative set of at least one-third of households in each study group was selected at the beginning of the study for elaborate recording of labour inputs in various activities of goat raising on standard semi-structured forms (Table 7). At the same time a detailed itemisation was made of all feed resources provided to sample flocks by way of grazing, tethering or supplementation for an average day of a month, with particular emphasis on additional costs to the households and any differences between the breed groups. More of mixed flocks were included to better capture breed differences. Delivery of formal and informal credits to the sample households and traditional insurance associations and use of manure were reviewed during monthly body weight checks.

Table 7: Number of households selected for in-depth interviews by study group

Descriptors	Flock type				
	Cross/ Improved	Mixed/ Improved	Indigenous/ Improved	Indigenous/ Traditional	Total (n)
Total sample households	28	62	31	37	158
Subset of households selected	10	33	13	16	72*
Per cent of selected households	35.7	53.2	41.9	43.2	45.6

* Initially 100 of the 165 the households were selected; this figure (72) is the final number of questionnaires administered every month.

Where applicable, the additional inputs utilised were recorded separately for breed groups; otherwise, inputs were divided in proportion to their body weights. The records on household labour input were collected, as far as possible, by breed group. Grazing time was partitioned to breed groups in proportion of goat numbers, because sheep and cattle were sometimes involved as well. Non-specific labour input on the rest of husbandry practices was assigned to breed groups by ratio of metabolic body weight.

The supply (delivery) and demand (acceptance) of all the introduced technologies were studied separately. The delivery of different components of the package (crossbred goats, improved forage, veterinary services, credit, extension training) was occasionally checked. The corresponding practices in sample households in receiving these technologies were recorded by the enumerators during the weekly visits. Furthermore, the use of these technologies by the farmers was surveyed at the beginning and end of the observation period.

All the potential sources of crossbred goats, namely the Alemaya goat breeding centre, Anglo-Nubian buck stations, and contract producers were visited regularly to collect data on their output and costs, and to see whether they had access to the necessary external inputs they require for their operations. Data was available on previous DGDP support to the farms.

3.3 Data transformation

LIMS (Metz and Asfaw, 1992), EPI-Info (Dean *et al.*, 1994) and SAS (SAS, 1989) software were used to transcribe data into the computer and to do data transformation. Subsequent data analysis was done using procedures of SAS (SAS, 1989) appropriate to the model of analysis.

3.3.1 Body weights

Because the monthly body weight measurements were not necessarily taken on the same date across the four study sites throughout the study period, linear extrapolation was used to estimate body weights for a reference date of month. All new entries were weighed within one week, and hence the extrapolations were done for records older than 7 days. For all goats disposed more than 7 days after weighing date, their disposal body weights were similarly estimated based on weight changes between the last two records of the animal.

In the valuation of off-take (other than sale) and acquisitions (other than birth and purchase), average unit prices were necessary to estimate values for each event. These average unit prices of goats (per kg body weight) were estimated from 215 observed sales and purchase records. The observed prices were divided by estimated body weights of the goats to arrive at unit prices per kg of body weight. These averages were found to be significantly influenced by body weight of the goat as well as its breed, sex and the direction of its movement (i.e. sale or purchase). A mixed linear model was applied to estimate coefficients for the co-variate (body weight) and the fixed effects (breed, sex, case) (Table 8). A total of 13 recorded unit prices over Birr 5.00 were excluded from the analysis as outliers.

Table 8: Coefficients of co-variate (body weight) and fixed effects (breed, sex, case) in a linear mixed model to describe the unit prices (Birr) of goats per kg of body weight - least squares coefficients (standard errors).

Components	Class	Coefficients (standard errors)	α*
Intercept	-	2.5533 (0.1799)	0.0001
Covariate:			
Body weight	-	0.0279 (0.0075)	0.0003
Fixed Effects:			
Breed	Cross	0.2484 (0.1400)	0.08
	Indigenous	0.0000	
Sex	Female	-0.4949 (0.1058)	0.0001
	Male	0.0000	
Case (Purchase or Sale)	Purchase	-0.1824 (0.1167)	0.12
	Sale	0.0000	

* Significance level: $\alpha \equiv p \mid \mu_1=\mu_2 \mid$

To apply this linear model, however, an entry or a disposal event other than sale or purchase should be classified either as “sales” or “purchase” cases to complete the equations, leading to either the purchase line of estimation, the sales lines of estimation, or the average between the two. The following rules were then applied:

1. Final Stock: average of sales and purchase.
2. Initial Stock: average of sales and purchase.
3. Outward transfer: sales rate.
4. Inward transfer: purchase rate.
5. Slaughter: sales rate.
6. Sales: actual sales value.
7. Purchase: actual purchase value.
8. Losses (death, predator, loss): average of sales and purchase.

Overall the average unit prices per kilogram of body weight were greater for crossbreds than for indigenous; males had higher unit prices than females, and the farmers sold goats at a higher unit price than they have purchased (Table 9).

Accordingly this linear model was applied to estimate the unit prices of individual goats on entry into or disposal out of the flocks, taking body weight as a co-variate, and the rest of the variables as fixed effects. These estimated unit prices were then multiplied by current or estimated weights to get the estimated price of individual goats at time of entry or disposal.

Table 9: Average unit prices (Birr) per kg body weight for goats sold and purchased during the study period - least squares means (standard errors)

Breed groups		Sex		Cases	
Crosses:	3.05 (0.13)	Female:	2.68 (0.10)	Sale:	3.02 (0.07)
Indigenous:	2.80 (0.06)	Male:	3.17 (0.09)	Purchase:	2.84 (0.11)

3.3.2 Annualised average flock size and body weights

Because the number of days sample goats stayed in flocks varied from 7 to 365 days, the annual stay-index was introduced, whereby the index for a particular goat was calculated as the number of days in flock divided by 365 days of the year. The sum of this index within flock gives the average current stock of that flock over the year period. Multiplying a goat's stay index by its annualised (i.e., weighted average monthly weights) body weight gives the weighted average body weight of that goat over the year period. And the sum of this latter value within flock gives the annualised average flock body weight.

These weighted values for flock size and body weight were applied in the analysis of flock sizes, estimation of metabolic body weights, estimation of manure output and partitioning of inputs.

3.3.3 Level of management

To account for possible differences in the level of care provided to goats within each study group, the level of management during the initial survey was classified as weak or strong for all the sample households. However, this valuation was very subjective. Later a checklist of 10 key activities were developed and monitored for all study households on quarterly basis. These activities were given a relative score of 0 to 3 (0=none; 1= a few; 2= some; 3= a lot). These scores were added up to arrive at a total management score. The three quarterly scores were added up into the aggregate management score of the household. The activities recorded were:

1. Production of improved fodder;
2. Forage reserves, purchased feed;
3. Supplementation to selected goats (lactation, pregnant, fattening, etc.);
4. Vaccination;
5. Use of paravet services;
6. Use of government or private veterinary services;
7. Cleanliness of the barn (house);
8. Level of care to sick goats;
9. Use of selected breeding bucks, and
10. Maintaining a breeding buck.

Then within each study group, the quartile distribution of management scores was used to classify the aggregate score as weak (score at and below the first quartile), strong (score at and above third quartile), and medium (score between first and third quartile). This stratification (Table 10) was applied to define level of management in the subsequent data analysis.

Table 10: Number of households and their management mean scores within management strata and study group

Management strata	Cross/ Improved		Mixed/ Improved		Indigenous/ Improved		Indigenous/ Traditional		Total (n)
	n	Mean scores	n	Mean scores	N	Mean scores	n	Mean scores	
Weak	6	46.2	18	46.4	7	45.0	11	38.3	52
Medium	14	52.6	25	55.0	16	52.2	16	50.1	62
Strong	8	61.7	19	63.9	8	60.9	10	59.0	45
Total (n)	28		62		31		37		158

3.3.4 Labour input

Labour input was recorded at the flock level on a selected representative subset (Table 7) of the study households. Part of the labour input that specifically went to a particular breed group (crossbred or indigenous) was separately accounted for. The rest of the input was partitioned to breed groups by ratio of their body weights. This was because about 82 per cent of the labour input went to feeding and rearing (routines of cleaning barn, releasing and returning goats, milking, care for the kids, etc), which are heavily dependent on body weight rather than goat numbers.

Labour input on attending free grazing was partitioned between breed groups by ratio of their numbers (because sheep and cattle were also involved). Total labour input (in minutes of work time) by individuals was standardised on the Labour Equivalent (LE)[2] scale to arrive at values that account for differences in age and sex. These values were summed up within households to arrive at the monthly average daily household labour input.

The total household labour input for the particular month was divided by body weights of the flock to get the average unit labour input per kilogram of body weight for that month. To account for that part of labour that specifically went to one or another breed group, particularly in mixed flocks, the unit averages were separately analysed by breed groups.

Using a linear fixed model, which included components of current flock size, district, study group and level of management within group, the coefficients for fixed effects were estimated. Both months and seasons of the year did not contribute significantly to the models, making the unit labour inputs relatively independent of time of the year. These coefficients were then applied to estimate the average daily household labour input per kg of body weight of individual goats (Table 11). District and study group were not significant variables in explaining the labour input for crossbreds.

Table 11: Unit labour input (in minutes per day per kilogram body weight) for local and crossbred goats during the study period - least squares means

Variable	Category	Least squares means	Standard errors
Indigenous goats			
District	Kombolcha	2.225	0.189
	Gursum	3.943	0.121
Study group	Mixed/improved	2.318	0.141
	Indigenous/improved	3.298	0.212
	Indigenous/traditional	3.637	0.177
Stratum (level) of management*	Strong	2.038	0.219
	Medium	3.176	0.140
	Weak	4.039	0.180
Crossbred goats			
Stratum (level) of management	Strong	3.166	0.278
	Medium	3.645	0.220
	Weak	4.406	0.353

* The stratum (level) of management is as described in section 3.3.3.

[2] LE: The indices were adapted after Abdulahi (1990) and modified to match the population structure: for ages 5 and 9 years: 0.25 for both sexes; for ages between 10 and 14: 0.60 for males and 0.70 for females; for ages between 15 and 50 years 0.75 for both sexes; for ages above 50 years: 0.65 for males and 0.55 for females.

The estimated unit labour input was multiplied by the number of days the goat stayed in flock, and then by the annualised average body weight of the goat to arrive at the total labour input on individual goats during the whole stay period.

3.3.5 Valuation of manure

First the dry matter faecal output was estimated at the level of individual animal. Then a chemical equivalence of the manure was sought with respect to two key nutrients (Nitrogen and Phosphorus), and this was related with current unit prices of the nutrients in commonly applied inorganic fertilizers, namely Diammoniumphosphate (DAP) and Urea. The additional contribution of manure to soil physical properties was estimated from known residual effects that relate to slower release of nutrients as well as improved water holding capacity, pH etc.

The total faecal output was estimated by the regression equation developed by Fernández-Rivera *et al.* (1995), on the basis of total (24-hour) manure production, using the physical constraints model of Ellis *et al.* (1988), which assumes that faecal output is a constant percentage of the fat-corrected body weight of an animal in stable metabolic and physiological state. This equation states as follows:

$$F = 26.5\text{g DM/kg } W^{0.645}$$

where **F** is the daily faecal dry matter output in grams, and **W** is the average body weight of the goat in kilograms.

The average nitrogen content of this faecal dry matter output was taken to be 1.5583% (Schlecht *el al.*, 1997). Urine was also valued along with faeces, because in the study area practically all the dirt and scrapings of barns with the leftover feed soaked in urine is damped into compost pits with faeces. For the purposes of this study, and based on the evidence presented by NAS (1983) and Schlecht *et al.* (1997), total N excretion through urine was estimated to be equal to N excretion through manure.

Loss of nitrogen from composted manure in the form of volatilisation and the subsequent uptake of nitrogen by crops (Gilbertson *et al.*, 1981; Jenkinson, 1982) was taken to be equivalent to similar losses of ammonia nitrogen and crop uptake from the common inorganic fertilizers (Bock, 1984; Tisdale *et al.*, 1985).

The overall phosphorus content of goat manure was taken to be 0.55% of faecal dry matter (Somda *et al.*, 1995).

Although residual effects of manure are known to manifest themselves even three years after application (ILCA, 1993), and reported crop response to these residual effects range from a low of 41.7% to a high of 113% (Ikombo, 1989; Onim *et al.*, 1990; Williams *et al.*, 1995), a more conservative estimate of one third additional benefits was taken for the purposes of this study. This is because the residual effects are partly because of slow release of nutrients in manure. Therefore, the estimated nitrogen and phosphorus equivalents were multiplied by a factor of 1.33 to arrive at the total estimated value of manure.

DAP contains on the average 18% of nitrogen and 21% of phosphorus, i.e. 39% of soluble nutrients. This, at the current commercial rate of DAP (Birr 140/50kg bag), gives an average price of Birr 7.2 per kg of soluble nutrient. Similarly Urea contains about 45% soluble nitrogen, which at current price of Birr 150/50kg bag gives a unit nutrient price of Birr 6.7 per kg of nitrogen. Because farmers in the study area commonly purchase both inorganic fertilisers, it is logical to use the average unit price of the nutrients of Birr 7.0 per unit of soluble nutrient. This rate was applied to estimate the equivalent value of manure from goats.

3.4 Aggregation of flock level composite productivity indices

Based on the theoretical background established in section 2.3.3, and on the concept of composite net benefits outlined in Table 1, three flock level productivity indices were determined for each of the study households. The technique of Value Added (VA) was applied to aggregate the net value (benefit) gained in terms of physical products (live animal, milk, manure). The Value Added to the flocks was calculated as the difference in monetary value between the value of gross output and the value of inputs purchased from outside the farm. The benefits in financing and insurance from the flock were then estimated (Bosman and Moll, 1995) and added up on to arrive at total net benefits. These were then divided by the three major resources used to produce the benefits, namely size of cultivated land, or metabolic body size of the annualised average flock size, or the estimated household labour input, namely unit net benefits per unit metabolic body weight of the average flock size, or per unit of labour used in goat raising, or per unit of cultivated land.

3.4.1 Physical production and Value Added to flocks

Meat production, in its broader definition of the net body weight change of the stock and flow of whole flock, during the observation period was quantified as:

$$\mathbf{Y_k = FS_k - IS_k + S_k - P_k + OT_k - IT_k + C_k}$$

where, $\mathbf{Y_k}$ = net production of goats (kg) of the $\mathbf{k^{th}}$ flock during the observation period of 1 year ($\mathbf{k}$ = 1,...158),

$\mathbf{FS_k}$ = body weight (kg) of the $\mathbf{k^{th}}$ flock at end of observation period, (final stock),

$\mathbf{IS_k}$ = body weight (kg) of the $\mathbf{k^{th}}$ flock at start of observation period (initial stock),

$\mathbf{S_k}$ = body weight (kg) (estimate) of all goats sold out of the $\mathbf{k^{th}}$ flock,

$\mathbf{P_k}$ = body weight (kg) of all goats purchased into the $\mathbf{k^{th}}$ flock,

$\mathbf{OT_k}$= body weight (kg) (estimate) of all goats transferred out of the $\mathbf{k^{th}}$ flock,

$\mathbf{IT_k}$= body weight (kg) of all goats transferred in to the $\mathbf{k^{th}}$ flock,

$\mathbf{C_k}$ = body weight (kg) (estimate) of all goats slaughtered in the $\mathbf{k^{th}}$ flock,

The net production of goats ($\mathbf{Y_k}$) expressed in body weights was converted to monetary value ($\mathbf{YM_k}$) by multiplying the respective current (estimated) body weights of each of the variable in the model with the estimated unit prices. The recorded prices of goats sold or purchased provided the basis to estimate the unit prices of inflow and outflow according to how the household would pay or receive if transactions were on cash.

The total milk off-take was estimated from a weekly regular recording of all lactating goats in all study flocks throughout the observation period. The current prices of milk were applied to determine its monetary value.

The value of manure was estimated as described in section 3.3.5.

Thus the sum of the monetary values of net meat production ($\mathbf{YM_k}$), milk off-take ($\mathbf{MM_k}$) and manure ($\mathbf{FM_k}$) utilised during the same observation period gave gross output ($\mathbf{G_k}$) of the $\mathbf{k^{th}}$ flock during the observation period, i.e.,

$$\mathbf{G_k = YM_k + MM_k + FM_k}$$

To arrive at total Value Added of the $\mathbf{k^{th}}$ flock ($\mathbf{VA_k}$), the sum total of purchased inputs ($\mathbf{I_{kj}}$) specifically used for the flock during the observation period was deducted from $\mathbf{G_k}$; i.e.

$$VA_k = G_k - \sum I_{kj}$$

where, VA_k = total Value Added of the k^{th} flock during the observation period,

G_k = gross output (in monetary value) of the k^{th} flock, and

$\sum I_{kj}$= sum (in monetary value) of all inputs (j=1,...,n) purchased and utilised in the k^{th} flock.

3.4.2 Socio-economic benefits

The **financing benefits** were estimated based on the concept that in a subsistence economy the value embodied in the flock and the opportunity of using the animals for specific purposes at the desired time without having to pay in the form of interest rate or insurance premium confers measurable benefits to smallholder households (Bosman and Moll, 1995). Hence, the benefits in financing (F_k) of the k^{th} flock during the observation period was calculated as:

$$F_k = OM_k \times f$$

where, OM_k = monetary value of flock outflow ($C_k + S_k + OT_k$), and

f = financing factor of the study area, estimated from the opportunity cost of credit.

Opportunity cost of credit (cost of alternative sources of credit) was arrived at as follows. Formal credit institutions were out of reach of the smallholder farmers. Informal credit is very common. The population is predominantly Muslim, and hence stated interest rates are not acceptable. Few in-depth studies on informal credit (Birke, 1966; Gebre-Michael, 1974) report that lenders usually arrange for the interest to be paid in kind, e.g. in terms of labour, or in reduced produce prices, etc. leading to effective interest rates as high as 40% per year, or even 200% for grain and cash credit (Bezabih Imana, pers. comm.). During the study period 133 (84.2%) of the 158 study households have taken at least one form of credit (Table 12). Only 21 (3.8%) of the 560 credits recorded were with a stated annual interest rate of 18.3% (for fertilizer) and 100% (for seed grain); the rest were not reported to be directly charged. Most of the reported credit was delivered by small kiosks and traders in the villages in the form of sold household supplies. In the four study villages the average sizes of credit delivered to a household during the study period varied from Birr 40 to 117, which were comparable to the price of a medium size goat in the local market.

However, these were not sufficient evidence to apply estimates of interest rates from the informal credit market. Instead, the current interest rates of the formal credit market were applied. The observed commercial interest rates for short and medium term credits during the study period have been 10 to 11.25%. Hence a conservative value of 10% was taken to estimate the financing coefficient (**f**).

Table 12: Delivery of credit to study households during the study period by district

Descriptors	Kombolcha	Gursum	Total
Total reported credit	416	144	560
Number of households which took credit	65	68	133
Per cent of households which took credit	100	73.1	84.2
Per cent of the credit with stated interest rate	0.7	12.5	3.8
Proportion of credit delivery by source:			
- Kiosks and local traders	90.4	84.0	88.8
- Relatives and neighbours	8.9	4.2	7.8
- Ministry of Agriculture (for fertilizer)	0.7	11.8	3.6
Size of credit (Birr):			
- Mean	30.5	118.9	53.1
- Minimum	2	5	2
- Maximum	600	600	600
- Standard deviation	55.10	108.26	81.98

Theoretically, the **insurance (security) benefit** can be estimated in two ways. The first works on the annualised current stock (weighted average body weight of the whole flock), assuming that the whole stock is available to provide household security through liquidation at any one time when the need arises. Alternatively, this benefit can be estimated from the actual insurance-oriented outflow (truly unexpected). The latter then requires that the whole outflow be divided/ disaggregated into:

- *insurance-oriented outflow*, that is imposed/forced on the household, due to unexpected undertakings such as social obligations in funerals and weddings, medication, and purchase of food during the lean season, and
- *liquidity-oriented outflow*, which the family decided to undertake because of expected expenditures, such as clothing, holiday expenses and purchase of another animal, in the interest of another perceived benefit.

The benefit in security from raising the goats ($\mathbf{S_k}$) was then calculated as:

$$\mathbf{S_k = W_k \times s}$$

where, W_k = monetary value of average (weighted) current stock of the $\mathbf{k^{th}}$ flock, or the size of forced (security-oriented outflow) and

s = insurance factor of the study area, estimated from the opportunity cost of insurance.

An opportunity cost of insurance (cost of alternative sources of insurance) existed although none of the study households bought insurance from the formal market during the study period, as these services were effectively inaccessible to them. However, almost every household is a member of the village-level community insurance groups, which join hands as any member faces difficulties (e.g. death of a member of family, sudden death of large livestock or loss of animals due to accident). A total of thirteen cases of informal insurance services were observed among the study households, where the community contributed to assist households with various difficulties (Table 13).

Table 13: Observed informal group insurance pay-outs and calculated insurance coefficients during the study period

Observed cases	Total pay-out (Birr)	Households participated	Average pay-outs Birr/household	Calculated insurance coefficient (%)
Husband dies	1160	170	6.823	0.59
Father dies	250	110	2.273	0.91
Step mother dies	210	120	1.750	0.83
Husband dies	800	150	5.333	0.67
Son dies	960	150	6.400	0.67
Husband dies	600	140	4.286	0.71
Son dies	250	100	2.500	1.00
Grand son dies	100	50	2.000	2.00
Rebuild a house	500	100	5.000	1.00
Relative dies	480	130	3.692	0.77
Relative dies	230	100	2.300	1.00
Fire accident	730	120	6.083	0.83
Wedding ceremony	750	120	6.250	0.83
Average	540	120	4.500	0.83

Because these community-level group insurance schemes are operated without profit with low management costs, the cost of insurance is equal to the annualised average pay-outs. All the contributions are readily paid out in insurance payments. Thus the theoretical coefficient of insurance is calculated as the ratio of the average of contribution of the households (i.e., Birr 4.50) to the average of total pay-outs (i.e., Birr 540), or 0.83%.

This coefficient was then multiplied by the average frequency of cases that initiate insurance contributions. The observed village level insurance schemes also cover adjacent communities outside the study villages. Thus the actual frequency of cases that initiated insurance contributions by the sample households was greater than the recorded 13 insurance payments to study households. Focus group discussions with leaders of these informal insurance groups revealed descriptive figures on membership and type of insurance cases during the study period (Table 14).

Table 14: Membership and supported insurance cases of informal self-help insurance groups in the study area during the study period (July 1998 – June 1999).

Descriptors	Villages				Average
	Awbere	Lafto	Onaya	Kende Shanko	
Membership in groups	124	112	60	125	105.25
Observed cases (total)	12	8	3	13	9.00
- adults deceased	10	8	2	10	7.50
- other accidents	1	-	-	3	1.00
- wedding	1	-	1	-	0.50

These observations provide a weighted average annual frequency of insurance cases of 9.95%. The insurance coefficient for calculating the security function of goats (**s**) was, therefore, estimated to be 0.83 x 9.95, or 8.2585%.

This coefficient was multiplied either by the annualised average stock (assuming that the whole stock is available to provide household security, through liquidation at any one time when the need arises), or by the sum total of insurance-oriented outflow (truly unexpected or forced onto the households). The underlying concept for alternatively using the forced outflow to estimate insurance benefits is that liquidity-oriented outflows are undertaken in the interest of another perceived benefit, but the security-oriented outflows are imposed on the households due to unexpected undertakings (such as social obligations in funerals and weddings, medication and purchase of food during the lean season). Therefore the whole outflow was dis-aggregated into:

- insurance-oriented outflow, that is imposed/forced on the household, and
- liquidity-oriented outflow, that the family decided to undertake because of expected expenditures, such as clothing, holiday expenses, purchase of another animal etc. that the family decides to do in the interest of another perceived benefit.

Accordingly the partitioning of the total outflow for the study households revealed that the forced part of the outflow accounted for 60 to 74% of the total for the four study groups (Table 15). The forced outflow reflects the value of goats that actually provided insurance (i.e. security) to the household during the observation period. In contrast, the annualised average stock represents the total potential insurance value.

Table 15: Total flock outflow (**C_k** + **S_k** + **OT_k**) and insurance-oriented (**FOM_k**) outflow by study group.

Descriptors	Study groups Cross Improved	Mixed Improved	Indigenous Improved	Indigenous Traditional
Number of flocks	28	62	31	37
Value of total outflow (Birr)	75.66	180.66	156.30	102.23
Value of forced outflow (Birr)	55.76	109.88	112.53	63.10
In per cent of total outflow	73.69	60.82	72.00	60.00

Thus the benefit in insurance (security) (**$S2_k$**) for the second method of aggregation (hereafter related to Method 2) can be calculated as:

$$\mathbf{S2_k = FOM_k \times s}$$

where **FOM_k** = monetary value of the forced outflow, and

s = insurance factor, estimated from the cost of alternative insurance.

The net benefits realised (**NB_k**) from raising goats in the **k^{th}** flock during the observation period was then calculated as the sum of Value Added (**VA_k**), benefit from financing (**F_k**) and benefit from insurance (**S_k**); i.e.

$$\mathbf{NB_k = VA_k + F_k + S_k}, \text{ (Method 1 of aggregation)},$$

or alternatively,

$$\mathbf{NB2_k = VA_k + F_k + S2_k} \text{ (Method 2 of aggregation)},$$

where **$S2_k$** is the benefit in insurance calculated from the forced (insurance-oriented) outflow.

While it is theoretically plausible to estimate the insurance function from the insurance-oriented outflow, the concept is challenged by the fact that total outflow was already used to estimate the financing functions, leading to double counting of the forced part of the outflow. Therefore, results of this study are presented based on estimates of insurance benefits from the average current stock. The output based on estimates of insurance benefits from the forced outflow is attached in Appendix 3.

4. DESCRIPTIVE RESULTS

4.1 Demographic and socio-economic characteristics of the households

The study households had an average family size of 5.7, with those in Gursum being about 21% larger than those in Kombolcha (Table 16). A fifth of the households in Kombolcha and 14% of those in Gursum were headed by women. The households generally have three to four children, who provide the bulk of labour input for grazing goats. The average reported holding of cultivated land was 0.35 ha in Kombolcha and 0.55 ha in Gursum, which are about a third to half of the country-wide average of cultivated land during the previous production year (CSA, 1999). Even these small holdings are fragmented into two or three pieces. Irrigation is fairly common in both districts, particularly for cultivation of marketable vegetables and *Chat.*

Table 16: Demographic characteristics of the study households by district - means (standard errors).

Variables	Kombolcha	Gursum	Total
Number of study households (n)	65	93	158
Average persons per household (July 1999)	5.11 (0.24)	6.20 (0.19)	5.75
Average age of householder	38.36 (1.12)	38.60 (0.94)	38.51
Average age of housewives	35.39 (1.13)	33.01 (0.89)	33.99
Per cent of women headed households	21.54	13.98	17.09

The households raise a mix of goats, cattle, sheep, donkeys and poultry. Goats are the most numerous ruminant species in the area as a whole. Households in Gursum frequently keep larger numbers of goats and lesser numbers of cattle than, those in Kombolcha (Table 17). Of those households who maintain crossbred goats, the number of crossbreds is about 1.8 crosses per household, and these account for 73% of the flock in Kombolcha and 55% in Gursum. The overall average of 63% crossbreds in flocks is slightly larger than the 57% observed on a larger study population three years earlier (Ayalew, 1996). The number of crossbreds around the study area has markedly increased from 255 in 1996 to an estimated over 400 at the beginning of this study.

A typical household in the area has a small homestead close to the field plots. A variety of trees, shrubs and vegetables are grown in the back yard. A combination of annual and perennial crops are grown, mostly simultaneously, but also in succession. Livestock are usually tethered around the homestead or crop fields during most of the day. All animals are housed in a separate sector of the family home. Suckling animals are usually tied away from dams and joined only soon after milking. The barn is cleaned every morning, and the dirt (with leftover feed) is damped into compost pits in the backyard.

Table 17: Socio-economic characteristics of the study households - means (standard errors).

Variables	Kombolcha	Gursum	Total
Average holding of cultivated land in *Timad* (=one eighth of a hectare)	2.83 (0.16)	4.28 (0.16)	3.68
Average number of pieces of the cultivated land	2.61 (0.12)	3.07 (0.13)	2.89
Per cent of households with irrigated plots	32.3	46.2	40.5
Average size of initial goat flock	2.45 (0.20)	2.76 (0.20)	2.63
Average number of crossbred goats in flocks with crossbreds	1.79 (0.20)	1.79 (0.26)	1.79
Average holdings of other livestock			
- Cattle	2.57 (0.21)	2.16 (0.18)	2.33
- Out of which, cows	1.04 (0.09)	0.69 (0.08)	0.83
- Sheep	1.06 (0.19)	0.56 (0.11)	0.77
- Donkeys	0.26 (0.05)	0.17 (0.44)	0.21
- Chicken	2.78 (0.36)	1.50 (0.24)	2.03

4.2 Dynamics of sample flocks

A total of 812 goats were observed during the study period (Table 18). The major exit routes were sales (35.7%), transfers including gift (26.5%), death and other losses (22.5%) and slaughter (15.2%). The disposal routes and their order of importance were similar for crossbred and indigenous goats. The overall mortality rate over the year was equally 10.5% for both breed groups. But there were clear disparities between the breed groups in sales, slaughter and transfer rates. The annual sales rate for indigenous goats was 34.7% of the initial stock size compared to 22.6% for the crossbred goats. Similarly, slaughter rates among the indigenous goats (16.2%) were more than double than those for crossbred goats (7.0%). Transfer rates were also 51% more frequent among the indigenous goats (15.9%) than among the crossbreds (10.5%).

The order of importance of entry routes was birth (53.8%), transfer (25.7%) and purchase (20.5%). Relating the birth records with the number of adult females gives a crude annual reproduction rate of 80%. This is a low figure given the observed rate of multiple births in the area between 1994 and 1996 of about 25% (W. Ayalew, unpublished observation). In the present study flock, only 12.7% of the births involved twins and one case was triplet (0.6%). Seventeen of the 20 multiple births involved crossbreds.

Table 18: Summary of flock dynamics of the 158 study flocks during the observation period (July 1998 – June 1999).

Disposals	Entries: Initial	Birth	Purchase	Transfer-in	Total
Sell	107	11	23	7	148
Slaughter	41	4	14	4	63
Transfer-out	59	18	3	30	110
Lost	62	15	6	10	93
End inventory	216	128	21	33	398
Total	485	176	67	84	812

In terms of net changes, the total current stock declined over the study period by about 18% from 485 to 398, with the crossbred population having decreased only 7.6% compared to 23.6% for the indigenous goats. On the whole the villages were net suppliers of goats as they have sold or given out 1.7 times as many goats as they have purchased or received. They have disposed of more goats than they have additionally acquired in ten of the twelve months of the study period, which relates to the overall decline of stock of goats during the study period.

Although births were recorded in every month of the year, they tended to increase between July and October (Figure 3), which was the wetter part of the year. Transfers of goats in the form of gift or temporary custody also increased in the same period. Sharing of lactation/milk off-take between relatives by way of temporary transfer of the dam with its kid is common in the area. Purchase of goats was evenly distributed, but its share out of the total entries was only 20.4%.

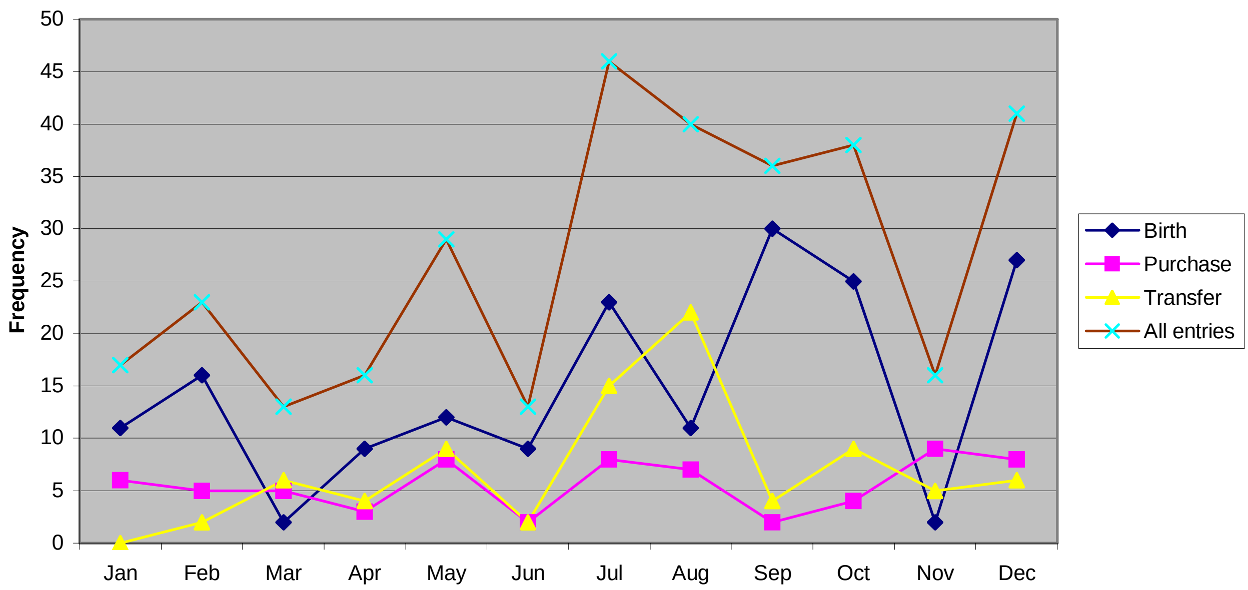


Figure 3: Monthly distribution of goat entries into study flocks

More frequent sales of goats were observed during the leaner months of the year in terms of food supply and the period of intensive field for major crops (April, May) (Figure 4). The higher sales observed in August are associated with the Ethiopian New Year celebrations and more frequent weddings during the same period. Slaughter appears evenly distributed unlike the case in urban areas where slaughters peak during religious and other holidays. Only one-third of the observed slaughter cases were meant for ordinary home consumption; the rest went to meet social obligations (to honour visitors, for weddings, funerals and to care for sick members of the household) that spread throughout the year.

Although flock sizes declined during the year in all the study groups (Tables 19 and 20), the proportional decline was far greater among the indigenous than the crossbred goats. Whereas 62 indigenous goats, or 28% of all indigenous entries, were added into flocks through purchase, only 5 crossbreds, or 4.8% of all crossbred entries, were purchased. Less of breeding crossbreds were sold in the market because the farmers had far fewer chances of acquiring crossbred goats from sources outside the villages, for instance commercial producers, or the breeding station at Alemaya. As a result they appeared to retain the crossbreds longer. This also explains the markedly less decline of stock in flocks with only crossbred goats (Table 19).

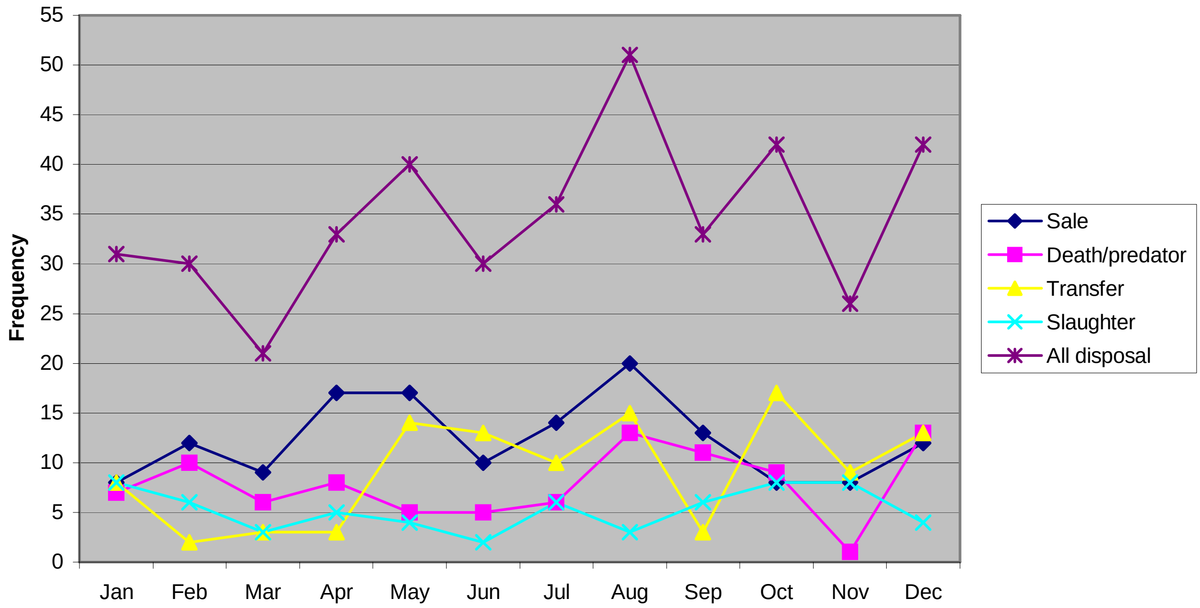


Figure 4: Monthly distribution of goat disposals from study flocks

The control households (indigenous/traditional) had generally less goats born (32%) in proportion to the annualised average flock compared to the combined ratio (41%) of the other three groups (DGDP participants), indicating better crude reproductive rate in the improved than in the traditional management. In the same manner, from the perspective of total loss (death and other losses) as proportion of the annualised flock size, the control households lost twice (31%) as much as those practicing improved management (16%) (Table 19).

Table 19: Summary of changes within sample flocks by study group

Descriptors	Cross/ improved	Mixed/ Improved	Indigenous/ Improved	indigenous/ Traditional	Total
Number of flocks	28	62	31	37	158
Stock					
Initial flock size	2.25	3.64	3.16	2.65	3.07
Final flock size	2.36	2.86	2.71	1.92	2.52
Balance	-0.11	-0.78	-0.45	-0.73	-0.55
Change from initial stock (%)	-4.9	-21.4	-14.2	-27.5	-17.9
Annualised average flock	2.36	3.52	2.90	2.61	2.98
Locals in average flock	0.00	1.68	2.90	2.61	-
Crosses in average flock	2.36	1.83	0.00	0.00	-
Flow					
Birth	1.07	1.27	1.19	0.84	1.12
Death and other loss	0.36	0.64	0.45	0.81	0.59
Balance	+0.71	+0.63	+0.74	+0.03	+0.52
Inflow:					
Purchased	0.04	0.53	0.77	0.24	0.42
Transfer-in	0.39	0.45	0.58	0.73	0.53
Subtotal	0.43	0.98	1.35	0.97	0.96
Outflow:					
Sell	0.46	1.14	1.23	0.70	0.94
Slaughter	0.07	0.55	0.42	0.38	0.40
Transfer-out	0.50	0.71	0.90	0.65	0.70
Subtotal	1.03	2.40	2.55	1.73	2.03

The variation in the annualised flock size was larger in flocks with indigenous goats (Table 20), because the crossbreds were more stable than the indigenous stocks. The variations in both inflow and outflow were also less in flocks with crossbred goats.

The number of days goats stayed in study flocks ranged from 2 to 365 days, with an overall mean of 212 days. In general crossbred goats stayed 42 days longer than indigenous goats, and females stayed 48 days longer than males (Table 21). Considering only goats present at the beginning of the study, any goat had a probability of staying in flock of 69.6%, or conversely a probability of leaving their flocks of 30.4%. Crossbreds had a significantly (p=0.003) higher probability of staying than indigenous goats; similarly female goats had a significantly (p=0.0004) higher probability of staying in their flocks. Similar trends were observed among the flock that finally remained in the study flocks (end stock). Home-bred goats stayed longer than purchased or transferred ones; purchased goats also had shorter stay period than even those which came in by way of transfer. At the district level, flocks in Kombolcha stayed longer than those in Gursum.

Table 20: Variation of changes in the annualised sizes of study flocks by study group

Descriptors	Cross/ improved	Mixed/ Improved	Indigenous/ Improved	indigenous/ Traditional	Total
Number of flocks	28	62	31	37	158
Annualised average flock:					
- Mean	2.36	3.52	2.90	2.61	2.98
- Minimum	0.44	0.36	0.07	0.22	0.07
- Maximum	5.28	9.02	7.68	6.75	9.02
- Variance	1.50	4.61	2.53	2.61	3.35
Total inflow:					
- Mean	0.43	0.98	1.35	0.97	0.96
- Minimum	0	0	0	0	0
- Maximum	5	5	5	10	10
- Variance	1.22	1.69	2.77	3.47	2.27
Total outflow:					
- Mean	1.04	2.40	2.55	1.73	2.03
- Minimum	0	0	0	0	0
- Maximum	6	7	8	9	8
- Variance	2.04	2.64	4.32	2.54	3.08

Across the study groups, the order of importance of physical products to the total biological production is meat, manure and milk. The external inputs were characteristically very small, and include only feed and medication costs. The socio-economic benefits generally accounted for about 10 per cent of the total net benefits (Table 22).

Table 21: The number of days goats stayed in study flocks - means (standard errors)

Categories	Total N	Kombolcha	Gursum	Total
Breed:				
- Indigenous	537	227.1 (12.1)	189.3 (6.3)	198.0 (5.6)
- Crossbred	275	252.4 (10.2)	228.0 (10.8)	240.1 (7.5)
Sex:				
- Female	506	251.6 (9.9)	219.6 (7.1)	230.4 (5.8)
- Male	306	219.1 (12.8)	166.9 (8.3)	182.3 (7.1)
Entry reason:				
- Initial flock	485	283.3 (8.3)	237.3 (7.5)	253.9 (5.7)
- Birth	176	188.2 (14.8)	177.4 (9.5)	180.6 (8.0)
- Purchase	67	60.8 (20.2)	101.7 (11.0)	90.1 (9.9)
- Transfer	84	140.8 (28.4)	134.6 (13.8)	135.6 (12.4)
Exit reason:				
- Sale	148	175.5 (16.0)	160.7 (11.2)	165.4 (9.2)
- Transfer	110	125.1 (18.7)	139.1 (11.9)	135.7 (10.1)
- Slaughter	63	173.2 (29.6)	130.1 (13.7)	139.0 (12.6)
- Death/Predator attack	93	159.1 (18.6)	140.4 (12.3)	145.2 (10.3)
- End inventory	398	300.6 (8.9)	264.6 (7.9)	278.1 (6.0)
Source of animal:				
- home-bred	543	250.8 (9.1)	207.6 (6.4)	219.8 (5.3)
- purchased/transferred	269	222.7 (14.4)	180.4 (10.4)	193.5 (8.5)
Study groups:				
- Crossbred/improved	136	220.4 (15.0)	198.4 (17.1)	211.1 (11.3)
- Mixed/improved	305	256.3 (12.0)	213.5 (9.4)	228.5 (7.5)
- Indigenous/improved	200	253.4 (33.8)	182.7 (9.2)	188.7 (9.0)
- Indigenous/traditional	171	234.2 (15.8)	200.3 (12.0)	211.6 (9.6)

4.3 Benefits

At the level of study groups, mixed flocks produced the greatest total benefits followed by the indigenous/improved, cross/improved and indigenous traditional. The value added to flocks contributed to 90% of the total benefits, and the socio-economic benefits contributed the remaining 10%. Meat accounted to 53.4% of total physical production, compared to 35.4% and 11.3% for manure and milk (Table 22).

At the level of individual goats and under improved management, crossbreds gained significantly higher net body weights that the indigenous goats when comparisons are made per head of the goat, per kilo gram average weight as well as per kilo gram metabolic weight of the same goat. However, the crossbreds have also lost significantly higher cumulative body weights (Table 23).

Table 22: Components of total benefits from flocks by study group – means (standard errors).

Variables	Crossbreds/ improved	Mixed/ improved	Indigenous/ improved	Indigenous/ traditional	Total
Total flocks	26	64	31	37	158
Biological production:	151.96 (25.81)	243.64 (25.34)	202.72 (20.51)	120.33 (20.54)	191.65 (13.29)
- Meat	73.56 (19.41)	136.72 (19.03)	117.15 (15.83)	50.36 (16.33)	102.27 (10.36)
- Milk	18.25 (4.88)	26.32 (4.15)	22.83 (3.76)	14.88 (2.29)	21.63 (2.09)
- Manure	60.13 (5.95)	80.60 (6.10)	62.74 (6.09)	55.09 (5.53)	67.76 (3.28)
External inputs:	15.60 (4.65)	26.17 (5.14)	19.34 (5.15)	9.97 (3.48)	19.30 (2.60)
- Feed costs	12.50 (4.58)	23.37 (5.10)	18.26 (5.19)	8.81 (3.14)	17.17 (2.56)
- Medication	3.10 (0.87)	2.80 (0.46)	1.08 (0.49)	1.16 (0.48)	2.12 (0.28)
Value added of flocks	136.36 (24.23)	217.45 (23.41)	183.38 (20.29)	110.36 (20.92)	172.34 (12.49)
Socio-economic:	12.32 (2.22)	23.89 (1.98)	20.16 (2.58)	14.27 (1.88)	19.00 (1.16)
- Financing	7.63 (2.00)	17.75 (1.76)	15.64 (2.92)	10.22 (1.63)	13.89 (1.33)
- Insurance	4.79 (0.48)	6.13 (0.48)	4.52 (0.45)	3.95 (0.40)	5.09 (0.26)
Total benefits	148.81 25.90	241.32 (24.80)	203.58 (21.57)	124.59 (22.27)	191.36 (13.3)

Table 23: Net body weight gain and cumulative weight loss between crossbred and indigenous goats under improved management during the study period – means (standard errors).

Variables	Means (se) in kg		t	α*
	crossbreds	Indigenous		
Number of goats	275	372		
Mean net weight gain per head of goat	5.77 (0.44)	3.38 (0.32)	4.54	0.000
Net weight gain per kg body weight of goat	0.41 (0.03)	0.30 (0.02)	2.85	0.005
Net weight gain per kg metabolic body weight of goat	0.77 (0.04)	0.54 (0.04)	3.36	0.001
Mean cumulative weight loss	5.84 (0.43)	4.09 (0.27)	3.59	0.001
Cum. loss per kg body weight of goat	0.25 (0.01)	0.21 (001)	2.34	0.018
Cum. loss per kg metabolic body weight of goat	0.54 (0.03)	0.43 (0.03)	2.65	0.008

$*\alpha = P \mid (\mu_1 - \mu_2 \neq 0)\mid$

Similarly, the crossbreds produced on the average significantly higher amount of milk off-take than the indigenous goats. However, when comparisons for milk off-take per kilogram body weight or metabolic weight of the doe, the differences between the crossbreds and indigenous are not statistically significant (Table 24).

Table 24: Milk off-take between crossbred and indigenous goats under improved management during the study period – means and their standard error

Variables	Means (se) in litre		t	α*
	crossbreds	Indigenous		
Number of goats	57	107		
Mean milk off-take per head of goat	8.88 (0.89)	5.89 (0.26)	3.73	0.000
Milk off-take per kg body weight of doe	0.26 (0.02)	0.24 (0.01)	0.83	0.586
Milk off-take per kg metabolic body weight of doe	0.58 (0.08)	0.49 (0.05)	1.03	0.302

$* \alpha = P \mid (\mu_1 - \mu_2 \neq 0)$

5. EXPERIMENTAL SECTION

5.1.Benefits from mixed flocks

5.1.1 Introduction

The general hypothesis was that crossbred goats generate more net benefits than indigenous goats under traditional management. It could be tested by comparing the 26 crossbred flocks under improved management with the 37 indigenous flocks under traditional management (Table 22). However, it was noted that a larger proportion of farmers actually maintain flocks containing both crossbred and indigenous goats in varying proportions. It was also observed that flocks with only crossbred goats later acquired indigenous goats and maintained them more or less similarly with crossbreds. During the initial survey of this study, 55% of the DGDP participant households were observed to keep mixed flock. Just over half of the final set of DGDP participant sample households was also mixed.

A closer examination of actual flock development of the DGDP participant households reveals that they had been assisted to acquire and maintain under improved management indigenous and then crossbred goats to enable them, in the long run, to achieve a higher level of overall flock productivity. The underlying assumption was that the mix of crossbred and indigenous goats generates higher net benefits than the indigenous goats under the traditional management. Against this background, the general hypothesis was modified to state:

> **Net benefits that accrue to the beneficiary households from raising mixed (crossbred and indigenous) flocks under improved management are greater than those from indigenous goats under traditional management.**

5.1.2 Materials and methods

The level of Anglo-Nubian blood in the crossbreds varied from a low of 6.25 to 75%, with an overall average of about 43% at the end of the study. The breeding difficulties associated with this assortment will be taken up in a later part of the thesis, but for the analytical purposes of this study all levels of crosses are considered as one: crossbreds.

A total of 62 mixed/improved and 37 control flocks were available for the analysis. The proportion of crossbred goats in the annualised average flock sizes of mixed flocks ranged from 4 to 96%. To ensure comparable representation of both breed groups, a “mixed flock” was taken to mean a flock of crossbred and indigenous goats with the crossbred goats constituting a minimum of 25 and a maximum of 75% of the annualised average flock size. Furthermore, for both study groups a minimum annualised average flock size of 1 head of goats, or an equivalent of 365 goat-days was set as the minimum size for a flock to be included in the study. As a result of these criteria, only 35 mixed and 33 indigenous flocks were used to test this hypothesis. Forty-three of these flocks are from Gursum and the remaining 25 flocks are from Kombolcha district.

The comparisons are made on the basis of multiple productivity indices (Unit Net Benefits) discussed in section 3.4. General description of the study groups was presented in section 4.

A fixed linear model was used to represent the variation in unit net benefits between the mixed and indigenous flocks. Both breed group (with management) and district were taken as fixed effects. The strata within management (weak, medium, strong) were considered as nested fixed effects, i.e.

$$\mathbf{Y_{ijk} = \mu + b_i + c_{ik} + d_j + bd_{ij} + e_{ijk}},$$

where, $\mathbf{Y_{ijk}}$ = unit net benefits, per unit *Timad* of land, unit metabolic body weight of the average flock, and per hour of labour used.

μ = overall (population) mean.

$\mathbf{b_i}$ = fixed effect of breed/management (mixed/improved versus indigenous/traditional) (i = 1,2).

$\mathbf{c_{ik}}$ = nested fixed effect of strata within breed/management ($\mathbf{c_{1k}}$ =1,2,3; $\mathbf{c_{2k}}$ =1,2,3)

$\mathbf{d_j}$ = fixed effect of district (j = Kombolcha, Gursum),

$\mathbf{bd_{ij}}$ = fixed effect of interaction between breed/management and district,

$\mathbf{e_{ijk}}$ = residual deviation: NID (0, σ^2_e)

The following overall assumptions were made in doing the analysis:

1. the net benefits can be explained as a linear combination of the treatment and the district factors;
2. the random error deviations are normally and independently distributed: NID (0,σ2e), and
3. there is no interaction between the flock size, land holding and labour used in the goat enterprise.

The interaction between breed/management and district was tested in the ANOVA using F-test (mean square of the interaction versus means squares of residuals). Because no significant interaction was observed, the whole data set was handled in one. Differences in unit net benefits between the mixed/improved and the indigenous/traditional flocks were tested in the ANOVA using the F-test (mean squares breed/management versus means squares residuals), which is equivalent to testing the null hypothesis that the differences are zero against the alternative hypothesis that the differences are unequal to zero.

When the analysis of variance indicated a significant difference between the study groups, the means were then compared to quantify the degree of difference in unit net benefits between the mixed and the indigenous flocks.

The two study groups were found to be significantly different in their initial goat flock sizes. Their annualised average flock sizes were also nearly significantly different (Table 25). But these can be taken as natural differences. Besides, these differences are taken care of in the analysis as the comparisons are made per unit of resources used (in this case metabolic body size of the average flock). However, the slight but statistically non-significant overall differences in average holdings of cultivated land required particular attention. This is because at district level the differences between groups are not similar. The average holdings of land do significantly differ between the two districts (Table 17), where farmers in Kombolcha own less than those in Gursum. In Kombolcha the two study groups have about similar holdings, but in Gursum the mixed/improved group owns significantly larger land.

The DGDP participant households were originally selected to participate in the project on the basis of their initial livestock holdings and relative wealth. Land was not specifically considered in the selection. This variable was not controlled during selection of sample households for this study, and only outliers were excluded. The observed differences in average holdings are, therefore, due to sampling and not necessarily because of natural differences between DGDP participant households and non-participant households. In other words, a higher land holding is not a necessary characteristic attribute of the mixed flocks, or conversely the control households do not always have smaller land holdings. Consequently, the possibility of including land holdings as a covariate in the model was examined.

The relationship of size of land holding with the three composite productivity parameters was tested in a simple regression analysis. The results show consistently significant negative correlation coefficients in the control group, and nearly significant negative correlation with the productivity parameter on land in the mixed flocks (Table 26).

Table 25: Characteristics of mixed/improved and indigenous/traditional study flocks - least squares means (standard errors)

Descriptor variables	Mixed/ Improved	Indigenous/ Traditional	α*
Family size	5.86 (0.34)	5.88 (0.34)	0.97
Size of cultivated land in *Timad**	3.84 (0.26)	3.41 (0.25)	0.25
Initial goat flock size	3.16 (0.28)	2.39 (0.27)	0.05
Annualised average flock size	3.66 (0.30)	2.84 (0.30)	0.06
Total goat-days of flocks	1339.7 (110.5)	1038.0 (108.9)	0.06

* Significance level: $\alpha = P \mid (\mu_1 - \mu_2) \neq 0 \mid$
** *Timad* = local unit of land (= one eighth of a hectare).

Table 26: Linear correlation coefficients of productivity parameters with holdings of cultivated land

Productivity parameter	Mixed/Improved, n= 35		Indigenous/Traditional, n=33	
	R	α*	R	α*
Net benefits per unit of land	-0.30	0.08	-0.44	0.01
Net benefits per unit of $BW^{0.75}$ of average flock	0.10	0.57	-0.42	0.01
Net benefits per hour of labour input	0.13	0.47	-0.34	0.05

* Significance level: $\alpha \equiv P \mid \rho \neq 0 \mid$

As is evident from the statistically significant and consistently negative correlation coefficients in the traditional flocks, the least squares means of productivity parameters in the traditional flocks decreased with the inclusion of land as a covariate in the model. But those of the mixed flocks remained more or less unchanged (weaker correlations with less statistical significance). This association indicates an important trend whereby declining land holdings in smallholder farms lead to improvements in land productivity. Because similar associations of land with those productivity parameters on flock size and labour input were observed, the size of cultivated land was included as a covariate in the model.

This modification improved the model by a reduction in the error variance of about 11% from 2295.38 to 2068.70, and the difference in average land productivity between the study groups changed from 69.92 vs. 50.96 to 69.95 vs. 46.10, and the level of significance on differences in productivity on land improved from 0.1313 to 0.0469.

5.1.3 Results and discussion

Mixed flocks had a significantly ($p<0.05$) higher aggregate productivity on land and labour (Table 27). Productivity per unit of metabolic body weight of the average flocks was also higher for the mixed flocks, but that was not significant ($p=0.15$). These differences were also consistent in the results obtained using the second method of aggregating the composite productivity indices, taking account of the forced stock off-take in calculating the security functions (Appendix 3). Thus mixed flocks were more productive per unit of the major resources used in the goat enterprise. On the whole mixed flocks were 51.7% more productive on land and 56.3% more productive on labour (Table 28).

Table 27: Composite productivity indices on land, metabolic body weight of average flock and labour input between mixed and traditional flocks - least squares means (standard errors)

Descriptors	Net benefits (Birr) per unit of		
	Cultivated land in *Timad*	Metabolic weight of average flock	Labour input in hours
Study groups:			
Mixed	69.9 (8.4)	7.5 (1.1)	0.17 (0.02)
Traditional	46.1 (8.4)	5.2 (1.1)	0.11 (0.02)
α*	0.05	0.15	0.05
Districts			
Kombolcha	54.3 (9.7)	6.1 (1.3)	0.14 (0.02)
Gursum	61.8 (7.2)	6.6 (0.9)	0.14 (0.02)
α*	0.55	0.72	0.97

* Significance level: $\alpha = P \mid (\mu_1 - \mu_2) \neq 0 \mid$

These differences in productivity relate to the large differences in the value of benefits realised in meat, milk and manure. Mixed flocks produced larger amounts of physical products, incurred on the average more than double in external inputs but in the end produced by far larger Value Added of the flocks (Table 28). Similarly, because of the significantly larger stock outflow (off-take), the mixed flocks gained better in asset and security benefits from the flocks. The net flock body weight gain among the traditional flocks over the year period was nearly half of what was gained in mixed flocks. The traditional flocks also lost slightly higher value in lost goats (death, predator attack, loss).

In terms of goat numbers, the mixed flocks had significantly ($p < 0.05$) larger flock size both at the beginning and end of the study period (Table 19). In both study groups average flock sizes declined over this period, by 16.4 and 24.4 per cent, respectively. The reasons for this are that mixed flocks had slightly larger number of births and purchased more goats than had the traditional flocks. The increases were despite more frequent slaughters in mixed flocks and larger number of inward transfers into traditional flocks. Overall, the mixed flocks appear to have produced more goats and benefited better from more frequent sales and slaughter. The increased benefits also came because of the significantly ($p < 0.05$) greater net body weight gains of the flocks over the observation period. The total value of losses including death and predator attack was comparable.

Table 28: Composition of gross output and aggregate benefits between study groups (in Birr)

	Mixed flocks		Indigenous flocks	
Components	Value (Birr)	Per cent	Value (Birr)	Per cent
Products				
Meat	145.6[a]	57	61.7[b]	44
Milk	26.2[a]	10	16.8[a]	12
Manure	82.7[a]	33	60.9[b]	44
Sub-totals	254.5[a]	-	139.4[b]	-
External inputs	27.4[a]	-	11.4[b]	-
Value Added	227.1[a]	-	128.0[b]	-
Socio-economic				
Asset	15.8[a]	72	10.4[a]	71
Security	6.2[a]	28	4.4[b]	29
Sub-total	22.0[a]	-	14.8[b]	-
Total net benefits	249.1[a]		142.8[b]	
Changes in stock				
Total stock outflow	158.5[a]		104.6[b]	
Forced stock outflow	101.6[a]		64.4[a]	
Net weight gain	29.8[a]		18.6[b]	
Price of goat losses	31.5[a]		38.8[a]	

Note: Means comparison on t-test; within rows, least squares mean values of components with different superscripts are significantly different at $p < 0.05$.

The three most important components of the overall benefits were, in their order of importance, meat, manure and milk (Figure 5).

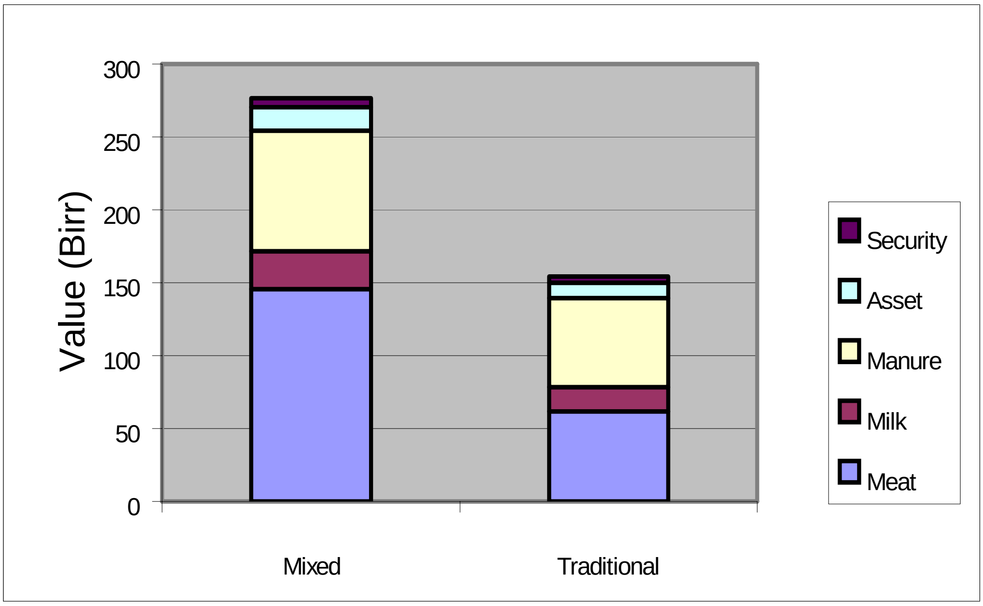


Figure 5: Comparison of benefits realised from mixed and traditional flocks

As the capacity of goats to provide multiple production functions represents a significant benefit to the farmers, attempt was made to account also for net changes from the point of view of the farmers in this benefit if there were considerable changes as a result of introduction of crossbred goats. These can be in the form of difficulties in selling crossbred goats or in transfers to invest in social relations. Crossbreds were observed to be involved in all forms of transactions as were the indigenous goats. No problems in transaction of crossbreds were observed, and farmers reported no difficulties because of breed differences. Crossbred goats always had higher market prices (Table 9). But purchase of crossbred goats was generally very low. As will be discussed in section 4.5, this was because the external sources of crossbred goats were declining after the DGDP has phased out. In response to this, the farmers also tended to reduce voluntary disposal (sales, slaughter) of their crossbreds. Furthermore, the higher market prices of crossbred goats at higher body weights may discourage selling animals at earlier ages.

These results provide sufficient evidence to accept the hypothesis that mixed flocks (crossbred and indigenous goats) maintained under improved management produce higher net benefits per unit of land and labour input than indigenous flocks under traditional management. The evidence on the third index (productivity on the metabolic body weight of the average flock) was weak, and the explanation for this will be sought at a later stage.

The higher unit net benefits generated in mixed flocks than in traditional indigenous flocks can be attributed to differences in the breed of the goats as well as in higher level of management. The mixed flocks have acquired crossbred goats. They were also introduced to improved goat management practices in feeding, health care, housing and controlled breeding. The issue of whether (and to what extent) these improvements in productivity come from the improved management or the breed improvement (crossbreeding) is the subject of the following experiments.

5.2. Benefits from improved management

5.2.1 Introduction

As stated earlier, in Ethiopia the basis for introducing exotic breeds of goats for crossbreeding has been the general prejudgment that indigenous goats do not adequately respond to improvements in level of management. Another reason is the widely held belief that genetic improvement of indigenous breeds by way of selection is slow and complicated, and that more rapid gains can be made through crossbreeding with improved exotic breeds (Pagot, 1992). This general assessment has got two critical limitations. First the improvement in the level of management assumed is not explicitly stated. Second, the expected higher performance of crossbred goats in the “improved management” has yet to be tested.

In this study, improved management was taken to mean the actual level of care provided by those households who have participated in the DGDP for at least 5 years and received at least indigenous goats on credit. This is because these farmers were introduced to, and assisted in, the improved feeding, basic health care and controlled breeding practices promoted in the DGDP technology package. Some of these have gone further to receive crossbred goats in the improved management. The nine years of promotion and demonstration through the DGDP are taken here to be sufficient just to promote and demonstrate the technologies. What have been achieved so far as actual improvements in these areas can, therefore, be taken as realistic goals for improvement of the traditional management.

A logical extension of this argument is then whether these improvements can generate higher net benefits to the farmers than is possible under the traditional management. And to build up on the evidence of the previous experiment, the same control households can be compared with similar indigenous flocks kept under the improved management. This sets the ground for the next hypothesis, which states that:

Indigenous goats generate higher net benefits under the improved management than under the traditional management.

5.2.2 Materials and methods

A total of 37 traditional and 31 improved flocks were available for analysis. The number of goat-days ranged from 25 to 2803, with a mean of 1002. A restriction of minimum of 365 goat-days was set in the analysis, requiring that flocks should be under the study at least for an equivalent of one goat maintained throughout the study period (365 goat-days). This is to reduce the drifting influence of some flocks that remained under monitoring for quite short periods. The analysis was then done on 29 flocks under improved management and 33 flocks under traditional management.

As shown in section 4.0, there were no significant differences between the study groups in average family size, holdings of cultivated land, total livestock holdings (TLU) annualised flock size and total number of goat-days. The slight differences in the initial goat flock sizes at the start of the study period disappeared later as the annualised average flock sizes stabilised.

A fixed linear model was used to represent the variation in unit net benefits between the improved and the traditional management. Management and district were considered as fixed effects. The stratum of management (weak, medium, strong) was included as a nested fixed effect within study group (in this case improved and traditional management); i.e.,

$$\mathbf{Y_{ijk}} = \mu + \mathbf{a_i} + \mathbf{c_{ik}} + \mathbf{d_j} + \mathbf{ad_{ij}} + \mathbf{e_{ijk}},$$

where,

$\mathbf{Y_{ijk}}$ = unit net benefits, per unit metabolic body weight, per unit labour used, and per unit of cultivated land,

μ = overall (population) mean,

$\mathbf{a_i}$ = fixed effect of management (i = improved, traditional)

$\mathbf{c_{ik}}$ = nested fixed effect of stratum within management ($\mathbf{c_{1k}}$ = 1,2,3: $\mathbf{c_{2k}}$ = 1,2,3),

$\mathbf{d_j}$ = fixed effect of district (j = Kombolcha, Gursum),

$\mathbf{ad_{ij}}$ = fixed effect of interaction between management and district

$\mathbf{e_{ijk}}$ = residual deviation: NID (0, σ^2_e).

The following overall assumptions were made in doing the analysis:

1. the net benefits can be explained as a linear combination of the management and district effects;
2. the random error deviations are normally and independently distributed with equal variance, and
3. there is no interaction between the flock size, land holding and labour used in the goat enterprise.

This model tests the null hypothesis that there is no difference in unit net benefits between improved and traditional management against its alternative of a real difference. It provides that if the analysis of variance indicates a significant effect of management, then the unit net benefits between the improved and the traditional management can be compared to quantify the degree of difference.

5.2.3 Results

The indigenous goats maintained under the improved management produced significantly ($p < 0.05$) higher net benefits per unit of cultivated land and labour used than those under traditional management (Table 29). The degree of difference is also large: 80% more for land and 71% for labour. There were also significant differences between the districts whereby farmers in Kombolcha generally produced 60% and 57% higher net benefits per unit of land and labour, respectively.

Although statistically not significant ($p=0.08$), the interaction of type of management (improved versus traditional) with district on productivity for land appeared to be important. Thus separate analysis was done by district. The results show that the differences are almost significant ($p=0.06$) in Kombolcha, but not in Gursum. This is explained by the relative land scarcity in Kombolcha (Table 17), and the general association of higher productivity with declining land holdings (Table 26). All other variables in the model did not contribute significantly in explaining the variations.

Taking milk production alone, the differences between the districts are significantly ($p <0.05$) different, whereby the overall milk off-take in Gursum is more than double than that of Kombolcha. This coincides with the higher frequency of occurrence of milking cows among households in Kombolcha (1.3 versus 0.6; $p=0.02$). However, milk contributes only about 9%

of the total net benefits, which leaves meat and manure as the major components of net benefits.

Table 29: Composite productivity indices on land, metabolic body weight of average flock and labour input of indigenous goats under improved and traditional management - least squares means (standard errors)

Descriptors	Net benefits (Birr) per unit of		
	Land holding Birr/*Timad* of land	Metabolic weight of average flock Birr/kg $^{0.75}$	Labour input Birr/hr of labour
Study groups:			
Improved	91.7 (13.6)	7.9 (1.5)	0.20 (0.03)
Traditional	51.0 (8.0)	5.6 (0.9)	0.11 (0.02)
α*	0.01	0.20	0.03
Districts			
Kombolcha	87.9 (14.1)	7.1 (1.6)	0.19 (0.03)
Gursum	54.8 (7.0)	6.4 (0.8)	0.12 (0.02)
α*	0.04	0.72	0.06

* $\alpha = P \mid (\mu_1 - \mu_2 \neq 0) \mid$

The study households with improved management had significantly larger final flock size. However, the annualised flock size was very close to the mean of the traditional management. In the course of the study period, households with improved management have received less number of goats by way of in-ward transfer, but they have given out more goats in temporary transfer. The slaughter rates were nearly equal. They purchased larger number of goats, but that was compensated by greater sales rates (Table 30). Yet by taking advantage of changing prices, these households had opportunities to generate higher benefits.

The traditional flocks lost about 29.4% of the average flock size in the form of death (due to disease, snake bite, plant poisoning) and predator attack, compared to 15.5% in the households with improved management. The losses due to predators, plant poisoning and snake bites relates to the significantly higher frequency of grazing practice throughout the year in the traditional households (section 5.4.3, Figure 8). The improved flocks tended to practice more of tethered management by feeding goats around homestead. However, as a study on effects of tethered management on feed intake and behaviour in Tanzania has shown, the length of tethering time may not have significant effect on feed intake or digestibility on mature non-reproductive goats (Romney, *et al*. (1996).

Table 30: Comparison of flock dynamics of indigenous goat flocks between improved and traditional management

Descriptors	Improved	Traditional		
Number of flocks	29	33	t	α*
Stock				
Initial flock size	3.31	2.84	0.98	0.67
Final flock size	2.90	2.15	2.01	0.05
Mean balance	-0.41	-0.70	0.58	0.57
Mean change from initial stock (%)	-6.90	-18.20	1.14	0.26
Annualised average flock	3.10	2.89	0.54	0.59
Flow				
Birth	1.28	0.94	1.55	0.12
Death and other loss	0.48	0.85	1.08	0.28
Mean balance	+0.79	+0.09	1.78	0.08
Inflow:				
Purchased	0.83	0.24	2.46	0.02
Transfer-in	0.62	0.82	0.50	0.62
Subtotal	1.45	1.06	0.83	0.60
Outflow:				
Sell	1.24	0.76	1.65	0.10
Slaughter	0.45	0.39	0.31	0.76
Transfer-out	0.97	0.70	0.77	0.55
Subtotal	2.66	1.85	1.69	0.09

* $\alpha = P\,|(\mu_1-\mu_2 \neq 0)|$

Overall flock off-take expressed both in absolute terms (in body weight) or as a ratio to the metabolic body weight of the average flock is slightly higher for improved management, but the differences were not statistically significant. The differences in milk production or socio-economic functions were not statistically significant. The socio-economic benefits account for only 7.8 and 10.6 per cent respectively of the total benefits for the two groups.

The differences in unit net benefits mainly came from the markedly higher meat production in improved management (Table 31 and Figure 6). Value of gross meat output represented 60% and 45% respectively of total physical production for the improved and traditional management. This higher production was partly because of the greater number of goats sold and kids born (Table 30). Besides, there was a significantly larger flock size (stock) at the end of the study. Similarly, improved management appeared to have produced higher net body weight gains and reduced total losses over the year, though the differences were not statistically significant (Table 31).

Table 31: Composition of gross output and aggregate benefits between study groups (in Birr)

	Improved management		Traditional management	
Components	Value (Birr)	Per cent	Value (Birr)	Per cent
Physical products				
Meat	138.8[a]	60	61.6[b]	45
Milk	20.7[a]	9	15.4[a]	11
Manure	71.6[a]	31	59.4[b]	44
Sub-totals	231.1[a]		136.4[b]	
External inputs	16.8[a]		12.0[a]	
Value Added	214.3[a]		124.4[b]	
Socio-economic				
Asset	12.8[a]	71	10.4[a]	71
Security	5.3[a]	29	4.3[a]	29
Sub-total	18.1[a]		14.7[a]	
Total net benefits	232.4[a]		139.1[b]	
Changes in stock				
Total stock outflow	127.7[a]		104.4[a]	
Forced stock outflow	63.7[a]		63.3[a]	
Net weight gain	27.1[a]		17.8[a]	
Price of goat losses	16.2[a]		35.8[a]	

NB: Within rows, least squares means values of components with different superscripts are significantly different at $p < 0.05$ on a t-test..

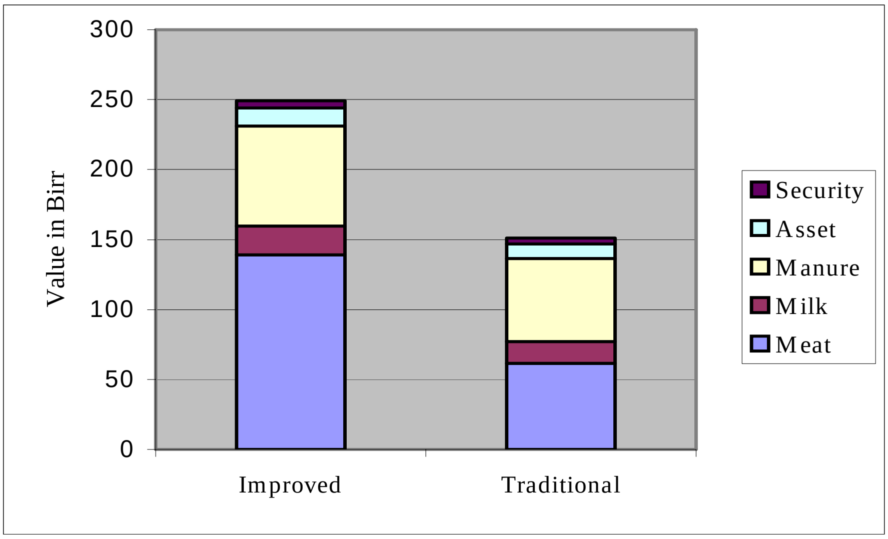


Figure 6: Comparison of benefits from indigenous goat flocks between improved and traditional management

There is, therefore, sufficient evidence to accept the hypothesis that indigenous goats maintained under improved management generate higher net benefits per unit of cultivated land and labour used, but not per unit of metabolic body weight of the average flock.

5.2.4 Discussion

An important observation in this experiment was the fact that the improved management was maintained without the presence or introduction of crossbred goats, which challenges the thesis that the crossbreds are the incentive to improvements in level of management.

The superiority of improved management in generating net benefits is brought about by a combination of larger stock, higher off-take, reduced losses and higher net weight gains. Patterns in flock dynamics do not suggest that the improved management exerts any more control in breeding over that of the traditional management. This relates to the observation that productivity on metabolic body size did not differ significantly both between the types of management and districts (Table 29). This parameter measures biological productivity. The improved management is not expected to have produced higher benefits for a given metabolic body weight of flocks. Higher benefits were generated from a larger biomass, and the biomass was equally productive. Farmers do not appear yet to have the means to purchase goats based on their genetic merit any more than can be established by way of visual appraisal. Even the average stay of goats in flocks was similar between groups (Table 21). The overall average stay of an indigenous goat in study flocks was 196 days, which gives an average probability of stay during the year of only 53.7%. Apart from the small flock sizes, such a high turn over of goats puts another restriction on selective breeding.

The observation that biological productivity of the indigenous goats did not change because of the improved management provides partial explanation on why the mixed/improved flocks were not as significantly more productive for the given biomass of goats as they were on land and labour inputs (Table 27).

The improved management resulted in maintaining more goats per unit of land or labour used and produced higher unit net benefits in a given time. More importantly the indigenous goats responded markedly to the observed improved management. However, the improvements were made horizontally (more animals) and not vertically (fewer animals). It enabled the keeping of more goats for the available land and labour resources. The external inputs were characteristically low, and these were not significantly different from those in the traditional management. This is what can be called intensification of animal production by multiplication, as opposed to specialization that entails investing more inputs in fewer animals to generate higher outputs.

The merit of improved level of care to goats is not disputed; but the issue is whether the additional costs of improvements are compensated for in the added benefits generated from the goat flocks. In the present study the additional external costs were accounted for in determining the net benefits. However, the sum of external inputs incurred in the improved management was very small, and that sum was not significantly different from that observed in traditional management (Table 31). The low external costs are basic characteristics of the subsistence and low-input mode of production (Doppler, 1991; Schiere, 1995).

Because of the modified procedure of measuring improvements applied in this study, it is incompatible to compare the 74% increase in net benefits from mixed flocks or the 67% increase in net benefits from improved indigenous flocks over the traditional flocks with the results of previous conventional comparisons on lactation, growth or reproductive performance. But previous work in Ethiopia (Galal and Awgichew, 1981; Abebe, 1996; Berhanu, 1997) or elsewhere (Devendra and Burns, 1983; Laes-Fettback, 1989; Rischkowsky, 1996) showed that goats respond to improvements in nutrition and health care.

Padhila *et al*. (1980) compared the productivity of the traditional Brazlian husbandry with three improved levels of care: (1) with improved hygiene and medication; (2) these plus improved feeding, and (3) these plus improved housing. With few exceptions, all treatments improved reproductive performance and reduced mortality. Improved health care was the most rewarding of the improvements, and inclusion of improved feeding and housing had little further effect on productivity on the goats.

In conclusion, the higher benefits from mixed as well as indigenous flocks maintained under improved management can be attributed to better feeding practices and greater attention to basic health care that the DGDP participants households maintained after the DGDP. Details are discussed in section 5.4.

Crossbreds were thought to produce better even if they need higher inputs, a tendency towards specialization. The evidence thus far becomes more relevant in the context of this study, when similar comparisons are made between indigenous and crossbred goats under the improved management.

5.3 Benefits from crossbreeding

5.3.1 Introduction

Crossbreeding can be justified only if the incremental benefits that come with it more than compensate for the additional costs of introduction and management of the crossbreds. This becomes even more important for the smallholder subsistence production system where capital is particularly limited relative to labour and land (Hayami, 1997). On the other hand, as Pagot (1992) has pointed out, there is a widespread assumption in countries like Ethiopia that crossbreeding of indigenous livestock with improver exotic breeds can provide for more rapid increase in animal production than is possible with selection within indigenous breeds.

The success of a crossbreeding technology ultimately depends on the net benefits that accrue to the farmers themselves. The demonstration by the DGDP of combining crossbreeding with a package of management improvements allows one to test the concept that crossbreeding is more beneficial than keeping the indigenous stock in an improved environment. This concept raises concerns of wider issues in sustainable use of livestock genetic resources. But the focus here is on improved human welfare of impoverished communities in a short time horizon.

Following the argument that crossbreeding brings in greater short-term benefits, it is possible to generate the hypothesis that:

> **The net benefits are greater from crossbred goats than from indigenous goats under improved management.**

5.3.2 Materials and methods

The same analytical procedures described in sections 4.1 and 4.2 were followed, except that comparisons were made between crossbred and indigenous goats under the improved management. Data on the output variables were collected by breed group. As far as possible, the additional inputs utilised were also recorded by breed group; otherwise, inputs (labour, purchased external inputs) were divided in proportion to their body weights. The same guidelines were applied to determine net benefits per units of resources employed.

The study design allows both intra-household and inter-household comparison of crossbreds versus indigenous goats maintained under improved management. The inter-household comparison is less optimal than the intra-household option; however, because this particular breed comparison is the core subject of this thesis, both avenues were explored.

For the intra-household comparison, the 62 mixed flocks were used. These flocks contain both indigenous and crossbred goats. The aggregate productivity measurements for the breed groups within each mixed flock were taken as separate observations to make the comparison at the level of the breeds for all households combined. The proportion of crossbred goats in flocks was restricted to a minimum of 35 and maximum of 65% to allow balanced representation of the two breed groups. As in the previous analyses, a minimum of 365 goat-days was set for each flock. Finally, a total of 26 balanced mixed flocks were used in the analysis.

A fixed linear model was fitted to the data. The stratum of management was taken as a nested effect within study group, in this case breed. Breed and district were considered as fixed effects:

$$\mathbf{Y_{ijk}} = \mu + \mathbf{b_i} + \mathbf{d_j} + \mathbf{c_{ik}} + \mathbf{bd_{ij}} + \mathbf{e_{ijk}},$$

where,

$\mathbf{Y_{ijk}}$ = unit net benefits (per unit metabolic body weight, per unit labour used, or per unit of land) from goats belonging to one breed,

μ = overall (population) mean,

$\mathbf{b_i}$ = fixed effect of breed (**i** = crossbred, indigenous),

$\mathbf{d_j}$ = fixed effect of district (**j** = Kombolcha, Gursum),

$\mathbf{bd_{ij}}$ = fixed effect of interaction between breed and district,

$\mathbf{c_{ik}}$ = nested fixed effect of management strata within breed group ($\mathbf{c_{1k}}$ = 1,2,3: $\mathbf{c_{2k}}$ = 1,2,3), and

$\mathbf{e_{ijk}}$ = residual deviation: NID (0, σ^2_e);

The following overall assumptions were made in doing the analyses using this model:

1. the net benefits can be explained as a linear combination of the factors included in the model;
2. the residual error deviation is normally and independently distributed: NID (0, σ^2_e);

3. there is no interaction between the flock size, land holding and labour used in the goat enterprise.

This model provides that when a significant variation due to the breed component of variance indicated real difference in unit net benefits between the crossbred and indigenous flocks the means can then be compared to quantify the degree of difference between the study groups.

Since there might be a correlation between the environmental effects influencing the two breed groups within the mixed flock of a household, the following model was also applied to take such a correlation into account. In this model the observation (**w**) is the difference in unit net benefits between the breed means within a household:

$$\mathbf{w_{jk}} = \mu + \mathbf{b_j} + \varepsilon_{jk}$$

where, μ = the average difference in unit net benefits between the breed means within the household;

$\mathbf{b_j}$ = effect of district (fixed);

ε_{jk} = residual error deviation: NID (0, σ^2_ε).

The actual observations were calculated as the difference in composite productivity indices between the crossbred and indigenous breed groups (crossbreds minus indigenous). This model tests whether the intra-household differences in composite productivity indices are significantly different from zero, giving a probability value for the null hypothesis that the mean of the differences is equal to zero.

The same 26 balanced mixed flocks were used in this analysis.

5.3.3 Results

Both of the intra-household comparisons of crossbred and indigenous goats under improved management resulted that there were no significant differences in unit net benefits between crossbred and indigenous goats within mixed flocks (Tables 32 and 33).

When maintained in the same management environment, and comparisons were made at the level breeds for all the households combined, the crossbred goats were not any better than the indigenous goats in the composite productivity indices (Table 33). The same holds true in the comparison of total output as well as in output per unit of metabolic weight of the average flock.

Table 32: Intra-household comparison of crossbred and indigenous goats on composite productivity indices on land, metabolic body weight of average flock and labour input - least squares means (standard errors).

Descriptors	Net benefits (Birr) per unit of		
	Land holding Birr/*Timad* of land	Metabolic weight of average flock Birr/kg $^{0.75}$	Labour input Birr/hr of labour
Study groups:			
Crossbreds	78.7 (16.4)	7.6 (2.5)	0.15 (0.05)
Indigenous	62.8 (16.4)	7.4 (2.5)	0.19 (0.05)
α*	0.50	0.95	0.56
Districts			
Kombolcha	72.6 (21.3)	6.5 (3.3)	0.15 (0.06)
Gursum	68.9 (9.9)	8.5 (1.4)	0.19 (0.03)
α*	0.87	0.58	0.55

$*\alpha = P \mid (\mu_1-\mu_2 \neq 0)\mid$

Similar and consistent results were obtained when the possible intra-household correlations of breed groups were considered, and comparisons were made at the level of each household (Table 33). The differences between the crossbred and indigenous breed groups were not statistically significantly. In the same manner, the differences in the total value of output or in output per unit of metabolic weight of the average flock were not significant.

Table 33: Intra-household dyad pair comparison of crossbred and indigenous goats in composite productivity indices on land, metabolic body weight of the average flock and labour input - mean differences and their standard errors.

Productivity variables	Means	Standard error	t	α*
Land holding Birr/*Timad* of land	0.71	12.59	0.06	0.95
Metabolic weight of flock Birr/kg $^{0.75}$	-1.23	2.29	-0.53	0.60
Labour input Birr/hr of labour	-0.06	0.05	-1.23	0.23

$*\alpha = P \mid(\mu_1-\mu_2 \neq 0)\mid$

Further inter-household comparison was also possible. However, these comparisons could be made on the assumption that the levels of management in the different households are similar. Validation tests for this assumption were first done by comparing the productivity of similar breed groups under the improved management across households: crossbreds in mixed flocks with crossbreds in sole flocks, and indigenous goats in mixed flocks with similar goats in sole indigenous flocks under improved management. As before, a minimum of 365 goat-days was set as a minimum for inclusion in both comparisons. The proportion of crossbred goats in the mixed flocks was also set to have a minimum of 35 and maximum of 65% to allow for fair representation of breed groups in a sample flock. This produced 23 sole crossbred, 29 sole indigenous and 56 mixed flocks. The same statistical model as the first intra-household comparison was applied, except that instead of breed effect, placement (in sole or mixed flocks) was considered.

The results showed that the unit net benefits did not differ between sole and mixed flocks for both crossbred and indigenous goats. The crossbred goats produced similar levels of unit net benefits in mixed and sole flocks (Table 34). The indigenous goats also produced similar levels of unit benefits under mixed and sole flock management (Table 35).

Table 34: Comparison of composite productivity indices of crossbred goats between sole and mixed flocks on land, metabolic body weight of average flock and labour input - least squares means and their standard errors

Descriptors	Net benefits (Birr) per unit of Land holding Birr/*Timad* of land	Metabolic weight of average flock Birr/kg $^{0.75}$	Labour input Birr/hr of labour
Study groups:			
Sole flock	66.5 (33.8)	6.3 (4.3)	0.14 (0.06)
Mixed flock	80.5 (17.5)	8.1 (2.2)	0.16 (0.03)
α*	0.71	0.71	0.76
Districts			
Kombolcha	64.5 (21.1)	4.9 (2.7)	0.11 (0.04)
Gursum	82.6 (30.5)	9.4 (3.9)	0.19 (0.06)
α*	0.62	0.33	0.21

* $\alpha = P \mid (\mu_1 - \mu_2 \neq 0) \mid$

Table 35: Comparison of composite productivity indices of indigenous goats between sole and mixed flocks on land, metabolic body weight of average flock and labour input - least squares means (standard errors).

Descriptors	Net benefits (Birr) per unit of Land holding Birr/*Timad* of land	Metabolic weight of average flock Birr/kg $^{0.75}$	Labour input Birr/hr of labour
Study groups:			
Sole flock	91.8 (37.7)	7.9 (4.8)	0.19 (0.11)
Mixed flock	105.2 (17.0)	11.9 (2.2)	0.32 (0.05)
α*	0.75	0.45	0.32
Districts			
Kombolcha	111.5 (37.9)	9.7 (4.8)	0.29 (0.11)
Gursum	85.4 (16.7)	10.0 (2.1)	0.22 (0.05)
α*	0.53	0.96	0.52

* $\alpha = P \mid (\mu_1 - \mu_2 \neq 0) \mid$

These results presented circumstantial evidence that the levels of management provided to crossbred and indigenous flocks in different households did not lead to significant differences in unit net benefits. Therefore, the inter-household comparison of unit net benefits between breed groups was considered valid.

The results were consistent with those of the intra-household comparisons. Even across households with similar levels of management, the crossbred goats did not produce significantly different unit net benefits than the indigenous goats (Table 36). This comparison also showed highly significant ($p < 0.01$) interaction of study groups with district for productivity on labour. Therefore, comparisons between study groups for unit net benefits on labour were made separately for each district. In Kombolcha, the indigenous goats in fact produced significantly greater ($p < 05$) unit net benefits per hour of labour than the crossbred goats. The mean differences were also high: 234%. Household labour on indigenous goats appears, therefore, to be more productive than for crossbred goats in Kombolcha. Frequency of off-farm work did not influence the total household labour input. The average holdings of cultivated land and average family sizes are less in Kombolcha than in Gursum (Tables 16 and 17).

In Gursum, the differences between the groups on unit net benefits for labour were not statistically significant, indicating that the farmers have realised similar improvements in benefits from indigenous and crossbred goats for the additional labour they invest on goat husbandry. As reported in another related study (Ayalew *et al*., 2000), during the same study period farmers in Gursum spent 28% longer time on goat husbandry than those in Kombolcha, mainly because of the markedly greater time taken on collecting fodder. Despite the smaller land holdings in Kombolcha, the higher frequency of irrigated vegetable fields around the study households provided more fodder during the dry season. The farmers in Kombolcha appeared to have relatively less time for goat husbandry and, for the time available, the indigenous goats proved more beneficial than crossbred goats.

In conclusion, therefore, the hypothesis that under improved management crossbred goats produce higher unit net benefits than indigenous goats is rejected.

Table 36: Inter-household comparison of crossbred and indigenous goats on composite productivity indices on land, metabolic body weight of average flock and labour input - least squares means (standard errors).

Descriptors	Net benefits (Birr) per unit of		
	Land holding Birr/*Timad* of land	Metabolic weight of average flock Birr/kg $^{0.75}$	Labour input Birr/hr of labour
Study groups:			
Crossbreds	66.5 (13.2)	6.3 (1.0)	0.14 (0.02)
Indigenous	91.7 (14.9)	7.9 (1.2)	0.19 (0.02)
α*	0.21	0.30	0.08
Districts			
Kombolcha	89.8 (15.3)	6.1 (1.2)	0.16 (0.02)
Gursum	68.4 (12.3)	8.0 (1.0)	0.17 (0.02)
α*	0.27	0.21	0.84

$* \alpha = P \mid (\mu_1 - \mu_2 \neq 0) \mid$

5.3.4 Discussion

The core assumption in the conceptual framework of the DGDP that under the improved management the crossbred goats are more beneficial or productive than the indigenous goats does not hold true. When the comparisons are made at the flock level for all the products used, and when the resources employed to produce the benefits are considered, the indigenous goats proved to be as productive as the crossbreds.

The conventional practice of focusing only on F1 crosses and measuring only off-take of meat and milk does not provide fair comparison of benefits from crossbred and indigenous goats. At the level of the individual doe, crossbreds produced very significantly ($p < 0.001$) greater amount of milk than the indigenous goats during the observation period; however, this superiority did not hold true when the comparisons were made per unit body weight ($p = 0.58$) or per unit of metabolic body weight ($p = 0.30$) of the doe. This indicated that, for the feed resources available, a comparable level of milk productivity could be achieved with the indigenous doe as well. Similarly, the crossbreds have produced very significantly higher net body weight gains per unit body weight ($p < 0.001$) and per unit metabolic body weight ($p < 0.001$) of the same goat. However, the cumulative total body weight losses of the crossbreds were significantly greater than those of the indigenous goats when comparisons were made per unit of body weight ($p < 0.02$) and per unit metabolic weight ($p < 0.005$) (Table 23). This again reflects greater losses of the available resources, particularly feed, in the crossbreds.

The implications of this contrast are obviously far reaching considering that even after nine years of promotion and institutional support the mix of crossbred goats is not any more beneficial to the farmers than the indigenous goats under similar level of care.

Unlike commercial producers who make management decisions based on their profit margins, the subsistence producer may be content with a mere increase in production using resources at his disposal. But again does this lateral increment in production fully justify the introduction and management of crossbred animals? The evidence presented here shows that it is also possible to bring about comparable increases in production as well as benefits using the indigenous goats alone. More importantly, the indigenous goats are more accessible and cheaper to the farmers. When availability of labour for goat husbandry is relatively low, as in the case of farmers in Kombolcha, the indigenous goats actually generate more benefits for the labour input.

Based on this it can be concluded that the higher unit net benefits realised from the mixed flocks managed under the improved management than those from the indigenous flocks of traditional management (Table 27) came because of the performance improvements in the indigenous stock as well as the equally productive crossbreds. However, the crossbred goats did not add significant net benefits on top of what was achieved with indigenous goats. If one also considers the other additional costs of procuring the animals, and the difficulties of maintaining the necessary stock of breeding animals to produce the crossbreds, the indigenous goats become even more worthwhile to the farmers than the crossbred goats.

It might be argued that, even if the breed groups produce equal levels of benefits for the resources used, the significantly larger body size of the crossbred goats (Tables 4) means that the farmers can generate, in absolute terms, more benefits from the crossbreds. But these benefits could be equally generated through multiplying the indigenous goats, which the farmers actually did by maintaining more stock of goats (Table 30). Besides, the argument assumes that feed supply is not a limiting constraint. The very significant cumulative body weight losses observed in the study flocks, mainly during the dry season (Table 23) could be explained mainly by the prevailing seasonal scarcity of feeds. Under such circumstances, the smaller and more adapted indigenous goats are expected to sustain themselves better than the crossbreds. In a similar comparison of indigenous tropical cows and cows with higher genetic potential for milk production in Uganda, Mbuza (1991) reported that the consequences of feed inadequacy for animals of lower genetic potential may not go beyond some live-weight loss; but cows of higher genetic potential also suffer substantial loss of fertility, and hence the decline in the longer-term overall production of the animal.

Another explanation for the low performance of the crossbreds may be the higher maintenance requirement of the larger crossbreds that leaves less feed energy for production when feed is in short supply (Richardson and Hahn, 1994; Vercoe, 1999).

As will be discussed in the next chapter, the other important problem of crossbreeding is the difficulty of maintaining the desired blood level in the crossbreds. The term ‘crossbreed’ is too often taken to mean the first generation cross (F1). On account of their hybrid vigour and the advantage that their parents are usually genetically selected, F1 crossbred animals under higher level of care are generally considered to be more productive than indigenous ones in terms of milk and meat output (Cunnigham and Syrstad, 1987). In the case of the present study flocks, however, the F1 goats constituted only about 43% of the assortment of crossbred goats after at least 5 years of reproduction. This is not only because of the production of second and third generation crossbreds but also because of the gradual backcrossing of crossbred does with indigenous bucks for lack of F1 breeding males in the villages.

Regardless of whether the improved management increases the contribution of indigenous or crossbred goats to the welfare of the farmers, the success of the whole DGDP technology package ultimately depends on how much the introduced technologies are sustained after cessation of support from the DGDP.

6. CONTINUITY OF INTRODUCED TECHNOLOGIES

6.1 Institutional support

The introduced technologies depended on minimum support from local institutions to ensure supply of necessary external inputs, specifically in the delivery of improved stock, forage planting material, veterinary drugs and equipment, credit and supervision. All the relevant institutional services provided to study households were followed through during the study period. Some descriptive results are discussed to relate with results of the breed comparisons.

Virtually very little serious attempt was made during the study period by the extension services at the district and zone level to deliver the necessary external inputs: no improved stock (crossbreds or Anglo-Nubians) was distributed; only some seedlings were distributed to farmers in Kombolcha, and no support was provided in Gursum; basic animal health care is entirely left to function on its own in both districts; they are not considered as part of the network of veterinary services; no farmer training of any kind was undertaken in both districts; only two quick field appraisals (one by district office in Gursum, and another on women group affaires by extension staff of zonal office) were done as far as follow up of any activity was concerned; no assistance was provided for continued use of the revolving credit funds (for goats and veterinary drugs) in women groups, both in the collection of repayments and disbursing new credit to members; the groups have not operated them either. This is a rather huge gap from the expectations.

This decline can be explained by two current problems: the mismatch of the organizational structure of the extension services and logistical limitations. The DGDP had always been operating through an assigned dairy goat officer who was responsible for the follow-up and liaison of the DGDP activities with the regular extension services at both district and zone levels. While this position facilitated implementation of the various programmes, it was a disadvantage in relieving some of the extension staff of their responsibilities within their mandate, as the officer was executing them. This led to the current opinion of different sections of the extension services that, although they were involved in every step of the work, they were not in full control of those activities.

Despite the provision in the agreement during handing over of the activities, it was observed during the study period that no operating budget was allocated specifically for dairy goat extension at either zone or district levels (which was said to be an oversight). As a result, the supervision necessary to sustain the package had not been accomplished.

The **Alemaya University of Agriculture** continued to operate the crossbreeding station with more focus on conducting on-station research, rather than crossbred goat production. During the study period the station could supply only 14 crossbreds, although there were about 25 breeding and extra F1 males ready for distribution. This is very low compared to the average annual supply by the station during the DGDP of about 45 F1 crossbreds and 4 pure Anglo-Nubian goats (Appendix 4; Table 4.2). The idea of distributing crossbred males *in lieu* of the Anglo-Nubian bucks that AUA should have supplied (and already received payments for) was not followed through, which could have sufficiently solved the shortage of crossbred bucks. The crossbreeding station did not have any working link with the villages, to the extent that the crossbred animals ready for distribution could not be delivered to the farmers. At a later stage during the study period the University initiated another donor-funded study around the same sites with the idea of linking up with the previous work.

Formal credit for women groups was neither requested nor delivered during the study period. Only three of the women groups in Gursum (at Lafto, Gende Abdi and Gende Yaya) have bank accounts. No transaction on these accounts was reported during the study period, which led to the commercial bank decision to freeze the accounts. The women felt that they always needed the assistance of extension staff to operate the accounts. The transaction costs of operating the group bank accounts in town on their own appeared too high. The formal credit service from the government-owned bank, though accessible in principle, remained out of reach for the subsistence farmers. The bank was not observed seeking creditors in the villages, because the common practice has been for the creditor to go to the bank for the service.

During the study period, all the **commercial dairy goat producers** have practically ceased to produce crossbred goats (Appendix 4; Table 4.3). All of them had entered contracts for production of crossbreds with the DGDP. They got gradually disillusioned with slow progress, lack of a reliable market and recurrent health problems. The farm in Dire Dawa was dissatisfied by the broken contracts with the Eastern Hararghe Zone Department of Agriculture, which could not collect the 16 crossbreds in the agreed timeframe, and thus decided to stop the crossbreeding work; the farm in Gursum lost all the Anglo-Nubian stock and the opportunities for procuring replacements were very remote; the farm in Kombolcha sold off all the remaining Anglo-Nubian stock. Although interest on dairy goats appears to be growing around urban centres (Harar, Dire Dawa, Alemaya, Gursum), it could not generate enough market to keep these private farms in business. The farmers had no direct working relationship with private farms.

In conclusion, the minimum institutional support necessary to sustain the introduced technologies had not been delivered, particularly in the supply of improved stock and forage planting material, in farmer training and in supervision of dairy goat activities in the villages.

6.2 Maintaining crossbred goats

Participants of the DGDP continued maintaining crossbred goats. The 121 participant households had 171 crossbred goats at the beginning of the study period, and this declined to 158 at the end of the study, a drop of 7.6%. The decline was common to the whole goat population in all study groups (Table 37). Crossbred owners tried to maintain crossbreds by reducing voluntary disposals. Only 4.4% of the crossbreds were slaughtered compared to 9.5% for indigenous goats. Similarly the sales rates were 41% less in crossbred than for indigenous goats. The overall loss (mortality and predator attack) rate was 10.2% for crossbreds compared to 12.1% for indigenous goats. The reduced sales and slaughter frequencies of crossbred goats could be explained by farmers' interest to maintain them longer.

Table 37. Breed composition of the study flocks at the start and end of the study period

Breed group	DGDP participants			Control households		
	Initial stock	End stock	% change	Initial stock	End stock	% change
Crossbreds	171	158	-7.6	-	-	-
Indigenous	215	169	-21.7	98	71	-27.5
Total	387	327	-15.5	98	71	-27.5

Crossbred goats, and in general female goats, stayed significantly longer periods in study flocks. However, the average stay of goats of participants was not any different than those of non-participants. Considering only goats present at the beginning of the study, any goat had a probability of leaving its flock of 30.4%. Only 56% the crossbred and 40% of the indigenous goats stayed in their flocks during the whole observation period. As stated earlier (Table 15), 60 to 74% of the off-take was involuntary, i.e. necessitated by the short-term objective of meeting subsistence needs. This rapid turn over of goats limits the scope of any possible genetic selection in the smallholder flocks.

The aim of maintaining 50%, and a maximum safe level of 62.5%, exotic blood level in the crossbreds was not attained in the study flocks. The proportion of 50% crosses declined from 72% at the start of the study period to 61% at the end. On the other hand, the proportion of backcrossed goats has nearly tripled from 3.6 to 10.1% (Appendix 4; Table 4.1). The extent to which the desired exotic blood level was maintained in crossbred needs to be viewed in the context of the general pattern during the implementation period (Figure 7). Some farmers opted to go up to 75% already in 1994, using the Anglo-Nubian buck stations in the villages. At the end of the study there were 10 goats with 75% exotic blood level. On the other hand, a large number quarter-breds were produced from the F1 bucks, although the DGDP did not actively promote this class of crossbreds. The proportion of these quarter-breds reached an annual average of 17% in 1996, and declined thereafter with the shortage of F1 bucks.

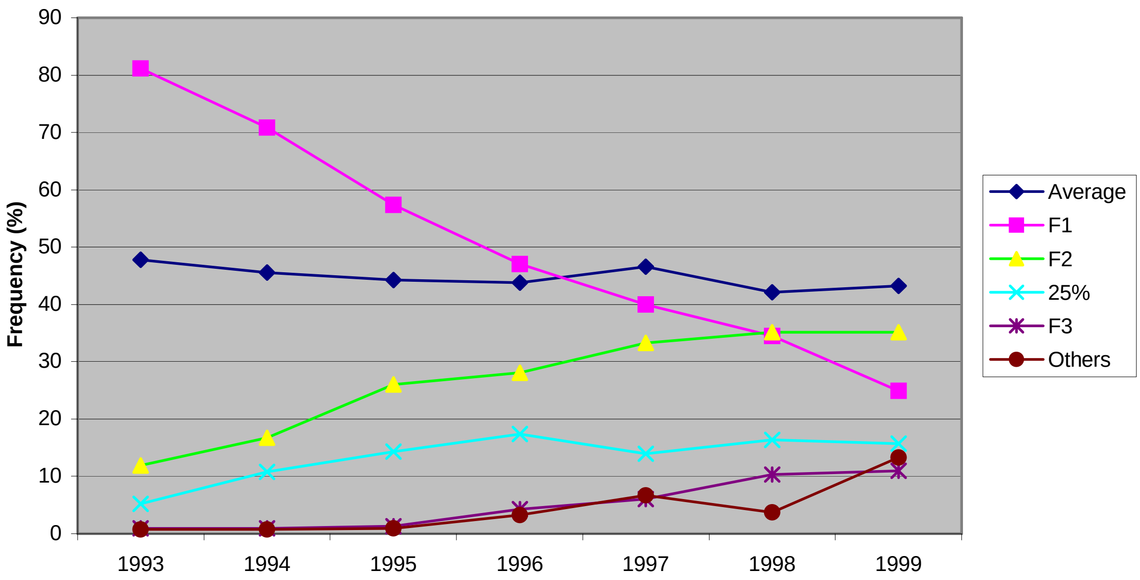


Figure 7: Changes in exotic blood level of crossbred goats between 1993 and 1999

The increase in the proportion of backcrosses and quarterbreds is related to the declining number of F1 breeding bucks. The larger F1 breeding bucks were difficult to maintain in smallholder flocks. The main reason appeared to have been the attractive high prices that castrated and fattened crossbreds fetch during religious festivities. The crossbred goats were observed to reach maximum body weights of 72 kg compared to 41 kg for indigenous bucks. Finished F1 bucks were observed to sell at Birr 600, compared to Birr 250 for the indigenous fattened castrate of the same age in the same market. The smallholder households were therefore always tempted to castrate the F1 bucks. The interest was so strong that extra males were castrated at body weights of 8 kg for the F1 and 6 kg for the indigenous goats. In recognition of this very practical problem, the DGDP established a consensus with the F1 buck owners that the adult F1 bucks received from the project should serve at least 2 years before they get castrated, which was very difficult to enforce consistently. As a result shortage of F1 breeding males was felt already in 1996 when the proportion of F1 bucks in the crossbred goat populations decreased to 8.7%, compared to 28% in 1993 (Table 38).

This shortage of crossbred breeding males also persisted during the current study period, and the proportion of F1 bucks in the crossbred population dropped from 5.1% at the beginning of the study to 0.6% at the end of the study. There were 10 F1 breeding males at the beginning of the study. Four of these were subsequently castrated for fattening. During the study period, two died, three castrates were slaughtered, four were sold and only one active breeding buck remained.

The calculated sex ratio dropped from about 2 does to one buck in 1993 to 4.2 in 1997, with a dramatic drop to 75 does to one buck in 1999. Crossbred breeding females have therefore been gradually backcrossed to indigenous bucks; hence the proportion of backcross goats grew from 3.0% to 10.7% during the study period alone (Table 38). This happened despite the availability of 25 F1 bucks at the crossbreeding station of the University and 7 F1 bucks in the private farm in Gursum, because a working direct link between the farmers and the producers was not in place, and the extension services failed to liaison in between.

Table 38: Comparison of the proportion of F1 breeding males in crossbred goat populations during and after the DGDP around the study sites

	during the DGDP					after DGDP	
Indicators	1993	1994	1995	1996	1997	1998	1999
Number of F1 breeding males	62	47	34	21	20	10	1
Total crossbred goat population	219	229	252	240	177	196	158
Proportion of F1 bucks among crosses (%)	28.3	20.5	13.5	8.7	11.3	5.1	0.6
Total breeding crossbred does	125	113	105	96	84	127	75
Average sex ratio (Does to 1 buck)	2.02	2.40	3.09	4.57	4.20	12.70	75.00
Proportion of backcrosses (%)	0	0.4	1.6	2.5	3.9	3.0	10.7

- Ratios were calculated from flock structures for June of each year, except for 1997 (March).
- Breeding males are taken to be all non-castrated males above 1 year of age.
- Breeding females are taken to mean all females above 1 year of age.
- Backcrosses are all crossbreds born with exotic blood levels less than their dams.

Source: W. Ayalew *et al* (Unpublished observation).

The crossbreeding exercise in the villages therefore produced a mosaic of crosses with Anglo-Nubian blood levels ranging from 6.25 to 75% with no signs of stabilizing around 50% blood level (Appendix 4; Table 4.3). The overall average exotic blood level in the crossbred population showed a slight decline from about 48% in 1993 to 43% in 1999 (Figure 7). More importantly, the proportion of F1 stock declined from 80% in 1993 to about 22% at the end of this study.

Apart from the farmers' behavior in the maintenance of F1 breeding males, the reason for these declining trends lies in the weak supply of improved stock (F1 goats and Anglo-Nubian bucks). During the study period only 14 crossbreds were distributed (May 1998) in one batch to farmers in Kombolcha. This particular distribution was as per the financial arrangement already put in place during the implementation period of the DGDP. Attempt was not made by the extension services to use the revolving credit fund with the women groups for the procurement of crossbreds even after the shortage of F1 bucks was reported.

The different sources of improved stock were also declining during the study period. Only one Anglo-Nubian buck station continued to operate in the study area. The buck station has been maintained with one member of the women group for over 3 years, despite the earlier agreement in the women group that the buck would rotate to selected members. The buck appears to have been left entirely to the buck handler. Members did not pay cash for the buck service as it was agreed at the end of the DGDP, but only some feed. No technical or administrative support was provided to this buck station during the study period. No buck station was set up during the study period; nor were replacements brought in for those which died. The main reason was the shortage of bucks in all sources.

Other potential sources of crossbred goats were the farmers themselves: this can be in the form of ordinary sales, and in re-distribution of credit repayment made in kind. This source of crossbred goats was not strong either even during the implementation period of the DGDP. By the end of the DGDP only of 21 crossbreds were collected in repayment of crossbred credit and soon redistributed to other members. This constituted only 5.7% of the total crossbred goats distributed by the project. The total redistribution could reach only 19% of the target set by the project (FARM-Africa, 1997b). During the study period no crossbred goat was repaid or redistributed, although in the observed groups 83 crossbreds remain unpaid, and some women were prepared to repay in kind from their current stock of crossbred goats.

In conclusion, there is no adequate supply of crossbred goats to sustain the production and reproduction of crossbred goats in the villages. The crossbreeding station in the University remains as the only source of Anglo-Nubian and crossbred stock. However, this station cannot produce pure Anglo-Nubians any more than it needs for replacements. The production of crossbred goats is not linked up with the market in the villages.

6.3 Improved feeding practice

Improved feeding includes three practices: 1) tethered and supplementary feeding; 2) introduction of forage legumes and grasses, and 3) use of suitable feeding structures. Participants were observed to consistently practice less frequent free grazing (and conversely more tethered feeding) throughout the year (Figure 8). Tethered management of goats was promoted by the DGDP for two main reasons: (1) to facilitate supplementary feeding, and (2) to reduce the risk of contracting disease during free grazing on communal pastures or wasteland.

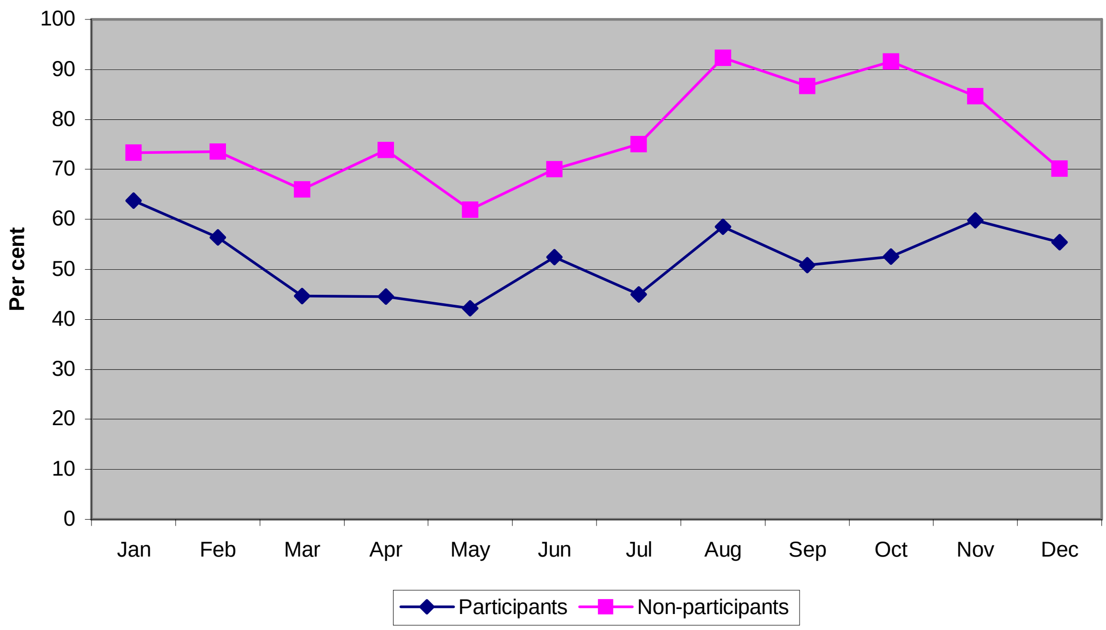


Figure 8: Frequency of free grazing of sample goat flocks in DGDP participant and non-participant households

During the study period, a long list of supplementary feeds were supplied by both the DGDP participant and non-participant households (Figure 9). The differences between the two groups lie not in the type of feeds supplied, but in the frequency of occurrence of the feeds in the supplement. The most frequently supplied supplements in both groups were kitchen waste, succulent grass, *Geraba* (or left over of *Chat*), sweet potato vines (with residual tiny tubers), crop thinnings (mainly maize) and table salt. The major differences between the DGDP participant and non-participant households were:

- participants practice less free grazing (more tethered feeding) (Figure 8), and provided more of the various supplementary feeds (Figure 9);
- participants have supplied more fodder from the available improved forage;
- *Geraba* is the most frequently supplied supplement for non-participants ;
- feeding hay and harvested succulent grass appeared more frequently in DGDP participant households;
- during the peak dry season, participants have more frequently provided unconventional feeds, such as barks, leaves of big trees (e.g. *Erythrine spp*, *Acacia spp*) and grass runners usually not fed to goats during other parts of the year.

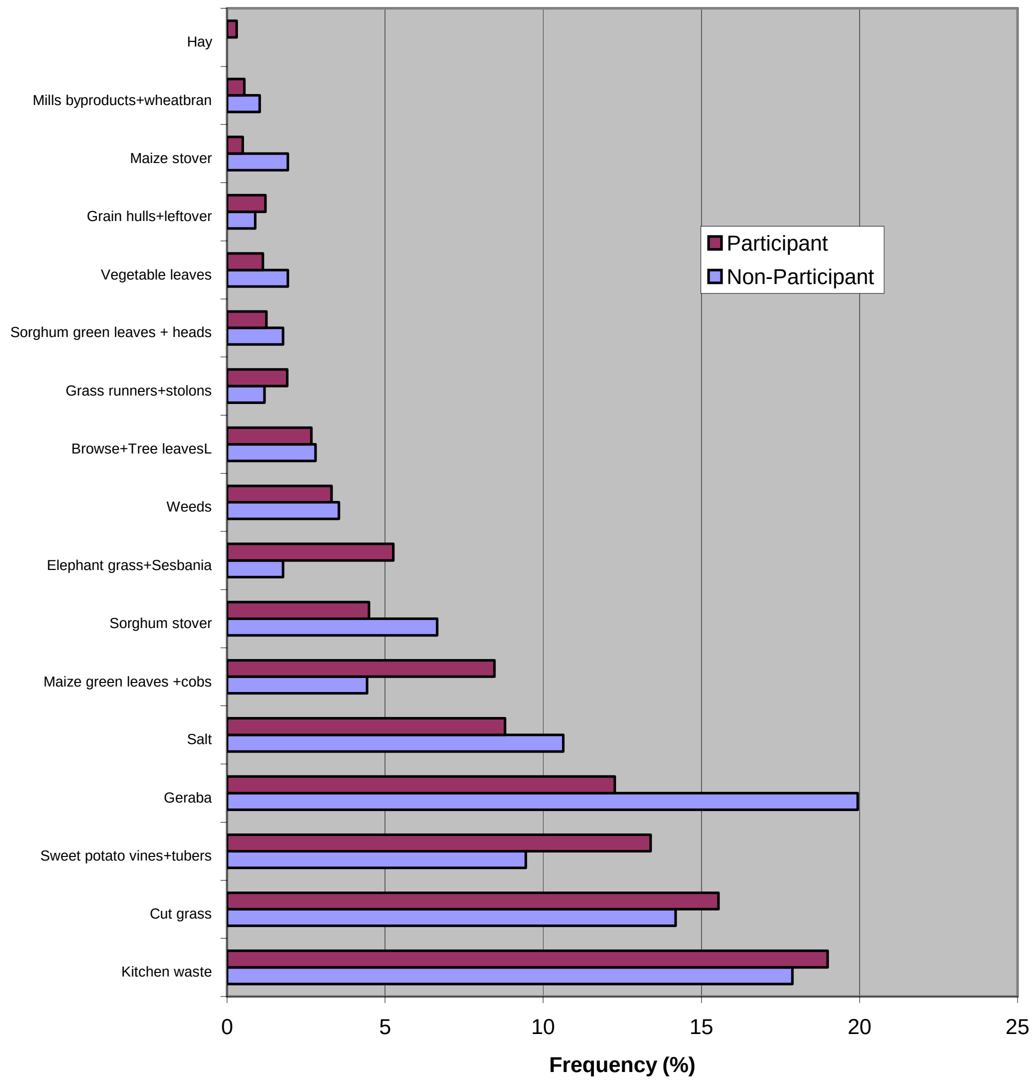


Figure 9: Frequency distribution of supplementary feeds to goat flocks in DGDP participant and non-participant households

Improved forages appeared in only 5% of the reported cases of supplementation among participant households. Thus it was not a relatively important source of feed in terms of its total share in supplementary feeds. Only Elephant grass (*Pennisetum purpureum*) and legume trees (*Sesbania sesban* and *Leucaena leucocephala*) were available. But these species have also been observed among the control households.

Out of the total household labour input in goat husbandry, about 48% went into feeding and 15% into grazing. This input was higher during the wet than during the dry season as a larger part of the fodder was cut and carried home. Women members of the family generally had less labour input into feeding or grazing than the rest of the family, but their share of the input increased during the dry season when they were also involved in collecting feed (Ayalew *et al*., 2000). Out of the total time spent on feeding, the labour input on improved forage development (land preparation, cultivation, etc.) accounted for only 7.4% among the DGDP participant households and 1.5% among the control households (Figure 11). Therefore, the activities on improved forage development of the type promoted by the DGDP had been very small in terms of labour time.

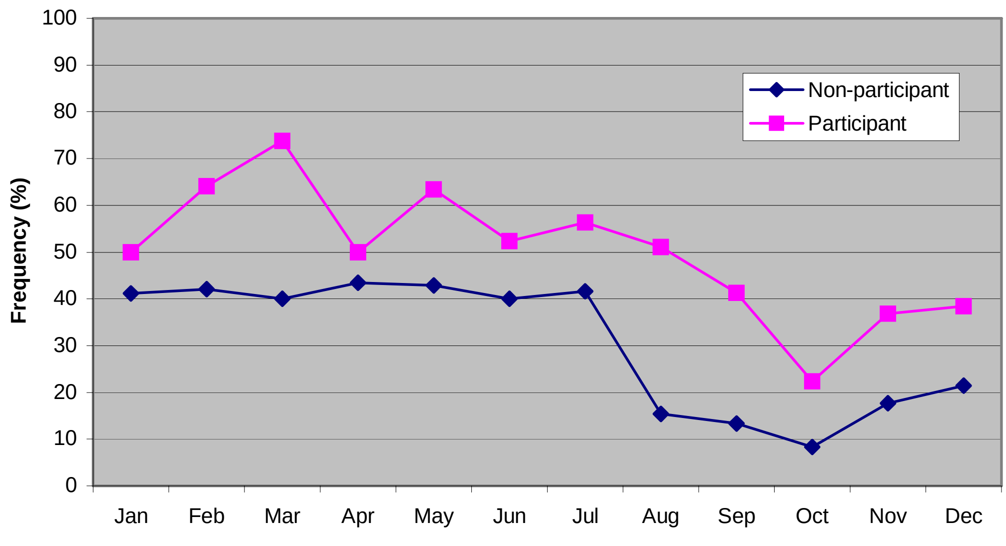


Figure 10: Frequency distribution of use of sweet potato vines and tubers

None of the **feeding structures** promoted by the DGDP (wooded feeding racks, fodder nets, suspending tied bundles of fodder) were observed during the study period.

The occurrence of both the surviving tree legume (*Sesbania sesban*) and Elephant grass (*Pennisetum perpureum*) among the control households is not surprising. The same species had been promoted by a previous project. Farmers identified a few attractive features of these species. Once they are successfully established and protected from damage by animals at early stages, they continue to produce fodder and planting material with little additional labour input. Secondly, planting materials can easily be secured: Elephant grass propagates without seeds, by cuttings, and seeds of *Sesbania spp* can easily be produced from a protected tree, and one tree produces the needs of many farmers. Third, they can be successfully established on ridges, waste land, and even as live fences, without competing for arable land. These are in fact the important issues considered before decision is made to promote improved forages (Bayer and Waters-Bayer, 1998).

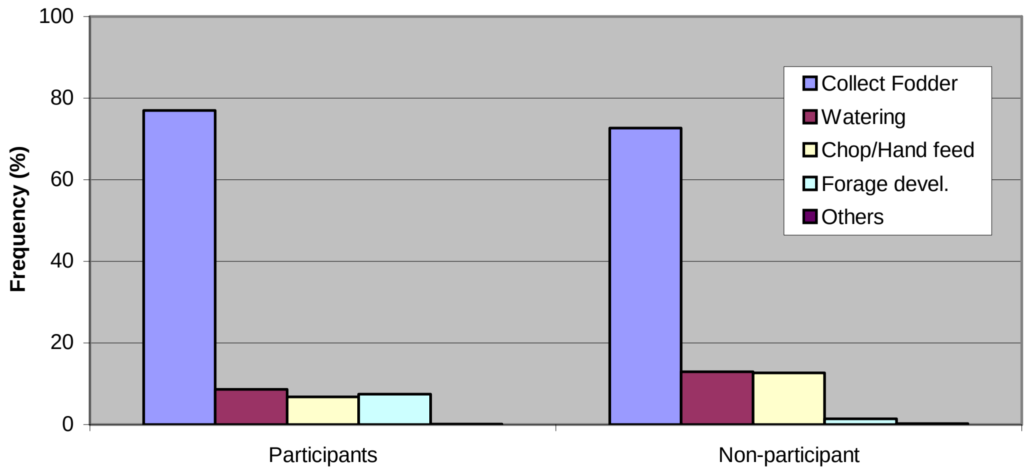


Figure 11: Partition of labour input on feeding of goat flocks in DGDP participant and non-participant households

6.4 Basic goat health care

This component of the DGDP technology package included use of the Community-based Animal health Services (CAHS) and provision of clean barns. The CAHS comprised the training and deployment of community animal health workers (paravets), and the setting up of private veterinary drug shops near the paravets. This study covered the activities of 15 paravets operating in the study area (11 in Gursum, 4 in Kombolcha) and the only private veterinary drug shop in Gursum.

Only nine of them in Gursum have been active during the year, and those in Kombolcha did provide very little service (Table 39). The type of paravet services provided included acaricide application, castration, wound dressing and some anthelmintic sales. Eight of them in Gursum have procured some drugs for paravet services from the private drug shop and well as the government veterinary clinics. Particularly anthelmintics and acaricides were highly demanded in the villages, but the paravets had very little stock of these. Because all of them owe some drug credit to be paid back to group revolving funds, further disbursement of drugs was not possible. The consensus established during the DGDP that the drug repayments should go to group accounts of revolving funds and used for further drug procurement had not been equally upheld by all involved (paravets, district clinics, veterinarians, other extension staff). No repayments were collected during the year. On the whole the government veterinary services expect the paravets to function largely on their own, without supervision or any technical support. No training or refresher training was conducted or planned during the study period, although almost all the veterinary staff had participated in one or another form of training on the concept and operation of CAHS. No supervision of paravet activity was observed during the study period. In short the paravets were not embraced as part of the veterinary services.

Table 39: Paravet activity in Gursum and Kombolcha between July 1998 and July 1999

Descriptors	Kombolcha	Gursum	Total
Number of paravets deployed	6	22	28
Number of paravets monitored in this study	4	11	15
Paravets active during most of the year	0	9	9
Value of purchased drugs during the study period (Birr)	0	2040	2040
Value of drug credit the paravet owe to group funds	1194	2384	3578

From the recorded expenses on sample goat flocks, direct veterinary costs accounted for only 11% with the rest being on purchased feeds. And from within the veterinary expenses, 58% were provided by the district veterinary clinics, paravets provided 35% of the value of the expenses, and informal drug dealers provided the rest. A major difference between the services was that most of paravets and kiosks have provided the services on credit whereas that of the clinics was always on cash.

The owner of the only private veterinary drug shop indicated that the drug shop had been economically viable, and that a growing number of paravets and farmers were using it. Most of the drug sales were on acaricides and anthelmenthics. However, the sales of acaricides and anthelminthics to the paravet services accounted for only 6 and 20%, respectively, of the total sales during the study period. He also provided timely vaccination services free of charge, and clinical treatments on site in an effort to establish contact with the villagers. He also provided some services on credit, unlike the government clinic. This drug shop had to operate under competition with subsidized drug prices of government clinics.

Overall the paravet services have been losing ground despite the firm belief that they are useful to extend veterinary services down to the village level. The services are available to DGDP participant and non-participant households alike, but the difference is that participants could get the services on credit under the auspices of the women groups. Viewed from the farmer's perspective, access to basic services on credit right in their villages means that the services reach the farmers irrespective their cash flows and their proximity to veterinary clinics. The villagers appeared to be more comfortable dealing with the paravets and kiosks than with clinics, as the transaction costs were less.

The rationale behind the concept of CAHS is that, while a wide range of diseases may potentially affect livestock, the overwhelming majority of morbidity and mortality in a given locality is caused by a finite set of common and predictably occurring disease problems that are conditioned by local geography, climate and animal management systems. Therefore, by selection and placement of community-based paraprofessionals who are trained to recognize and equipped to treat or prevent a selected and specific group of diseases and conditions previously determined to commonly affect livestock, it is possible to reduce morbidity and mortality, thereby increase the productivity of local livestock (Sherman, 2000). Furthermore, making available veterinary drugs at community level by supporting the establishment of private veterinary drugs stores alleviates the problems of adequacy and reliability of supply.

Cleanliness of the barns, as part of the improved management, was evaluated three times during the study period. A subjective score of poor (1), medium (2) or good (3) was given by the enumerators, after examining how frequently and thoroughly the barns were cleaned, and the degree of wetness of the floor. These quarterly scores were added up to arrive at aggregate relative scores that ranged from 3 to 9. Comparison of these scores between the DGDP participant and control households showed that participants had a slightly higher score, but the differences were not statistically significant. However, crossbred owners had very significantly higher scores (7.3 versus 6.7; p=0.006). In the same manner, the level of care provided to sick goats was similarly scored (poor = 1; medium = 2; good = 3). Again crossbred owner households had significantly higher scores (p=0.005). However, the mean score of participants did not differ from that of control household. The practice of providing cleaner barns and caring for sick goats appeared to have persisted after the DGDP.

In conclusion, the level of health care is slightly better for DGDP participants, and especially crossbred owner households. But the component of delivering the support for the paravets services had been weak.

6.5 Revolving credit and self-help women groups

The DGDP women groups were organized to serve the immediate objective of facilitating DGDP implementation, and were envisaged to function as a focus of extension services directed to women, including family planning and public health. They had been facilitating the administration of revolving credit funds for goats and veterinary drugs. Nine of the thirteen women groups operating in the two districts were followed through in this study.

All the DGDP participant households included in this study were member in one of the groups. At the end of the study period, the nine groups had a total membership of 211 women with official estimated capital of Birr 21,000 (Table 40). Three quarters of this capital was in outstanding credit given out to members in the form of crossbred goats (55.3%), local goats (42.7%) as well as petty cash credit (1.8%). About 63% of the local goats and 72% of the crossbred goats remain unpaid. The large amount of outstanding drug credit (Birr 3,578) was not accounted for as part of their capital.

Table 40: Status of the Dairy Goat women groups by districts in June 1999

Descriptors	Gursum	Kombolcha	Total
Current membership	132	78	211
Total capital (estimated) (Birr)	14129	6777	20902
Cash at hand	489	1445	1934
Cash in bank	2649	-	2649
Outstanding petty credit	300	-	300
Outstanding goat credit (Birr)	10691	6773	16019
Indigenous goats given on credit	108	15	123
Indigenous goats repaid (from credit)	39	7	46
Crossbred goats given on credit	61	54	115
Crossbred goats repaid (from credit)	19	13	32

Because of lack of support from the extension services, members appeared discouraged to meet, repay outstanding credits or pay the monthly contributions. On the other hand, the district extension staff said that the current policy on farmers' cooperatives lacks a clear guideline on how to organize and assist self-help groups. As a result the women groups had not been integrated into the regular extension programmes. These declining trends were well recognized both at the district and zone levels. However, no particular measures were taken to revitalize group activity. The groups had lost momentum, and they appeared to be unable to continue operating without external support, as had been provided during the DGDP. In fact, the question of how the groups should function after the DGDP was not sufficiently dealt with during the DGDP. Should the credit revolve for ever, or when should it stop? Who finally claims the fund? At one point during the DGDP, some groups tried to look forward to a wider scope of economic activity such as setting up grain mills, but that was not sustained (Ayalew, 1996).

There are parallel networks of indigenous institutions that provide community level credit, marketing and insurance services (Tables 12 and 13). They do not require external support. The DGDP women groups, organized based on common short-term interest for a selected subset of the community, were not affiliated to these institutions.

In conclusion, the level of acceptance by the farmers of the introduced technologies was mixed. The farmers have continued to practice some of the technologies. However, because of the declining institutional support they need in the delivery of essential external inputs, the application of these technologies will continue to gradually decline.

6.6 Farmers` perception of the improved goat management

Opinion of farmers on the introduced technologies was assessed at the end of the study. Each of the households, including the controls, was asked to express its overall opinion about the usefulness of selected components of the DGDP. Nearly 90% of the responses were clear enough and were summarized into four classes: no comment, not useful, useful and very useful. The results are presented in Appendix 4, Table 4.4.

Virtually all the study households were well aware of the **improved forage development** strategies tried in the villages. Nearly all of the participants and non-participants valued this component of the DGDP as useful. Feeding racks were given very low score. The reasoning was that in the first place there was not much feed to worry about; secondly no feed was virtually considered as lost.

Opinion on **women groups** varied between participant and non-participant households. Some appear to have lost the benefit of being a member of the groups. One quarter of the non-participant households and 8% of the participants said that the women groups were either not useful, or they could not see their use. Only 21% of the participants believed that the women groups were very useful for promotion of the DGDP technology package.

Both participant and non-participant households valued the **local and crossbred goat credit** scheme either as useful or very useful. They wished to continue receiving goats on credit; but the genuine desire for assistance is obscured by large sum of outstanding credit within the groups. The credit repayment rate has been very high in the early stages of the DGDP. Although some members expressed willingness to repay debt, they always expected the extension staff to come and collect the repayments. The groups have not been able to operate on their own to continue to revolve the group funds in the form of goat or petty cash credit.

Participant and non-participant households alike evaluated the **CAHS** as very useful, mainly because the services could be provided on credit and they were more accessible in the villages than government clinics or the informal traders.

Only 60% of both the participant and non-participant study households indicated that the **Anglo-Nubian buck stations** were useful. About 90% of participant households who currently own no crossbreds and 65% of mixed flock owners expressed high opinions about the buck stations, compared to only 19% of the households who keep only crossbred goats.

In summary, the farmers had high opinion of the goat credit and the basic animal health services. Opinions on improved forage development were mixed. Farmer training, women groups and buck stations were accorded as less useful. It was laid down in the conceptual framework of the DGDP that in order to attain the higher level of flock productivity by way of improved management and crossbreeding, the various components of the technology package had to be promoted together. This approach was vigorously pursued during implementation of the DGDP. However, it was observed that each of the components of the package was influenced by different sets of attributes within as well as outside the household, leading to mixed courses of development.

A similar varying trend of adoption was reported in a study of adoption pathways of an innovative land preparation implement (broadbed maker) to smallholder farmers in Ethiopian highlands, which indicated that technology adoption was not a matter of one-time decision leading to continuous use of the technology. The smallholder farmers appeared to be engaged in a multi-stage decision process. They start by learning to adopt the technology, and subsequently decide for continuous or discontinuous use of it (Jabbar *et al.*, 1998). In the present study a number of improved technologies were involved: improved forage development and feeding practice, better health care, selective breeding, crossbreeding and social development. Each of these technologies required minimum institutional support for the farmers to continue to use them, which were not delivered. However, farmers continued to practice some components of the package in supplementary feeding and basic health care.

Following the concept of net benefits applied in this study to evaluate the crossbreeding technology, it is curious to see that those components of the package that persisted after the DGDP are all low-input and generate immediate benefits. Supplementary feeding and basic health care help the farmers generate higher benefits from the indigenous goats. This also explains why some of the control households were also observed practicing them. It is therefore logical to relate that if crossbreeding cannot generate net benefits to the farmers, it is unlikely to continue as an attractive proposition to the smallholder farmers. Lessons learnt from a similar project of technology transfer to smallholder farmers in Zimbabwe also suggest that for a new technology to succeed the farmers should be able to make a profitable use in very quickly (Fischer *et al.*, 1994).

7. GENERAL DISCUSSION

The study shows that, under improved management and with the limited land, labour and capital (goats) available, it is worthwhile for the smallholder mixed farmers to raise crossbred (Somali x Anglo-Nubian) goats but not any more worthwhile than raising indigenous goats (Somali, Hararghe-Highland). The general assumption behind promoting crossbreeding programmes for improvement of traditional livestock production that crossbreds can generate more benefits than would be possible with indigenous goats alone is inaccurate. The concept that genetic improvement of traditional indigenous livestock through selective breeding is extremely slow and that faster gains could be made through crossing with selected improver exotic breeds (Pagot, 1992) needs to be revisited. Although farmers generate markedly higher unit benefits from keeping mixed (crossbred and indigenous) flocks under improved management than from indigenous flocks under traditional management, the higher gains from mixed flocks come mainly from the indigenous goats that strongly respond to improved management. In fact, in Kombolcha where farmers have a relatively lower wealth status than those in Gursum, and where land and hence feed is scarcer, the indigenous goats produced more aggregate benefits per unit of cultivated land than the assortment of crossbred goats. If one also considers the additional (subsidised) costs of procuring and maintaining the exotic animals that are necessary to produce the crossbreds, the indigenous goats come out with a clear overall superiority.

The indigenous goats maintained under the improved management generated up to 80% more aggregate benefits over those under traditional management. They produced more net benefits per unit of land and labour used, but not so on metabolic body weight of the average flock. The latter is true, because the additional benefits were generated by keeping a larger biomass of goats, and not through higher output per unit biomass. These came in the form of reduced goat losses (mortality and weight losses), more kids born, higher off-take and bigger average stock of goats. The additional benefits were produced by a larger biomass. Net meat production accounted for nearly two-thirds of the values added of the flocks, and the improved management increased this part of the total production by more than twice, thus it accounted for most of the improvements in aggregate productivity. This additional output in meat did not affect the slaughter rates, but the sales have increased and farmers maintained larger stock of goats than those under traditional management.

These improvements in overall performance are expected because the common health problems due to internal helminth parasites, external parasites (mange mites, ticks) and respiratory problems are known to be major causes of morbidity and mortality in the area (Bekele, 1993), and basic health care can reduce losses associated with these problems. Furthermore, goats were reported to respond to supplementary feeding (Abebe, 1996; Berhanu, 1997), and the better feeding practice under the improved management at least reduces the body weight losses and improves reproductive performance (Abebe, 1996).

Both the intra-household and inter-household comparisons of the crossbred and indigenous goats showed that at the flock level the mix of crossbred goats did not produce any better than the indigenous goats for all three factors of production. It might be argued that, even if the breed groups produce equal levels of benefits for the resources used, the significantly larger body size of the crossbred goats (Tables 3 and 42) means that the farmers can generate, in absolute terms, more benefits from the crossbreds. But this argument assumes that feed supply is not a limiting constraint. The significant body weight losses (Table 23) came due to the seasonal scarcity of feeds. This study does not provide quantitative data on the adequacy rates of nutrients available from the various roughage feed resources supplied to goats; however, from the diversity of feed resources used (Figure 10), particularly low-digestibility crop residues during the dry season, it can be inferred that feed remains a major limiting input. Under such circumstances, the smaller and more adapted indigenous goats are expected to sustain themselves better than the crossbreds. In a similar comparison of indigenous tropical cows and cows with higher genetic potential for milk production, Mbuza (1991) reported that the consequences of feed inadequacy for animals of lower genetic potential may be a reduction or cessation of the already low level of milk production, and even some live-weight loss, but fertility and health will be maintained. For cows of higher genetic potential, with similar proportional reduction in feed the milk production will fall; the animal will also suffer substantial weight loss and loss of fertility, which reflect negatively on the longer-term overall production of the animal.

Better adaptive attributes of the indigenous goats also translate into better overall production under low-input agriculture. Vercoe (1999) has discussed the importance of adaptation and its relationship with production. Indigenous breeds of the tropics are generally heat tolerant relative to the European breeds. This has been achieved partly through having a lower maintenance requirement and as a consequence their genetic potential for production (milk, meat) is much lower than that of European breeds. The evolution of these breeds has produced a package of attributes that have put a premium on survival; for example, they are resistant to most parasites and have a high capacity to survive when feed is in short supply. Their lower maintenance requirements due to lower metabolic rate also results in a lower voluntary feed intake for a given weight, relative to temperate breeds, leading to lower production when feed is plenty.

The smaller body size of the indigenous goats is also advantageous during feed scarcity. In a comparative study of pastoral production, where feed was very limiting, Richardson and Hahn (1994) related protein produced for human nutrition to the feed energy intake for a large and a small cattle breed. In the environment characterised by low biomass production and low feed quality the smaller breed proved more efficient than the larger breed. Dry matter intake of range forage decreases with decreasing forage quality, hence, feed intake might cover maintenance requirements and a surplus for lactation in smaller breeds, while in larger breeds it might not even meet maintenance requirements. Under more favourable forage conditions, larger breeds can cover their energy requirements and, as their maintenance energy requirement per unit of product is lower, are then more efficient than the smaller breeds.

One might then ask why did farmers in the study still keep the mix of crossbreds? Most of the animals were either acquired during the DGDP or are descendants of these. The higher prices that these larger crossbreds can fetch at seasonal markets and the expectations of larger volume of milk off-take can encourage farmers to keep the crossbreds longer than the average indigenous goat (Table 21). Despite the declining supply of crossbred stock into the villages, a large number of farmers do maintain crossbred goats. As the patterns of disposal of goats have shown (Table 37) farmers tend to reduce the voluntary disposal of crossbreds (slaughter, sales). But reduction of voluntary disposals is not necessarily a desirable outcome in terms of meeting short-term objectives of improved welfare. For the food insecure households, goats may serve the households better when sold and the revenue is used to procure staple grain during the lean season. In any case, because of the limited supply from outside the villages, the numbers of crossbred goats will continue to decline.

The results (Tables 28 and 31) also showed that more improvements were observed in net meat production (up to 2.3 times) than in milk (1.3 times). Milk contributed only about 10% of the total net benefits from the flocks. The strong contribution of meat to household welfare was recognized by the DGDP midway through its nine years of implementation. Based on the evidence presented here, it can be argued that the breeding objectives, or the improvement strategies as such, should be designed from the farmers' rather than the evaluators' perspective. The farmers' perspective enables one to appreciate the multiple production functions of the animals, and the actual product uses of the farmers so as to make a more realistic judgment in selecting the type of technologies to promote.

Mention should be made of the higher absolute volume of milk produced by the heavier crossbred does, which was the major reason behind promoting crossbreds. However, this superiority does not hold true if the comparison with the indigenous goats is made on the basis of the unit metabolic body weight of the lactating doe and the whole flock that should be maintained, which essentially reflects overall feed cost (Tables 24). This means that, even when the primary product is taken to be milk, under the circumstances of the subsistence producers, similar milk productivity levels per unit feed cost can be achieved in the longer term using the average milking doe by modest improvements in feeding and health care.

The recourse towards seeking livestock improvements in low-input tropical agriculture in broader context has been increasingly appreciated. Steinbach (1986) found out in a comparative study in Tunisia of indigenous and exotic goat breeds (Boer, Alpine, Saanen and Poitou) as well as their crosses that the indigenous Tunisian goats had a higher productivity than any of the imported breeds when feed conversion and resistance to disease were considered into the measurement of productivity. Furthermore, although those exotic goats that survived longer had higher milk yields than indigenous goats, the overall performance (including economic factors) was better in the indigenous Tunisian goats.

Along this line Peters (1991,1993) pointed out, in discussing the relative importance of adaptation, to overall production in dairy cattle, that broad-based fitness indicators including reproduction and body weight should be considered along with milk production as breeding objectives for livestock improvement in developing countries. Similarly, Valle-Zarate (1995) questioned the applicability of animal breeding methods developed in industrialized countries to harsh environments in the tropics and subtropics. She believes the main constraint on the success of breeding programmes in these conditions is improper definition of breeding goals, due to inadequate information on production conditions and the needs of farmers, and hence the need for better collaboration between breeders, economists and sociologists for effective application of long-term genetic improvement interventions.

In situations where the high-input technologies cannot be delivered in a sustainable manner, the subsistence producers are more secure and better assisted with the more adapted and more accessible indigenous goats. For the poorest of the households, a mere provision on credit of only local goats can make a significant contribution to their income.

Donor-assisted livestock projects from the 1970’s have evolved from one of merely delivering of high-producer exotic dairy and meat animals and promotion of capital-intensive large farms to tropical countries to one with greater emphasis on the diversity of local stock, and their multiple production functions (van Gennip, 1990). Crossbreeding has also been considered as a better option of transferring the high production technology into traditional livestock (Tropenzentrum, 1993). Failures of these projects have been attributed to poor infrastructure, weak markets and poor project management. As the results of the present study would suggest, some explanation should be sought in the conceptual planning of the projects whereby the low-input traditional production strategies are not accorded due recognition. Such livestock development projects, while ultimately aiming at the improvement of the living conditions of the rural population, often have a preoccupation with the technical aspects of livestock production (Beerling, 1990). The experiences with goat crossbreeding projects in east Africa also show that projects designed for high-input management are difficult to implement under resource-poor and subsistence farmers (Tropenzentrum, 1993).

There are also technical problems in the process of crossbreeding. Crossbreeding as a way of genetic improvement entails effective control of breeding. The small size of the crossbred population in the villages limited the scope for any genetic selection within the pool of crossbred goats. The long-term goal of the DGDP crossbreeding programme was to create a pool of crossbred animals to reproduce enough replacements so as to stabilize the exotic blood level in the crossbreds around 50 per cent level. However, the total number of F1 and F2 goats distributed and reproduced was so small that it was practically impossible to undertake any selective breeding of the crossbreds or the indigenous goats. If there is no selection and controlled mating, a basic tenet of any genetic improvement as such (Cunningham and Syrstad, 1987), then the very basis of doing crossbreeding work as a way of genetic improvement is missing. The flock dynamics patterns also suggest that the short-term objectives of the farmers override longer-term benefits (for themselves and the community), and hence farmers' decision making behaviour does not favour the keeping and selection of high performance breeding males just for the purpose of breeding.

But where should the focus be – on the farmer or the technology? In reference to sustainable livestock development, Reynolds and de Leeuw (1995) stressed that the debate should go beyond the concept of carrying capacity and focus on the net flow of nutrients taking the households as a unit of reference. This concept is also valid in the analysis of net benefits; the emphasis should be on the overall benefits gained rather than how well or badly animals are maintained in the households. Flavey (1999) also shares the same view and pointed out that this is actually a common problem of specific technology promotion projects in developing countries, because they focus too much on animals and investment (output), and much less on the farmer himself.

Even at the level of the animal, the rapid decline of F1 breeding bucks in the villages led to more frequent backcrossing of crossbred does with unselected indigenous bucks (Table 38). At the end of the study period, the exotic blood level in the crossbreds ranged from a low of 6.25% to a high of 75%, with an overall average of 43% (Figure 7). The resulting mosaic of crossbred goats left to mate more or less freely in the villages ended up being more of a threat to the existing indigenous genetic pool rather than a means for genetic improvement.

These operational difficulties of crossbreeding have also been common experiences in many dairy cattle crossbreeding programmes. In their extensive review of crossbreeding programmes of the *Bos indicus* with *Bos Taurus* in the tropics, Cunningham and Syrstad (1987) have concluded that the continuous production of F1 crosses is either operationally difficult to set up or economically difficult to justify even for the more important dairy cattle industry. Bondoc *et al*., (1989) also reviewed breeding strategies for genetic improvement of dairy cattle in developing countries. Although the evidence indicates that heterosis realised from crossbreeding is higher in poor than in good environments**,** the breeding programmes in developing countries are generally constrained by both physical and social environments. Lack of records of performance, ill-defined breeding objectives, and small population sizes are major inhibitors of genetic improvement in local cattle populations.

To develop a new gene pool, and gradually a new breed, through crossbreeding as tested by the DGDP, the emphasis should be on producing the breeding males through nominated matings and then selecting the best for extensive use (Cunnigham and Syrstad, 1987; Taneja, 1999). This requires measurement of individual performance, evaluation of animals, choice of breeding stock and organization of their use. But judging by the experiences of managing the crossbreeding station at Alemaya and its working link with the pilot villages, organizing such a systematic selection of breeding males and distributing them to the villages is difficult to manage either by the extension services or the academic institution. Neither have they tried it before, nor are they logistically ready for it yet. Although the preliminary forms of animal breeding in the form of culling of inferior animals and selective matings by the farmers are theoretically possible, systematic performance recording as part of a genetic improvement process still remains a major constraint.

Ironically, these technical constraints of operating long-term breeding programmes are the very reasons for the general recourse taken to the introduction of blood from breeds already selected in developed countries. Introduction of high producing exotic breeds has been carried out since the nineteenth century by importation of male breeding stock, and more recently by semen. Experience shows that an essential condition of the success of a crossbreeding programme is the presence of an integrated selection programme in the pure indigenous breed (Pagot, 1992).

Neopane (2000) also reported that crossbreeding of local breeds of goats with introduced breeds was not successful in increasing productivity in the hill goats of Nepal. After 14 years of trial with crossbreeding, decision was taken to set up selection within the local breeds in an open nucleus scheme as a more viable tool for making genetic improvement in the hill goats.

In a similar donor-funded development project in Morocco, to promote a commercial dairy goat industry based on imported European goat breeds, Chiche *et al*., (2000) reported that 20 years of promotion could not lead to transformation of the traditional mountain and steppe husbandry into intensive commercial dairy industry. The local breed proved a better option to survive and produce in the low-input management environment, satisfy the needs of the poor villagers and small local markets.

Given that on-station testing is still weak and the setting up of effective on-farm performance testing is currently unrealistic in Ethiopia, what can be done as far as improvement of livestock production goes?

It is possible to achieve significant improvements in realised benefits by providing the same level of improvements in the husbandry practices to the indigenous goats, without introducing exotic animals, which are seen as the incentive to increasing livestock production. Through measures directed at reducing mortality and morbidity, and through better use of the available feed resources, it is possible to bring about significant improvements in the contribution of goats to the household economy.

Even when the smallholder farmers move towards longer-term genetic improvement, the financial resources to support such a long-term programme are very limited at best. As in many developing countries, the public funds available for livestock development are relatively small; and even these may not be released in time, and when released they are not properly utilized (Meier, 1995). In such a situation, the public investment in promoting livestock development can be more effectively utilized if it supports basic health services, disease control, vaccination programmes as well as improvements in feeding practices. Government budgets leave little for on-farm research on animal performance. The resources that go to specific technology promotion for livestock development with the expressed objective of increasing the contribution of livestock to the livelihood of the subsistence producers need to be weighed against the total changes in the net benefits that accrue to the beneficiaries.

Findings of this study have implication to a wider context. As part of the integrated crop-livestock production system, livestock can have only a secondary and complementary role in the highlands, because in a system where cropping is possible, animals produce fewer nutrients per unit area th,an crops (Jahnke, 1982; Spedding, 1988). Consequently, any vigorous animal component in mixed systems based on fodder production can operate at the expense of crops, which would negatively affect the total system output in terms of food produced for humans. The large production increases that are necessary to sustain the high population pressure will have to come from advances in cropping. Integrated livestock development in the highlands then functions on the basis of optimisation of the contribution of livestock to the process of agricultural intensification based primarily on cropping. The role of animals in this system is to maximise use of the available resources (land, labour, feed resources), and add value to particularly crop residues (Schiere, 1995). The limited market and cash available to farmers make any capital-intensive technology less appropriate. As a result, alternative technologies that aim at rapid intensification of management for higher output per animal become too optimistic.

In smallholder subsistence livestock production, the animals are expected to contribute small but consistent output for a large part of the year. Indigenous animals adapted to the environment (seasonal feed scarcity, disease challenge, climatic stress) may produce less during lush season and store the extra energy in body fat to be able to continue producing during the dry season (Ørskov, 1993; Ørskov and Viglizzo, 1994). The scope for improvement of these animals should be based on a low-input strategy to reduce various losses of production. But this intervention should make the best out of the specific adaptation abilities of the indigenous animals, particularly the capacity to continue producing despite variations in body conditions and the low metabolic rates. This includes interventions to reduce the losses in body weight due to morbidity and mortality; improve use of available roughage feeds; reduce longer-term losses of production due to slow maturity and older age at puberty, and reduce part of the flock/herd that is maintained apparently as replacement (follower) and compete for the scarce feed resources with the producer animals (mostly breeding females). This leads to a more effective exploitation of the potential of indigenous animals.

In small mixed farms, production resources have to be used for maximum advantage to generate immediate farm income and meet subsistence needs, thereby providing economic stability to the household economy. This is particularly important when land becomes increasingly scarce. Livestock enable these households to increase income from the use of otherwise waste feed resources and feed from common property. Under such circumstances, livestock enable farmers to allocate plant nutrients across time and space in as much as they accelerate transformation of nutrients in crop by-products to fertilizer, speeding up the process of land recovery between crops (Ehui *et al*.,1998). Subsistence oriented small farmers in developing economies allocate resources rationally and respond effectively to profitable economic opportunities (Hayami, 1997). Even under the improved management as applied in this study, the external inputs purchased from outside the farm in the form of feed and medicaments were very small (Tables 28 and 31). This means that the improvements were not capital-based.

Improved productivity is imperative to farmers in traditional systems, but the question is what type of technology to promote these changes. Even without external support, subsistence farmers with declining land holdings tend to intensify farm activities and increase net benefits from goats (Table 26). This supports Schultz's (1964) hypothesis that subsistence-oriented farmers may be poor, but they are rational and efficient in resource allocation and are responsive to new profit opportunities arising from changes in technology and market demand.

If appropriate technology is defined as technology whose resource use is strongly related to resource availability within the system, and whose products are more suited to the major consumer (Meir, 1995), crossbreeding is inappropriate to the smallholders**.** According to Simmonds (1986), it is this misapprehension of realities of the poor farmers operating in uncertain environments which led to the emergence of farmer-focused farming systems studies. A good case in point is the observation by Hayami and Rutan (1985) who noted that even in nations with well developed agricultural experiment stations, a significant portion of total effort, until as late as the 1930's and 1940's, was devoted to the testing and refinement of farmers' innovations. They argue further that even in most advanced agricultural nations this activity is likely to have contributed more to the growth of agricultural productivity than the more scientific work carried on by the experiment stations until at least the middle of the last century. It is therefore reasonable to focus on the farmers' practices and strengthen the natural forces towards intensification of traditional agriculture.

Delgado *et al.* (1999) argue that, with proper policy adjustments, the poor livestock owners can join in the on-going unprecedented growth of world livestock production, which is driven by a fast growing demand. But it is unclear how this intensification can be financed; the markets are small and limited to the local villages and urban centres; these constraints are exacerbated by poor infrastructure and policy disincentives.

Small farmers invariably have a cash flow problem, for instance for the purchase of inputs during the lean season. The improvements in livestock production (or increase per animal) will have to be made within the constraints of the available feed resources. Because farmers are increasingly using their animals to meet their short-term subsistence needs, to the extent that the scope for long-term development is limited, another (direct) way of helping them is to focus on ways of assisting to meet the consumption needs through micro-financing schemes

(Zeller, 1999). As data presented in the present study have shown, there are indigenous institutions that provide some form of informal financing and insurance services. These institutions may provide the basis for these micro-financing schemes.

Collaborative local institutions have not been able to deliver the necessary minimum institutional support for the continued supply of improved stock, basic animal health care, the external inputs for improved forage and farmer training. As a result activities around the introduced technologies have gradually declined. However, farmers continue to practice some of the introduced technologies, particularly supplementary feeding and basic health care. The common reasons for the decline of institutional support are logistic limitations, poor organizational structure and lack of policy guidelines.

Supplementary feeding and tethered feeding are not entirely new concept to the area, but the DGDP package encouraged participant households to practice them more frequently. Most of the introduced forage legumes and grasses have disappeared. Given the scarcity of land in the villages and the multiple tiers of cropping prevalent in the area, forage development strategies that compete for land are less likely to be acceptable by the farmers.

A similar low adoption rate for improved feed production methods for crossbred dairy cattle in Ethiopian highlands was reported by Shapiro *et al*. (1992), who found out that many of the farmers opted to feeding concentrates to their crossbred cows without adopting intensified forage production practices. Contrary to an expectation that this dairy promotion project would lead to substitution of crossbreds for local stock, use of concentrates enabled farmers to increase their stocking rates, which they did instead of substituting more productive animals for local breeds. Opportunities to improve livestock nutrition in these systems should focus on optimum use of available resources including crop residues, and improve possible supplementary feeding techniques (Bayer and Zimmelink, 1998; Nitis, 1999).

There is demand for the basic goat health services through the paravets; but the essential minimum institutional support is missing, and hence the trained paravets have been performing gradually less. The idea of bringing the basic veterinary services closer to the villages is very desirable and has been beneficial to the farmers (Sherman, 2000), but putting it in practice has become very difficult. There are no clear policy guidelines as to how the paravets function and become integrated into the network of veterinary services. Without the minimum institutional support to supervise their activities, conduct refreshment training and replenish their stocks of drugs and equipment, it is practically difficult, if not impossible, to maintain their largely voluntary services. This is despite the current trends in economic liberalization and privatization of the extension services. Because of the declining budget upon veterinary services in sub-Saharan Africa in general, it is increasingly proposed that livestock services should be reorganized, cost recovery measures introduced and the private sector involved (de Haan and Nissen, 1985).

Although it is claimed that DGDP credit programme has played a major role in lobbying the Agricultural and Industrial Development Bank to supply credit funds to women who were not previously allowed to take loans, and although it is now possible for a women's group to receive funds directly, with the approval from the local MoA extension staff (de Haan *et al.*, 2000), no credit was disbursed during the study period. In fact, the existing saving accounts were frozen. The self-help credit groups have literally ceased to operate the revolving credit. The revolving credit funds (for goat credit and paravet services) remain largely unaccounted for. By contrast the informal financing services have been functioning. This intriguing disparity between the formal and informal financing services deserves further investigation.

In a nutshell, as a technology to the smallholder farmers, crossbreeding lacked sustainability at the institutional level, and more so at the farm level – the latter being now understandable because the net benefits it generates are not higher than those from indigenous goats. The farmers continued to sustain some components of the package because they helped them to generate higher net benefits from the indigenous goats. Improvements in traditional livestock management can therefore be promoted with the indigenous stock alone without the incentive of introducing crossbreeding.

This study produced strong evidence on the productivity of the indigenous goats partly because of the way the evaluation was made. Evaluative productivity criteria should essentially reflect the broad objectives of the owners for raising the animals. On this basis, the available productivity indices were extended in this study to include all physical products that are in use, namely meat, milk and manure, as well as quantifiable socio-economic functions, namely financing and insurance. The concept of value added (Bosman and Moll, 1995) was applied to derive overall net benefits at the flock level. These aggregate net benefits were then standardised on the key resources that the households utilised, namely the total biomass of animals maintained, expressed in standard biological equivalents (metabolic body weight); the current land holdings that produce most of the feed supply, and the household labour input. This procedure produced three complementary productivity indices, referred to as the Unit Net Benefits.

The idea of aggregating productivity at the flock level is not new (Peacock, 1987;Upton, 1989). However, the procedure for quantifying some of the socio-economic functions with the purpose of measuring the realised benefits is a recent development (Bosman and Moll, 1995; Ifar, 1996; Slingerland, 2000). The simultaneous use of multiple indices is logical because in the smallholder economy the three factors of production, land, labour and animals are equally important and the same resources are commonly used for the different agricultural activities (Ruthenberg, 1980). The concept of evaluation from the farmers' perspective (i.e., based on the actual production objectives), is not new either; Peacock (1987) has demonstrated that applying 'traditional' indices better reflects owners' preferences.

The need for valuation of manure as part of the overall benefit from livestock in countries like Ethiopia is not disputed; it is one of the reasons that led to reassessment of the contribution of livestock to the national economy (Sansoucy *et al*., 1995). Profitable use of manure has a long history (Pusey, 1842). The monetary value of manure in this study was estimated based on a number of parameter assumptions in the literature. The major assumption was that under *ad libitum* feeding regime, manure output is mainly a function of the metabolic body size of the animals (Fernández-Rivera, *et al*., 1995). When comparisons of productivity are made on the basis of metabolic body weight, this concept may not contribute to the difference between breed groups. But its relative contribution to the total benefit certainly reduces the degree of differences between the breed groups. The procedure led to estimates in which manure represents about one third of the total quantified benefits (Table 22). Following the arguments of this study, manure is as valuable a product as are meat and milk.

The quantified socio-economic benefits for the different study flocks ranged from 8.3 to 11.45 per cent with an overall average of 10.0 per cent (Table 22.). These are low compared to the estimates by Ifar (1996) in Upland mixed–farming systems in east Java, Indonesia where these accounted for one third of the total value added from physical products, and even very low compared to the 80 per cent estimate of Bosman and Moll (1995) for smallholder goat production system with meat as its only output.

The concept of accounting the financing and insurance functions of livestock in smallholder economy was further developed by Slingerland (2000), by arguing that these socio-economic benefits also have costs, but these costs are generally considered to be low because livestock have desirable qualities to smallholder farmers to serve as a self-generating and easily disposable asset and provide a low-cost insurance benefit at time of difficulty, compared to the costs of other alternatives.

This method of aggregating total net benefits of goat flocks is incidentally analogous to the calculation of Gross National Product (GNP). As the GNP measures the total value added claimed by residents of a country, and available for consumption and investment, the total net benefits to the household are expressed as value added of the flocks (net meat production, plus milk, plus manure less purchased external inputs) plus the socio-economic benefits realised in financing and insurance. The benefits are either used for immediate consumption (slaughter, sell), or set aside for future use (in the form of stock or transferred as investment in social relations). The analogy is particularly relevant in conferring a perspective of maximum total production rather than specific productivity of a single component. It also emphasizes the concept of aggregate benefits that accrue to the households, regardless of the form they are realised. More importantly, it provided a more realistic platform to seek improvements in overall benefits to subsistence farmers.

8. SUMMARY

In countries like Ethiopia, development programmes on improvement of livestock production for the dominant smallholder sector nearly always promote improved management combined with the introduction of exotic animals for crossbreeding. The crossbreds are promoted on the premise that they are more productive than the indigenous animals. This was also the concept of the Dairy Goat Development Programme (DGDP), which implemented a comprehensive programme of crossbreeding and improved goat management in the Ethiopian highlands between 1989 and 1997. A year after the DGDP had finished, this study was set up to test the general hypothesis that the benefits that accrue to households from raising crossbred goats under improved management are greater than those from indigenous goats under traditional management.

The field data collection was conducted between April 1998 and June 1999. The study covered 275 crossbred (Somali x Anglo-Nubian) and 537 indigenous (Somali, Hararghe Highland) goats belonging to 121 DGDP participant and 37 non-participant (control) households in Gursum and Kombolcha districts of eastern Ethiopia. Three complementary flock-level composite productivity indices were developed, which stemmed from the actual uses of the flocks by aggregating both physical as well as quantifiable socio-economic functions of goats under subsistence production. The indices measure the monetary value of total physical net production (meat, milk, manure), and deduct the total value of purchased external inputs to produce the Values Added of the flocks. Addition of the socio-economic benefits in asset (financing) and security (insurance) to the added values gives the total benefits, or the realized Net Benefits. These were then divided by the three major resources used to produce the benefits, namely size of cultivated land, or metabolic body size of the annualised average flock size, or the estimated household labour input. The resultant three indices, referred to as Unit Net Benefits, were used to test the first and subsequent hypothesis.

The test of the general hypothesis had to be modified because flocks of purely crossbred goats usually acquired indigenous goats subsequently and a large number of farmers keep mixed flocks. Therefore, the mix of crossbred and indigenous goats managed under improved level of care in terms of feeding, health care and housing was compared with indigenous flocks under traditional management, and found to produce significantly higher unit net benefits than the indigenous flocks under traditional management for the available land and labour input ($p=0.05$), but not for metabolic body weight.

These higher unit net benefits were attributable to both the crossbred and the indigenous goats performing under improved management. The good response of indigenous goats to the improved management was confirmed by comparing them with those kept under traditional management. The improved management practices have produced significantly higher unit net benefits than traditional management for the land available ($p = 0.01$) and average labour input ($p < 0.03$). However, the assortment of crossbred goats did not produce higher unit net benefits than the indigenous goats on comparisons based on land, metabolic body weight and labour input. Therefore, the superiority of mixed flocks over the traditional flocks also came from the indigenous goats producing in the improved environment, particularly where land was scarce and farmers had less time for goat husbandry.

Crossbreds did however produce significantly ($p < 0.001$) more milk per doe than the indigenous goats, but not per unit body weight ($p = 0.58$) or per unit of metabolic body weight ($p = 0.30$). Similarly, the crossbreds produced significantly higher net body weight gains per unit body weight ($p < 0.001$) and per unit metabolic body weight ($p <0.001$) of the same goat. However, the cumulative total body weight losses of the crossbreds were significantly greater than those of the indigenous goats when comparisons were made per unit of body weight ($p < 0.02$) and per unit metabolic weight ($p < 0.005$). The greater weight losses of the crossbreds lead to a higher risk of reaching critically low body conditions during the dry season.

The attributes of crossbreeding were not maintained because the pool was too small to maintain 50% exotic blood level in the crossbreds, which ranged from 6.25 to 75%, with the 50% crosses representing less than a quarter of the crossbred population. Shortages of crossbred breeding males also led to gradual backcrossing of the does, resulting in an increasingly mosaic mix of crossbreds. Collaborative local institutions were unable to ensure the necessary supply of the improved stock, or to deliver the necessary minimum institutional support for basic animal health care, improved forage and farmer training. As a result activities relating to the introduced technologies have declined after the DGDP was phased out. However, farmers continued to sustain some components of the technology package (supplementary feeding, basic health care), because these enabled them to generate higher net benefits from the indigenous goats.

These results challenge the prevailing prejudgment in Ethiopia that indigenous goats do not adequately respond to improvements in level of care compared to crossbred goats, a

judgement which in the past has been based on incomplete evaluation of productivity. The case for the introduction of crossbred goats was further eroded by the practicalities of maintaining an appropriate breeding programme. Thus the core hypothesis that the net benefits are greater from crossbred goats than from indigenous goats under improved management is rejected. However, it was noted that improvements in aggregate productivity can be achieved with indigenous goats alone and that the higher level of management can be upheld without the incentive of introducing crossbred goats.

9. ZUSAMMENFASSUNG

Die meisten Entwicklungsprogramme zur Verbesserung der Tierhaltung im kleinbäuerlichen Sektor fördern die Einführung von verbesserten Managementtechniken im Verbund mit der Einkreuzung von exotischen Leistungsrassen. Diese Bevorzugung von Kreuzungstieren basiert auf der weit verbreiteten Annahme, dass diese wesentlich produktiver als einheimische Genotypen seien. Ein solches Konzept lag auch dem „Dairy Goat Development Programme" (DGDP) zugrunde, das ein Kreuzungszuchtprogramm zusammen mit einem umfassenden Paket von Verbesserungen in der Ziegenhaltung im äthiopischen Hochland in den Jahren von 1989 bis 1997 durchführte. Die vorliegende Untersuchung begann ein Jahr nach Projektende und testete die Hypothese, dass Haushalte mit Kreuzungsziegen und verbessertem Management einen höheren Gewinn erzielen als solche mit einheimischen Ziegen und traditionellem Management.

Die Datenerhebung fand zwischen April 1998 und Juni 1999 in 121 Haushalten des DGDP und in 37 nicht teilnehmenden Haushalten (Kontrolle) in den Gebieten Gursum und Kombolcha im östlichen Äthiopien statt. Insgesamt wurden Daten von 275 Kreuzungsziegen (Somali x Anglo-Nubier) und von 537 einheimischen Ziegen (Somali, Hararghe-Hochland) erhoben. Drei Indizes zur Herdenproduktivität wurden entwickelt, die alle Produkte aus der Ziegenhaltung im Jahresverlauf erfassen. Dabei wurden physische Produkte sowie quantifizierbare sozioökonomische Funktionen der Ziegen unter Subsistenzbedingungen berücksichtigt. Zunächst wurden vom monetären Wert der gesamten physischen Produkte (Fleisch, Milch und Dung) die Kosten der zugekauften externen Inputs abgezogen, und anschließend der geschätzte Wert des sozioökonomischen Nutzens in Bezug auf Finanzierungs - und Sicherheitsfunktion hinzu addiert. Der Wert des realisierten Nettonutzen wurde in Beziehung zu den wichtigsten Produktionsfaktoren gesetzt, nämlich zur Größe der Anbaufläche, zum geschätzten Arbeitseinsatz des Haushalts und zum durchschnittlichen metabolischem Gewicht der Herde im betreffenden Jahr. Mit Hilfe der resultierenden drei Indizes, im weiteren mit „Unit Net Benefits" bezeichnet, wurden die oben genannte und die im folgenden abgeleiteten Hypothesen getestet.

Die der Arbeit zugrunde liegende Hypothese wurde modifiziert, um der Tatsache gerecht zu werden, daß in den meisten Fällen gemischte Herden gehalten wurden, da die Inhaber von

Kreuzungsziegen zusätzlich lokale Ziegen erwarben oder lokale Ziegen von Kreuzungsziegenböcken gedeckt wurden. Folglich wurden in einem ersten Schritt diese Mischherden unter verbesserten Haltungsbedingungen mit lokalen Ziegen mit traditionellem Management verglichen. Die verbesserte Haltung betraf Fütterung, Gesundheitsfürsorge und Unterbringung der Ziegen. Die gemischten Herden erreichten signifikant höhere (p=0,05) „Unit Net Benefits" als die einheimischen Ziegen bezogen auf eingesetzte Landfläche und Arbeitskraft, jedoch nicht auf metabolisches Herdengewicht bezogen.

Diese höheren „Unit Net Benefits" der gemischten Herden basierten auf höheren Leistungen der Kreuzungsziegen und der einheimischen Ziegen. Die Leistungssteigerung der einheimischen Ziegen bei verbessertem Management wurde zusätzlich bestätigt, indem die Leistungen von lokalen Ziegen mit verbesserten Management mit denen unter traditionellen Haltungsbedingungen verglichen wurden. Die verbesserte Haltung führte zu signifikant höheren „Unit Net Benefits" bezogen auf die Anbaufläche (p=0,01) und den durchschnittlichen Arbeitseinsatz (p<0,03). Im sich anschließenden direkten Vergleich der Kreuzungsziegen mit den lokalen Ziegen unter verbesserten Haltungsbedingungen zeigte sich keine Überlegenheit der Kreuzungsziegen bezogen auf Landfläche, Arbeitskräfteeinsatz oder metabolisches Herdengewicht. Die Überlegenheit der gemischten Herden verglichen mit dem traditionellen System beruhte also auf den höheren Leistungen der lokalen Ziegen unter verbessertem Management. Da für die Kreuzungsziegen immer ein höherer Arbeitseinsatz als für die einheimischen Ziegen erforderlich war, erwiesen sich lokale Ziegen hinsichtlich der eingesetzten Arbeitskraft als wesentlich produktiver. Dieser Vorteil war besonders ausgeprägt in Haushalten, in denen die verfügbare Arbeitszeit für die Ziegen und die eigene Anbaufläche knapp (begrenzt) waren.

Kreuzungsziegen produzierten signifikant (p<0,001) mehr Milch pro Mutterziege als die einheimischen Ziegen unter verbesserten Haltungsbedingungen. Diese Überlegenheit blieb jedoch nicht bestehen, wenn die Milchmenge auf Lebendgewicht (p=0,58) oder auf metabolisches Lebendgewicht (p=0,30) bezogen wurde. Gleichzeitig erreichten die Kreuzungsziegen auch signifikant höhere Nettogewichtszunahmen bezogen auf Lebendgewicht (p<0,001) und metabolisches Körpergewicht (p<0,001), wenn alle Zu- und Abnahmen für die einzelnen Tiere über das ganze Jahr addiert wurden. Zugleich war die Summe der während dieser Zeit auftretenden Gewichtverluste bei den Kreuzungsziegen signifikant höher als bei den einheimischen Ziegen, sowohl bezogen auf Lebendgewicht ($p<0{,}02$) als auch auf metabolisches Lebendgewicht ($p<0{,}005$). Dies weist auf große Gewichtsschwankungen im Jahresverlauf hin und beinhaltet für die Kreuzungsziegen ein größeres Risiko, eine kritische Körperkondition zu erreichen.

Der gewünschte Genanteil von 50 % Anglo-Nubier in der Kreuzungsziegenpopulation konnte nicht erreicht werden. Der zur Verfügung stehende Genpool war zu klein, so dass die Genanteile in den Kreuzungsziegen von 6,25 bis 75% schwankten und nur knapp ¼ der Kreuzungsziegen einen Anteil von 50% Anglo-Nubier Gene erreichte. Der Mangel an Kreuzungsziegenböcken führte zu einer Rückkreuzung von Kreuzungsmutterziegen mit lokalen Böcken und somit zu einem „Genmosaik“ in der Kreuzungsziegenpopulation. Die beteiligten lokalen Institutionen waren nicht in der Lage, die notwendige Anzahl an männlichen Zuchttieren bereit zu stellen oder die benötigte institutionelle Unterstützung für den Basisgesundheitsdienst, für den Anbau von Futterpflanzen oder die Beratung der Kleinbauern zu gewährleisten. Infolgedessen verringerten sich alle auf die Einführung neuer Technologien bezogenen Aktivitäten, nachdem sich das DGDP zurückgezogen hatte. Jedoch führten die kleinbäuerlichen Betriebe einige Komponenten des verbesserten Managements fort, z. B. die Gesundheitspflege und Ergänzungsfütterung, da so höhere Gewinne („Net Benefits“) mit einheimischen Ziegen erzielt werden konnten.

Diese Ergebnisse widersprechen dem in Äthiopien vorherrschenden Vorurteil, dass einheimische Ziegen im Vergleich mit Kreuzungsziegen nicht in ausreichendem Maße auf verbesserte Haltung und Pflege ansprechen. Dieses Urteil beruhte sicherlich auch auf einer unzureichenden Bewertung von Produktivität im Kontext von kleinbäuerlichen Betriebssystemen. Die Befürwortung von Kreuzungszuchtprogrammen muss auch deshalb in Frage gestellt werden, weil es sich als nicht möglich erwies, ein praktikables und nachhaltiges Züchtungsprogramm zu organisieren. Die Hypothese, dass mit Kreuzungsziegen ein höherer Nettonutzen als mit einheimischen Ziegen unter verbesserten Haltungsbedingungen erreicht werden kann, wurde eindeutig widerlegt. Es hat sich vielmehr gezeigt, dass Produktivitätsverbesserungen auch mit einheimischen Ziegen erzielt werden können und ein verbessertes Management auch ohne Einführung von Kreuzungsziegen aufrecht erhalten werden kann.

10. REFERENCES

Abdulahi, A M. 1990. *Pastoral Production Systems in Africa: A study of nomadic household economy in central Somalia*. Farming Systems in Resource Economics in the Tropics. Vol. 8. Wissenschaftsverlag Vauk Kiel, Germany.

Abebe, Girma. 1996. *Studies on the performance potential of Somali goats and their crosses with Anglo-Nubian: A contribution to breed documentation and evaluation*. Ph.D Thesis, Humboldt University, Berlin.

Abebe, Workineh. 1996. *Assessment of nutritive value and consumer preference on cheese varieties from goat milk*. M.Sc Thesis. Alemaya University of Agriculture, Alemaya, Ethiopia.

ADB (Asian Development Bank). 1993. Policies and Strategies for Livestock Development, *Regional Seminar on Polocies and Strategies for Livestock Development, Manila, Philippines, 18 – 22 January 1993.* ADB. Manila, Philippines (as cited in De Boar, 1999).

Ademosun, A A. 1990. Achievements, difficulties and future prospects in small ruminant livestock development in the Tropics. In: *Livestock Production and Diseases in the Tropics.* Faculty of Veterinary Medicine. University of Utrecht, Utrecht, The Netherlands, pp 39 - 46.

Alemayehu, Nigatu. 1994. *Characterization of indigenous goat types of Eritrea, Northern and western Ethiopia*. M.Sc. Thesis. Alemaya University of Agriculture, Alemaya, Ethiopia.

Amir, P and H C Knipscheer. 1989. *Conducting On-farm Animal Research: Procedures & Economic Analysis.* Winrock International for Agricultural Development and International Development Research Centre. Morrilton, USA.

Ayalew, W. 1992. *Preliminary Survey of Indigenous Goat Types and Goat Husbandry Practices in Southern Ethiopia*. M. Sc Thesis, Alemaya University of Agriculture, Alemaya, Ethiopia.

Ayalew, W. 1996. Progress of the Dairy Goat Development Project in Eastern Hararghe: Terminal Report. July 1996. FARM Africa/AUA, Alemaya (Mimeograph).

Ayalew, W and C P Peacock. 1993. The goat as an important milk producer in southern Ethiopia. *In: Proceedings of the Fourth National Livestock Improvement Conference, Addis Ababa, Ethiopia., 13-15 November, 1991*, Institute of Agricultural Research, Addis Ababa., Ethiopia, pp 165 - 170.

Ayalew, W, H Kassa and Z Wolde-Gebriel. 1998. *Improving Vitamin A status through a women-focused Dairy Goat Development Project in Ethiopia*. Final Report. FARM-Africa, Addis Ababa (Mimeo.).

Ayalew, W, Z Wolde-Gebriel and H Kassa. 1999. *Reducing Vitamin A Deficiency in Ethiopia: Linkages with a Women-Focused Dairy Goat Farming Project*. International Centre for Research on Women (ICRW) / Opportunities for Micro-Nutrient Interventions (OMNI) Research Program. Research Report Series 4. ICRW, Washington, D C.

Ayalew, W. B Rischkowsky, J M King, E W Bruns, B Kassa and C P Peacock. 2000. Contribution of women to household labour input into the subsistence goat husbandry in eastern Ethiopia. In: *Lucas Gruner and Yves Chabert (eds). Proc. 7th International Conference on Goats, 15-21 May, 2000, Tours, France*. Institut de l'Elvag and INRA. Part II, pp 680 – 683.

Baker, L. 1992. Group C: Research methodology. In: Rege J E O and M E Lipner (eds), *African Animal Genetic Resources: Their Characterization, Conservation and Utilization.*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 125 - 107.

Barlow, R. 1981. Experimental evidence for interaction between heterosis and environment in animals. *Anim. Br. Abstr*. 49: 715 - 737.

Bationo, A, A Buerkert, M P Sedogo, B C Christianson and A U Mokwunye. 1995. A critical review of crop-residue use as soil amendment in the West African semi-arid tropics. In: Powell J M, S Fernández-Rivera, T O Williams and C Renard (eds). *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 305 - 322.

Bayer, W and A Waters-Bayer. 1998. *Forage Husbandry*. The Tropical Agriculturalist Series. Macmillan Educational Ltd, London.

Bayer, W and G Zemmelink. 1998. Management of livestock and forage resources. In: Bayer, W and A Waters-Bayer. 1998. *Forage Husbandry*. The Tropical Agriculturalist Series.Macmillan Educational Ltd, London, pp 41 - 65.

Beerling, M L. 1990. The Concept of ownership in livestock development. In: Kuil, H, R W Paling and J E Huhn (eds). 1990. *Proc. 6th International Conference of Institutes for Tropical Veterinary Medicine*. 28 August – 1 September, 1989, Wageningen, The Netherlands, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands. pp 123 - 126.

Becker, B. 1997. *Sustainability Assessment: A review of Values, Concepts, and methodological Approaches*. Issues in Agriculture 10. Secretariat of the Consultative Group on International Agricultural Research, The World bank, Washington, D.C.

Behnke, R K. 1985. Measuring the benefits of subsistence versus commercial production in Africa. *Agric. Syst*. 16: 109 – 135.

Bekele, G. 1993. *Health Monitoring of local and crossbred goats in Gursum, Eastern Hararghe*. DVM Thesis. Faculty of Veterinary Medicine, Addis Ababa University, Debre Zeit, Ethiopia.

Bekele, W and H Kassa. 1994. *Assessment of the Socio-economic Impact of the dairy Goat Development Project in Eastern Hararghe, Ethiopia*. Alemaya University of Agriculture, Dire Dawa, Ethiopia.

Berhanu, G. 1997. *Effect of supplementing various proportions of ground nut cake and wheat bran on the performance of Somali goats*. M.Sc Thesis, Alemaya University of Agriculture, Alemaya, Ethiopia.

Birke, L. 1966. *A Credit Study of Alemaya Farmers Cooperative Society*. Bulletin No. 46. Imperial Ethiopian College of Agriculture and mechanical Arts, Dire Dawa, Ethiopia.

Birner, R. 1996. *The Role of Livestock in Economic Development: theory and empirical evidence: the case of Sri Lanka*. PhD Thesis, Faculty of Agricultural Sciences, Georg-August-University Göttingen. Göttingen, Germany.

Bock, B R. 1984. Efficient use of nitrogen in cropping systems. In: *Hauck R D (ed), Nitrogen in crop production.* American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Madison, Wisconsin, USA, pp 273 – 294. (as cited in Murwira *et al.*,1995).

Bondoc, O L, C Smith and J P Gibson. 1989. A review of breeding strategies for genetic improvement of dairy cattle in developing countries. *Anim. Br. Abs*. 57(10): 819 - 829.

Bosman, H G. 1995. *Productivity Assessment in Small Ruminant Improvement Programmes: A case Study of the West African Dwarf Goat*. PhD Thesis. Department of Animal Production Systems, Wageningen Agricultural University, Wageningen.

Bosman, H G and H A J Moll. 1995. Appraisal of small ruminant production systems: benefits of livestock and missing markets: the case of goat keeping in South-western Nigeria. In: *Bosman, H G (1995). Productivity Assessment in Small Ruminant Improvement Programmes: A case Study of the West African Dwarf Goat*. PhD Thesis. Department of Animal Production Systems, Wageningen Agricultural University, Wageningen, pp 157 - 182.

Bosman, H G and H M J Udo. 1995. Appraisal of small ruminant production systems: Productivity indices for the assessment of current flock state and impact of innovations. In: *Bosman, H G (1995). Productivity Assessment in Small Ruminant Improvement Programmes: A case Study of the West African Dwarf Goat*. PhD Thesis. Department of Animal Production Systems, Wageningen Agricultural University, Wageningen, pp 15 – 31.

Chagunda, M G G. 2000. *Genetic Evaluation of the Performance of Holestein Friesian Cattle on large-scale Dairy Farms in Malawi*. Ph.D. Thesis. University of Goettingen, Cuvillier Verlag, Goettingen, Germany.

Chambers, R. 1997. *Whose Reality Counts? Putting the first last*. Intermediate Technology Publications, London.

Chiche, J, A El Aich, A Outmani. 2000. Emergence of a milk goat production in Morocco: experiences and prospects. In: *Lucas Gruner and Yves Chabert (eds). Proc. 7th International Conference on Goats, 15 - 21 May, 2000, Tours, France*. Institut de l'Elvag and INRA. Part I, pp 311 – 316.

Conway, G R. 1983. *Agroecosystem Analysis*. Imperial College of Science and technology. London (as cited in Becker, 1997).

Cossins, N J. 1985. The productivity and potential of pastoral systems. ILCA (International Livestock Centre for Africa) Bulletin 21:10 – 15.

Cossins, N J and M Upton. 1987. The Borana pastoral system of southern Ethiopia. *Agric. Syst*. 25: 251 – 278.

CSA (Central Statistical Authority). 1990. *Ethiopia: Statistical Abstract 1989*. CSA, Addis Ababa, Ethiopia.

CSA (Central Statistical Authority). 1995. *Agricultural Sample Survey 1994/95 (1987 E.C). Report on Livestock, Poultry and Beehives Population (Private Peasant Holdings)*. Volume II Statistical Bulletin 132. CSA, Addis Ababa, Ethiopia.

CSA (Central Statistical Authority). 1998. *Agricultural Sample Survey 1997/98 (1990 E.C.). Report on Land Utilization (Private Peasant Holdings)*. Volume IV. Statistical Bulletin 193. CSA, Addis Ababa, Ethiopia.

CSA (Central Statistical Authority). 1999. *Ethiopia: Statistical Abstract 1998*. CSA, Addis Ababa, Ethiopia.

Cunningham E P and O Syrstad. 1987. *Crossbreeding Bos indicus and Bos taurus for milk production in the tropics*. FAO Animal Production and health Paper No. 68. FAO, Rome.

de Haan, C and N J Nissen. 1985. *Animal Health Services in Sub-Saharan Africa: Alternative Approaches*. World Bank Technical Paper 44. The World Bank, Washington.

de Haan, N C, K Tibbo, E Kinsey and C Valdivia. 2000. Social dimensions of goat projects in east Africa. In: Lucas Gruner and Yves Chabert (eds). *Proc. 7th International Conference on Goats, 15 - 21 May, 2000, Tours, France. Institut de l'Elvag and INRA.* Part I, pp 507 – 513.

de Haas, H J. 1986. Die Bedeutung der kleinen Wiederkäuer zur Entwicklung Ländlicher Räume. *Giessener Beiträge zur Entwicklungsforschung*, Tropeninstitut Gießen, Reihe I, Band II: 11 - 18.

de Leeuw, P N. 1990. Interactive effects of environment, management and mortality on cattle productivity in livestock systems in sun-Saharan Africa. In: Kuil, H, R W Paling and J E Huhn (eds). *Proc. 6th International Conference of Institutes for Tropical Veterinary Medicine*. 28 August – 1 September, 1989, Wageningen, The Netherlands, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands, pp 29 – 38.

de Ridder, N and K T Wagenaar. 1984. A comparison between the productivity of traditional livestock systems and ranching in eastern Botswana. *ILCA Newsletter 3 (3)*. ILCA (International Livestock Centre for Africa), Addis Ababa.

de Ridder, N and K T Wagenaar. 1986. Energy and protein balances in traditional livestock systems and ranching in eastern Botswana. *Agric. Syst*. 20(1): 1 – 16.

de Wit, J, J K Oldenbroek, H van Keulen and D Zwart. 1995. Criteria for sustainable livestock production: a proposal for implementation. *Agriculture, Ecosystems and Environment* 53: 219 - 229.

Dean, A G , J A Dean, D Coulombier, K A Brendl, D C Smith, A H Burton, R C Dicker, K Soulivan, R F Fagan and T G Arner. 1994. *EPI Info, Version 6: a word processing, database and statistics program for epidemiology on microcomputers*. Centers for Disease Control and prevention, Atlanta, Georgia, USA.

Delgado, C. M Rosegrant, H Steinfeld, S. Ehui and C Courbois. 1999. *Livestock to 2020: The Next Food Revolution*. Food, Agriculture and the Environment Discussion Paper 28. International Food Policy Research Institute, Washington.

Demeke, E. 1994. Health Monitoring and disease investigation of goats at Awassa college of Agriculture. DVM Thesis, Faculty of Veterinary medicine, Addis Ababa University, Debre Zeit, Ethiopia.

Devendra, C. 1990. Goats. In: Payne, W J A. 1990. *An Introduction to Animal Husbandry in the Tropics*.4th ed. Tropical Agriculture Series. Longman, New York, pp 505 – 536.

Devendra, C. 1991. Milk and kid production from dairy goats in developing countries. In: *Proceedings of the XXIII International Dairy Congress, Montreal. 8 - 12 October, 1990. International Dairy Federation, Brussels, Belgium*. Vol. 1: pp 327 - 351.

Devendra, C. 1992. Goats and rural prosperity. In: *Preconference Proceedings: Plenary Papers and Invited Lectures*. V International Conference on Goats, 2 - 8 March, 1992, New Delhi, pp 6 – 25.

Devendra, C. 1993. *Sustainable Animal Production from Small Farm Systems in South-East Asia*. FAO Animal Production and Health Paper. Vol. 106. FAO, Rome.

Devendra, C. 1999. Dairying in integrated farming systems. In: Falvey L and Chantalakhana C. (eds). *Smallholder Dairying in the Tropics*. International Livestock Research Institute, Nairobi, Kenya, pp 277 – 288.

Devendra, C and G B McLeroy. 1982. *Goat Production in the Tropics*. Longman, London.

Devendra, C and M Burns. 1983. *Goat Production in the Tropics*. Commonwealth Agricultural Bureaux, Slough, UK.

Doppler, W. 1991. *Landwirtschftlische Betriebssysteme in den Tropen und Subtropen. Agrarökomonie in den Tropen und Subtropen*. Eugen Ulmer GmbH, Stuttgart.

Egan, A R. 1999. Sustainability of smallholder dairy production. In: Falvey L and Chantalakhana C. (eds). *Smallholder Dairying in the Tropics*. International Livestock Research Institute, Nairobi, Kenya. pp. 387 – 402.

Ehui, S, H Li-Pun, V Mares and B Shapiro. 1998. The role of livestock in food security and environmental protection. *Outlook on Agriculture* 27(2): 81 - 87.

Ellis, W C, M J Wylie and J H Matis. 1988. Dietary-digestive interactions determining the feeding value of forages and roughages. In: Orskov E R (ed.), *Feed Science*. Elsvier, Amsterdam, The Netherlands, pp. 177 – 229 (as cited in Stuth *et al.*, 1995).

Falconer, D S. 1989. *Introduction to Quantitative Genetics*. 3rd ed. Longman Scientific & Technical.

Fall, A., M Drop, J Sandford, Y J Wissocq, J Durkin and J C M Trail. 1982. Evaluation of the productivities of Djallonke Sheep and N'Dama cattle at the Centre de Researches Zootechnique, Kolda, Senegal. *ILCA Res. Rep*. No.3, ILCA (International Livestock Research Centre for Africa), Addis Ababa, Ethiopia.

FAO. 1989. *Production Yearbook 1988*. vol. 42. FAO, Rome.

FAO. 1996. *Production Yearbook 1995*. vol. 48. FAO, Rome.

FAO. 1999. *Production Yearbook 1998*. vol. 52. FAO, Rome.

FAO/ILCA/UNEP. 1980. *Trypanotolerant Livestock in west and central Africa*. Vol. 1. General Study. FAO, Rome.

FARM-Africa. 1990. DGDP Annual Report – 1989. FARM-Africa (Ethiopia), Addis Ababa, Ethiopia.

FARM-Africa. 1996. *Goat Types of Ethiopia and Eritrea. Physical description and management systems*. Published jointly by FARM-Africa, London, UK and International Livestock Research Institute, Nairobi, Kenya.

FARM-Africa. 1997a. *Dairy Goat Development programme: Six-monthly report: January - June 1997.* FARM-Africa (Ethiopia), Addis Ababa, Ethiopia.

FARM-Africa. 1997b. *Dairy Goat Development Project: Completion Report (1989 – 1997).* FARM-Africa (Ethiopia), Addis Ababa, Ethiopia.

FARM-Africa. 1998. *Implementation Manual: Goat Project.* FARM-Africa (Ethiopia), Addis Ababa, Ethiopia (Mimeo.).

Fernández-Rivera, S, T O Williams, P Hiernaux and J M Powell. 1995. Faecal excretion by ruminants and manure availability for crop production in semi-arid West Africa. In: Powell J M, S Fernández-Rivera, T O Williams and C Renard (eds). *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 149 - 169.

Ferras, B. 2000. The South American perspective on the use of animal genetic resources. In: *Proceedings of the Animal Breeding and Animal Genetic Resources*. World-Expo Workshop, 17 - 18 July, 2000, Mariensee, Germany (in press).

Fischer, R P Starkley, E Mwenya and J Stares. 1994. Transfer of animal traction technology: lessons from project experiences in Zimbabwe, Cameroon and Tanzania. In: *Improving Animal Traction* technology*: Proceedings of the First Workshop of the Animal Traction Network for Eastern and Southern Africa (ATNESA). 18 - 23 January, 1992, Lusaka, Zambia*. Technical Centre for Agricultural and Rural Co-operation , Wageningen, The Netherlands, pp 296 - 376.

Fitzhugh, H A and Bradford G E. 1983. *Hair sheep of western Africa and the Americas*. Westview Press, Boulder, Colorado.

Fitzhugh, H. 1987. Systems approach to small ruminant research and development. In: Quershi A.W. and Fitzhugh H A (eds), *Small Ruminants in the Near East. Volume 1. FAO Animal Production and Health Paper 54*. FAO (Food and Agriculture Organisation of the United Nations), Rome, Italy, pp 1 - 12.

Flavey, L. 1999. The future of smallholder dairying. In: Falvey L and Chantalakhana C. (eds). *Smallholder Dairying in the Tropics*. International Livestock Research Institute, Nairobi, Kenya, pp 417 – 432.

Frisch, J E and J E Vercoe. 1978. Genotype x environment interactions in growth of cattle – their ocurence, explanation and use in the genetic improvement of growth. *Proc. IV World Conference on Animal Production*, Vol. 2, pp 615 – 622.

Galal, E S E and K Awgichew. 1981. A note on the relationship between duration of mating season and flock fertility in some Ethiopian breeds of sheep and goats. *World Review of Animal Production* 17 (1): 9 - 13.

Gall, C. 1981. *Goat production*. Academic Press Inc., New York.

Gebre-Meskel, T and A Tedla. 1995. Development opportunities in animal agriculture. In: *Proc. Second Annual Conference of the Ethiopian Society of Animal Production. 26-27 May 1993, Addis ababa, Ethiopia*. Ethiopian Society of Animal Production, Addis Ababa, Ethiopia.

Gebre-Michael, D. 1974. *The Kottu of Hararghe – an introduction to the eastern Oromo*. Haile-Silasie I University (HSIU), College of Agric. Experiment Station Bulletin (Eth.). No. 68.

Getahun, A. 1991. Growth and Sustainability: Conditions for their Compatibility in the Tropical East African Highlands. In: *Stephen A Vosti, Thomas Reardon and Winfried von Urff (eds). Proc. Deutsche Stiftung fuer Entwicklung (DSE) / International Food Policy Research Institute (DSE) Conference on Agricultural Sutainability, Growth and Poverty Alleviation: Issues and Policies*: September 23 – 27, 1991. Feldafing, Federal Republic of Germany. DSE, Zentralstelle fuer Ernaerung und Landwirtschaft. Feldafing, pp 451 – 468.

Gilbertson, C B, Doran, J W and R M Hill. 1981. The Effect of Total Solids content, temperature and storage depth on nitrogen content of stored beef cattle manure. In: *Livestock Waste: A Renewable Resource*. St Joseph, MN, American Society of Agricultural Engineers, pp 395 - 398. (as cited in Thorne *et al.*, ND).

GoE (Government of Ethiopia). 1986. *Ethiopian Highlands Reclamation Study.* UTF/ETH/037/ETH Final Report, Vol. I., FAO, Rome.

Habtewold, D and S Worku. 1994. Population growth and food security. In: *Proceedings of National Workshop on Integrating Population and Development Planning.* 5 – 7 May, 1994. Population and Development Planning Unit, Ministry of Planning and Economic Development (MoPED), Addis Ababa, Ethiopia, pp 205 - 214.

Hall, S J G. 2000. Economic evaluation of animal genetic resources with special reference to sub-Saharan Africa. In: *Proceedings of the Animal Breeding and Animal Genetic Resources. World-Expo Workshop, 17-18 July, 2000*, Mariensee, Germany (in press).

Hayami, Y. 1997. *Development Economics: From the Poverty to the Wealth of Nations.* Oxford University press, New York.

Hayami, Y and V M Ruttan. 1985. *Agricultural Development: an international perspective.* Baltimore: John Hopkins University Press (as cited in Hayami, 1997).

Horst, P. 1983. The concept of production adaptability of domestic animals in tropical and subtropical regions. *J. S. Afr. Vet. Ass*. 54(3): 159 (as cited in Peters, 1987).

Ifar, S. 1996. *Relevance of Ruminants in Upland Mixed-Farming Systems in East Java, Indonesia*. PhD Thesis, Wageningen Agricultural University. Wageningen, The Netherlands.

Ikombo, B M. 1989. Effect of farmyard manure and fertilizers on maize in semi-arid areas of eastern Kenya. *East African Agricultural and Forestry Journal*. 44: 266 - 274 (as cited in de Leeuw and Reynolds, 1995).

ILCA (International Livestock Centre for Africa). 1993. *Handbook of African Livestock Statistics*. ILCA, Addis Ababa, Ethiopia.

ILRI (International Livestock Research Institute). 2000. Newsletter of the International Livestock Research Institute. Livestock and nutrient cycling: maintaining a balance. *Livestock Research and Development* No. 4: 1 – 5.

Jabbar, M A, B M Swallow, G D M d'Ieteren and A A Busari. 1997. Farmer preferences and market values of cattle breeds of west and central Africa. *Socioeconomic and policy research working paper no. 21*. Livestock Policy Analysis Programme, International Livestock Research Institute, Addis Ababa, Ethiopia, pp 1 - 22.

Jabbar, M A, H Beyene, M A Mohammed-Saleem M A and S. Gebreselassie. 1998. *Adoption pathways for new agricultural technologies: An approach and an application to Vertisol management technology in Ethiopia*. Socio-economic and Policy Research Working Paper No. 23. Livestock Policy Analysis Project, International Livestock Research Institute, Addis Ababa, Ethiopia.

Jahnke, H E. 1982. *Livestock Production Systems and Livestock Development in Tropical Africa*. Kieler Wissenschaftsverlag Vauk. Kiel, Germany.

Jenkinson, D S. 1982. The Nitrogen Cycle in long term field experiments. *Philosophical Transactions of the Royal Society* 13: 563 - 571. (as cited in Murwira *et al*., 1995).

Johnson, H D. 1992. Adaptation indices. In: *Preconference Proceedings: Plenary Papers and Invited Lectures*. V International Conference on Goats, 2 - 8 March, 1992, New Delhi, pp 231 – 243.

Kahi, A K, W Thorpe, G Nitter, J A M Van Arendonk and C F Gall. 2000. Economic evaluation of crossbreeding for dairy production in a pasture based production system in Kenya. *Livestock Production Science* 65: 167 – 184.

Kassa, H. 1999. *Livestock production, household food security and sustainability of smallholder mixed farms in the Harar highlands of Ethiopia. A case study from Kombolcha woreda*. Department of Rural Development Studies. Swedish University of Agriculture, Uppsala, Sweden (Mimeo.).

Kaufmann, B. 1998. *Analysis of Pastoral Camel Husbandry in Northern Kenya*. PhD Thesis, Center for Agriculture in the Tropics and Subtropics, University of Hohenheim. Margraf Verlag, Weikerheim, Germany.

Knipscheer, H C, U Kusnadi and A J De Boar. 1984. Some Efficiency measures for analysis of the production potential of Idonesian Goats. *Agric. Syst*. 15: 125 - 35.

Laes-Fettback, C. 1989. *Untersuchungen zum Leistungspotential der ägyptischen Baladiziege – Moeglichkeiten de Evaluarung lokaler ziegenrassen unter Stationsbedingungen*. Dissertation. Georg-August Universitaet Goettingen.

Mason, I L and V Buvanendran. 1982. *Breeding Plans for Ruminant Livestock in the Tropics*. FAO Animal Production and Health Paper No. 34. FAO, Rome.

Mbuza F M B. 1991. A Systems Analysis of Milk Production Systems in Uganda and prospects for Technological Change. PhD Thesis, University of Melbourne, Melbourne, Australia. (as cited in Egan, 1999).

McDowell, R E. 1972. *Improvement of Livestock in Warm Climates*. W H Freeman & Co. San Francisco.

McDowell, R E. 1988. Strategies for genetic improvement of cattle in warm climates. In: Proc. Second National Livestock Improvement Conference. 24 - 26 Feb. 1988, Addis Ababa. Institute of Agricultural Research, Addis Ababa, Ethiopia.

Meier, G M. 1995. *Leading Issues in Economic Development*. 6th Ed. Oxford University Press. New York.

Metz, T and M D Asfaw. 1992. *LIMS (Livestock Information Management System): Database for Livestock Performance Data. Version 1.2. Computer Program with System Documentation*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.

MoA (Ministry of Agriculture, Ethiopia). ND. Forage Extension Manual. MoA, Animal & Fishery Resources Development Main Department, Addis Ababa, Ethiopia (Mimeo.).

Morand-Fehr, P. 1981. Nutrition and Feeding of goats: applications to temperate climatic conditions. In: *Gall, C. (ed). Goat Production*. Academic Press, London, pp 193–232.

Neidhardt, R, H Grell, W Schrecke und H Jacob. 1993. *Standortangepaßte viehwirtschaft im Östlichen Afrika*. Giessener Beiträge zur Entwicklungsforschung, Wissenschaftliches Zentrum Tropeninstitut der Justus-Liebig-Universität Gießen. Reihe I (20): 69 - 78.

Neopane, S P. 1997. The genetics of productivity traits in a Nepalese Hill goat herd. PhD. Thesis, University of London, London (as cited in Neopane, 2000).

Neopane, S P. 2000. Selection for improvement of the productivity of the hill goats in Nepal. In: *Lucas Gruner and Yves Chabert (eds). Proc. 7th International Conference on Goats, 15 - 21 May, 2000, Tours, France*. Institut de l'Elvag and INRA. Part II, pp 206 – 208.

Nitis, I M. 1999. Production of forage and fodder. In: Falvey L and Chantalakhana C. (eds). *Smallholder Dairying in the Tropics*. International Livestock Research Institute, Nairobi, Kenya, pp 157 – 184.

NRC (National Research Council). 1981. *Nutrient Requirements of Domestic Animals. Number 15. Nutrient Requirements of Goats: Angora, Dairy, and Meat Goats in Temperate and Tropical Countries*. National Academy Press, Washington, D.C.

Onim, J F M, P Ochala, P Fitzhugh, H A Odour and K Otieno. 1990. Potential of Goat Manure as a valuable fertilizer for small scale farmers. In: *Proc. 8th SR-CRSP Scientific Workshop. 7 – 8 March, 1990. ILRAD*, Nairobi, Kenya.

Ørskov, E R and E F Viglizzo. 1994. The Role of Animals in Spreading Farmer's Risks: a new paradigm for Animal Science. *Outlook on Agriculture*, Vol. 23 (2): 81 - 89.

Ørskov, E R. 1993. *Reality of Rural Development Aid: with emphasis on livestock*. Rowett Research Services Ltd. Aberdeen. UK.

Padilha, T N; S G de Albuquerque, C F Guimaraes, J G G Soares, L C Freire, L M C Salviano, M C de Oliveira. 1980. [A comparison of goat management systems]. Comparacao entre sistemas de producau para caprinos. *Pesquisa em Andamento*, EMBRAPA No.8 (as cited in Anim. Br. Abst. 49: 2713).

Pagot, J. 1992. Animal Production in the Tropics. Macmillan Press.

Peacock, C P. 1982. Sheep and Goat Production at Elangata Wuas group ranch in Maasai pastotal system, Kenya. ILCA Research Briefs, Nairobi, Kenya.

Peacock, C P. 1983. A Rapid Appraisal of Goat and Sheep flock demography in eat and west Africa: method, results and application to livestock research and development. *ILCA Working Document No. 28*. ILCA, Nairobi.

Peacock, C P. 1987. Measures for assessing the productivity of sheep and goats. *Agric. Syst*. 23: 197 - 210.

Peacock, C. 1996. *Improving Goat Production in the Tropics: A Manual for Development Workers*. 274 Banbury Road, Oxford, OX27DZ, UK, Oxfam.

Peacock, C P, Z Alemayehu, K Banjaw and T Forsido. 1990. The Dairy Goat Development Programme in Ethiopia. In: *Proc. Eighth Scientific Workshop of the Small Ruminant Research Support Programme (SR-CRSP), 7-8 March, 1990*. Nairobi, Kenya. (SR-CRSP), Nairobi, Kenya.

Peters K J. 1991. Selection and breeding strategies for production in warm climates. In: *Animal husbandry in warm climates. 1991, 55-63; EAAP Publication No. 55*; Pudoc, Wageningen, Netherlands, pp 55 – 63.

Poschen, P. 1986. An evaluation of the Acacia Albida-based agroforestry practices in Hararghe highlands of eastern Ethiopia. *Agroforestry Systems (The Netherlands)*. Vol. 4 (2): 122 – 143.

Pusey P. 1842. On the Progress of Agricultural Knowledge during the last four years. Journal of Royal Agricultural Society of England III: 205 (as cited in ILRI, 2000).

Rajaguru, A S B. 1988. Goat meat production in Sri LankaIn: Devendra C. (ed.) *Goat Meat Production in Asia*. International Development Research Centre, Ottawa, pp 179 – 187.

Reda, A.1993. Characterization (phenotypic) of indigenous goat and goat husbandry practices in East and Southeastern Ethiopia. M.Sc. Thesis, Alemaya University of Agriculture, Alemaya, Ethiopia.

Reynolds, L and P N de Leeuw. 1995. Myth and manure in nitrogen cycling: A case study of Kaloleni Division in Coast Province, Kenya. In:. Powell J M, S Fernández-Rivera, T O Williams and C Renard (eds). *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 509-521.

Richardson, F D and B D Hahn. 1994. Models for the selection of cow types for extensive meat and milk production in developing areas. ODI Pastoral Development Network Paper 36d, ODI, London, (as cited in Hall, 2000).

Rischkowsky, B. 1996. Untersuchungen zur Milcherzeugung mit Saanenkreuzungsziegen in kleinbäuerlichen Betreiben Malawis. Dissertation. Justus-Liebig-Universität-Gießen, Gießen.

Romney, D L, D S C Sendalo, E Owen, L A Mtenga, P D Penning, R W Mayes and C R C Hendy. 1996. Effects of tethering management on feed intake and behaviour of Tanzanian goats. *Small Ruminant Research* 19: 113 - 120.

Ruthenberg, H. 1980. *Farming Systems in the Tropics*. 3rd ed. Clarendon Press, Oxford.

Ruvuna, F, J K Kogi, J F Taylor and S M Mkuu. 1995. Lactation curves among crosses of Galla and east African with Toggenburg and Anglo-Nubian goats. *Small Ruminant Research* 16(1): 1 - 6.

Sansoucy, R, M A Jabbar, S Ehui and H Fitzhugh. 1995. The Contribution of livestock to food security and sustainable development. In: Wilson R T, Ehui S and Mack S (eds). 1995. *Livestock Development Strategies for Low Income Countries.* Food and Agriculture Organization / International Livestock Research Institute, Nairobi, Kenya, pp 9 – 21.

Saithanoo, S; W Pralomkarn, S Kochapakdee and J T B Milton. 1993. The pre-weaning growth of Thai native (TN) and Anglo-Nubian X TN kids. *Journal of Applied Animal Research*. 3(2): 97 - 105.

SAS Institute Inc. 1989. SAS Release 6.12 TS Level 0020. SAS Campus Drive, Cary, NC 27513.

Schiere, J B. 1995. *Cattle, straw and system control: a study of straw feeding systems*. PhD Thesis, Wageningen Agricultural University, Wageningen, The Netherlands. Royal Tropical Institute, Amsterdam.

Schlecht, E, S Fernández-Rivera and P Hiernaux. 1997. Timing, size and nitrogen concentration of faecal and urinary excretions in cattle, sheep and goats: Can they be exploited for better manuring of croplands? In: G Renard, A Neef, K Becker and M von Oppen (eds). *Proc. Soil Fertility Management in West African Land Use Systems. Niamey, Niger, 4 – 8 March 1997*. Margarf Verlag, Weikersheim, Germany, pp 361 - 367.

Schmidt-Nielson, Knut. 1984. *Scaling: Why is animal size so important?* Cambridge University Press. New York.

Schultz, T W. 1964. *Transforming Traditional Agriculture*. Yale University Press. New Haven, USA.

Scoones, I and C Toulmin. 1995. Socio-economic dimensions of nutrient cycling in agropastoral systems in dryland Africa. In: Powell J M, S Fernández-Rivera, T O Williams and C Renard (eds) 1995. *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 353 - 369.

Scoones, I. 1992. The economic value of livestock in the communal areas of southern Zimbabwe. *Agric. Syst*. 39: 339 – 359.

Shapiro, B I, L Dadi, E Zerbini and Getachew Feleke. 1992. *Adoption of recommended feed production and feeding practices for crossbred cows in Ethiopian Highlands*. ILCA (International Livestock Centre for Africa), Addis Ababa, Ethiopia.

Sherman, D M. 2000. Community-based animal health programs: a catalyst for economic and social development for the rural poor. *In: Lucas Gruner and Yves Chabert (eds) 2000. Proc. 7th International Conference on Goats, 15 - 21 May, 2000, Tours, France. Institut de l'Elvag and INRA*. Part I: 514 – 518.

Simmonds, N W. 1986. A short review of farming systems research in the tropics. *Experimental Agriculture* 22: 1 - 13.

Singh, R P. 1982. Note on Performance characteristics and analysis of cattle in rural areas. *Indian J Anim. Sci*. 52(9): 790 - 792.

Slingerland, M. 2000. *Mixed Farming: Scope and Constraints in West African Savanah*. PhD Thesis. Wageningen Agricultural University, Wageningen, The Netherlands. Tropical Resource Management Papers. No. 34.

Somda, Z C, J M Powell, S Fernández-Rivera and J Reed. 1995. Feed factors affecting nutrient excretion by ruminants and the fate of nutrients when applied to soil. In: Powell J M, S Fernández-Rivera, T O Williams and C Renard (eds). *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 227 - 243.

Spedding, C R W. 1988. *An introduction to agricultural systems*. 2nd ed, Elsvier Applied Science, London, New York.

Spedding, C R W, J M Walsingham and A M Hoxey. 1981. *Biological Efficiency in Agriculture*. Academic Press, London.

Stangel, P J. 1995. Nutrient Cycling and its importance in sustaining crop-livestock systems in sub-saharan Africa: An overview. In: Powell J M, S Fernández-Rivera, T O Williams and C Renard (eds). *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 37 - 59.

Steinbach, J. 1986. Erfahrungen mit der Evaluierung des Leistungspotentials von autochthonen und importierten Ziegen in Nordtunesien. *Giessener Beiträge zur Entwicklungsforschung*, Tropeninstitut Gießen, Reihe I(13): 27 - 42.

Steinfeld, H. 1988. *Livestock Development in Mixed Farming Systems: A study of smallholder livestock production systems in Zimbabwe. Farming Systems and Resource Economics in the Tropics*. Vol. 3. Werner Doppler (ed.). Wissenschaftsverlag Vauk. Kiel, Germany.

Storck, H, Berhanu Adinew, Bezabih Emana, R. Begander and Getu Hailu. 1997. *Management Strategies for farming systems in uncertain environment and approaches* *for improvement*. Farming Systems and Resource Economics in the Tropics (Germany). Vol 27. Wissenschaftsverlag Vauk, Kiel, Germany.

Stuth, J W, R K Lyons and U P Kreuter. 1995. Animal/plant interactions: Nutrient acquisition and use by ruminants. In: Powell J M, S Fernández-Rivera, T O Williams and **C** Renard (eds). *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 63 - 82.

Taneja, V K. 1999. Dairy breeds and selection. In: Falvey L and Chantalakhana C. (eds) 1999. *Smallholder Dairying in the Tropics*. ILRI (International Livestock Research Institute), Nairobi, Kenya, pp.71 – 99.

Throne, P, Robert Delve, Georg Cadisch, Jan Tanner, Ken Giller, Steven Kimani, William Thorpe, Derrick Thomas. (Not Dated). *R6283: Implications of Livestock Feeding Management for Long-Term Soil Fertility in smallholder mixed farming systems.* A Final Technical Report on a Research Project Funded by the Department for International Development`s Livestock Production Research Programme (Mimeo.).

Tilahun, F. 1995. Transforming the Ethiopian pastoral economy: a preliminary assessment of urban-rural linkages in predominantly pastoral economies. In*: Proc. Fourth Annual Conference on the Ethiopian Economy, Debre Zeit, 26 – 29 November 1995*. Department of Economics of Addis Ababa University and Ethiopian Economic Asociation. Addis Ababa University, Addis Ababa, Ethiopia.

Tisdale, S L, W L Nelson and J D Beaton. 1985. Soil Fertility and Fertilizers. 4th Edition. Macmillan Publishing Company, New York.

Tropenzentrum, Universität Hohenheim. 1993. Burundi-Malawi-Kenya: Development of self-help Structures For Smallholder Goat Breeders. Stuttgart, Germany.

UNDP (United Nations Development Programme). 1999. *Human development Report 1999*. UNDP, Oxford University press, Oxford.

Upton, M. 1985. Returns from small ruminant production in South West Nigeria. *Agric. Syst*. 17: 65 - 83.

Upton, M. 1989. Livstock Productivty Assessment and Herd Growth Models. *Agric. Syst*. 29: 149 – 164.

Utech, K B W, R H Wharton and J D Kerr. 1978. Resistence to *Boophilus microplus (Canestrini)* in different breeds of cattle. Aust. J. Agric. Res. 29: 885-895. (as cited in Cunningham and Syrstad, 1987).

Valle-Zarate, A. 1995. Zuchtungsstrategien fur marginale Standortbedingungen der Tropen und Subtropen. *Archiv fuer Tierzucht* 38(5): 461 - 478.

van Wyk, J A, M O Stenson, J S van der Merwe, R J Vorster and P G Viljoen. 1999. Anthelmintic resistence in South Africa: surveys indicate an exteremely serious situation in sheep and goat farming. *Onderstepoort Journal of Veterinary Research* 66: 273 – 284.

van Gennip, J J A M. 1990. Openning Adress: Dutch livestock policy illustrated. In: Kuil, H, R W Paling and J E Huhn (Eds). 1990. *Proc. 6th International Conference of Institutes for Tropical Veterinary Medicine. 28 August – 1 September, 1989, Wageningen,* The Netherlands, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands, pp1 - 7.

Vercoe, J E. 1999. Climatic and environmental factors affecting dairy productivity. In: Falvey L and Chantalakhana C. (eds) 1999. *Smallholder Dairying in the Tropics*. International Livestock Research Institute, Nairobi, Kenya, pp 61 - 69.

von Braun, J, H Bouis, S Kumar and P Pandya-Lorch. 1992. *Improving Food Security for the Poor: Concept, Policy and Programs*. International Food Policy Research Institute, Washington, D.C.

von Kaufmann, R R and K J Peters. 1990. Achievements and difficulties in ruminant livestock development in the humid and subhumid zones of west and central Africa. In: Kuil, H, R W Paling and J E Huhn (Eds). 1990. *Proc. 6th International Conference of Institutes for Tropical Veterinary Medicine. 28 August – 1 September, 1989, Wageningen,* The Netherlands, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands, pp 21 - 28.

WCED (World Commision on Environment and Development). 1987. *Our Common Future. The Brundtland Report.* Oxford, U.K.: Oxford University Press.

Webb, P and J von Braun. 1994. *Famine and food security in Ethiopia: Lessons for Africa.* John Wiley and Sons Ltd. Chichester, England.

Wibaux, H. 1986. *Agriculture in the highlands of Hararghe, Kombolcha area: Study of six farms*. Department of Agricultural Economics, French Technical Cooperation, Alemaya University of Agriculture. Alemaya, Ethiopia.

Williams,T O, J M Powell and S Fernández-Rivera.1995. Manure utilization, drought cycles and herd dynamics in the Sahel: Implications for cropland productivity. In: Powell J M, S Fernández-Rivera, T O Williams and **C** Renard (eds) 1995. *Livestock and Sustainable Nutrient Cycling in Mixed Farming Systems of sub-Saharan Africa. Volume II: Technical Papers*. International Livestock Centre for Africa, Addis Ababa, Ethiopia, pp 393 - 409.

Wilson, R T 1982. Husbandry, Nutrition and productivity of goats and sheep in tropical Africa. In: *Gatenby, R M and C M R Trail (eds.) 1982. Small Ruminant breed productivity in Africa*. International Livestock Centre for Asfrica, AA, Ethiopa.

Wilson, R T. 1984. Indigenous Goats: Productivity in Traditional Livestock Systems of Semi-Arid Africa. *Int. Goat and Sheep Res*. 2(3): 243 - 251.

Wilson, R T, C P Peacock and A R Sayers. 1981. *A study of goat and sheep production in the Masi group ranch at Elangata Wuas, Kajiado district*. ILCA Working Document No 24. ILCA, Addis Ababa.

Winrock International, USA. 1992. *Assessment of Animal Agriculture in sub-Saharan Africa*. Winrock International, Morrilton, Arkansas, USA.

Wolde-Gebriel, Zewdie and Workneh Ayalew and Habtemariam Kassa. 1997. *Formative Study on the socio-economic and Nutritional Status of Mothers and Children in Gursum and Kombolcha, Ethiopia*. FARM-Africa (Ethiopia), Addis Ababa, Ethiopia.

Zeller, M. 1999. On the safty net role of micro-finance for income and consumption smoothing. In: *Proc. Social Protection and Poverty. Poverty and Inequality Advisory Unit, Sustainable Development Department, Interamerican Development Bank. 4 – 5 February, 1999*. International Food Policy Research Institute (IFPRI), Washington, D.C. (in print).

Zerfas, H P und B Rischkowsky. 1993. Role und funktion der Ziegenhaltung in kleinbäuerlichen Betreibssystemen in Malawi. *Giessener Beiträge zur Entwicklungsforschung*, Wissenschaftliches Zentrum Tropeninstitut der Justus-Liebig-Universität Gießen. Reihe I (20): 79 - 92.

11. APPENDIX

Appendix 1: Total progress of the Dairy Goat Development Project during its lifetime (1989 – 1997)

Project output	Total target as reviewed in Phase III	Total achieved	Per cent achieved	Remark
Restocking of indigenous goats	1500 households	1541	103	Achieved in phase II
Total indigenous goats distributed	-	1867	-	942 more redistributed from repayment
Self-help dairy goat women groups	95	105	-	-
Distribution of F1 crossbred goats: total - From breeding stations - From private producers - From buck stations - Redistribution of repayment	891 491 91 197 112	914 344 128 419 21	103 70 141 213 19	Only 72% of the target on F1 female distribution met.
Anglo-Nubian buck stations established	15	15		12 were functional by June 1997
Private commercial producers established	16	12	75	11 were active by June 1997
Training and equipment of paravets	190	100		79 were active by June 1997
Establishment of private drug shops	3	2	65	
Training of extension staff: - basic level - advanced level - advanced goat health training	 375 100 15	 407 95 32	 108 95 213	-
Numeracy training of women cashiers	46	116	252	-
Production of dairy goat development extension training package (flip charts)	1	1	100	-
DGDP quarterly newsletters produced	18	18	100	
Formal handing over of DGDP activities to collaborating institutions: - Ministry of Agriculture - Alemaya Univ. of Agriculture - Awassa College of Agriculture	 1 1 1	 1 1 1	 100	-

Source: FARM-Africa (1997b).

Appendix 2: Data collection forms

2.1. Inventory of goats in flock

Flock No:....................... Village:................... Owner:............………. Date opened:.................

Id. No.	Serial No.	Goat name	Sex	Breed	Dent./ DoB	Coat Patt.	Coat type	Entry type	Entry date	Dispo. type	Disp. Date	Remark

2.2 Inventory of family members Flock No:……..

Id. No.	Name of member.	Sex	Age	Relation	Occupation	Education

Other descriptors:

A. Size of cultivated land……B. Number of other livestock owner……C. Any income generating activities…..

2.3 Goat acquisitions

2.3.1 BIRTH Flock No:...............

Id. No.	Serial No.	Goat name	Sex	Breed	Dent./ DoB	Coat Patt.	Coat color	Dam Id. No	Sire Id. No.	Body weight	Birth type	Parity

Birth type: 1=single 2=twin 3=Triple

2.3.2 PURCHASE Flock No:...................

Id. No.	Serial No.	Goat name	Sex	Breed	Dent.	Coat Patt.	Coat color	Purch. date	Price (Birr)	Reason	Body weight	Remark

2.3.3 TRANSFER from another flock Flock No:....................

Id. No.	Serial No.	Goat name	Sex	Breed	Dent.	Coat Patt.	Coat color	Trans. type	Trans. Date	Reason	Body weight	Remark

Type of transfer: 1=temporary 2=gift 3=credit repayment 4=return to owner 5=contract

2.4. Goat disposals

2.4.1 SALES Flock No:..................

Id. No.	Serial No.	Goat name	Sex	Breed	Dent.	Coat Patt.	Coat color	Sales. date	Price (Birr)	Reason	Remark

2.4.2 DEATH Flock No:...................

Id. No.	Serial No.	Goat name	Sex	Breed	Dent./DoB	Coat Patt.	Coat color	Death. date	Cause	Remark

2.4.3 TRANSFER to another flock Flock No:………

Id. No.	Serial No.	Goat name	Sex	Breed	Dent.	Coat Patt.	Coat color	Transfer type	Transfer date	Reason	Remark

Type of transfer: 1=temporary 2=gift 3=credit repayment 4=return to owner5=contract

2.4.4 SLAUGHTER Flock No:.................

Id. No.	Serial No.	Goat name	Sex	Breed	Dent./DoB	Coat Patt.	Coat color	Slaughter. Date	Reason	Remark

Reasons for slaughter: home consumption, honoured guest, sick family member, other (specify).

2.4.5 Other forms of disposal (loss, theft, etc.) Flock No:..................

Id. No.	Serial No.	Goat name	Sex	Breed	Dent./DoB	Coat Patt.	Coat color	Disposal type	Disposal sate	Remark

2.6 Monthly body weight and body condition scoring:

Date of recording: ....

Flock No.	Id. No	Serial No.	Goat name	Body weight1	Body weight2	Dentition	Remark

Formal and informal credit services during past month:

- description of credit ………………….
- amount of credit …………………..
- terms of credit …………………..

Formal and informal insurance services during past month:

- description of insurance …………….
- description of the payments …………
- other details …………………….

Disposal and use of manure during past month:

- sources of manure (number and type of animals) ……………………
- description of disposal ………………………………….
- Any uses of manure ………………………………

2.7 Weekly check-list of study flocks

Flock No: …………….. Date opened: …………………….

Id No.	S.No.	Name	Sex	Breed	DoB	Presence and case during week (indicate data)					Remark
						Wk1	Wk2	Wk3	Wk4	Wk5	

2.8 Register of Milk off-take:

ID. No of doe	Parturition date	Lactation length	Amount of off-take and per cent sold during week				
			Wk1	Wk2	Wk3	Wk4	Wk5

2.9 Register of purchased inputs for goats:

Id. No of goat	description	Type and amount of expense during week				
		Wk1	Wk2	Wk3	Wk4	Wk5

Any change in family size: ……………….. Any change in other livestock: ……………………..

2.10 Labour input on goat husbandry:

Flock No: ………………… Date administered: …………………….

Types of work:		Labour input in minutes by					
		Housewife	Husband	Child1	Child2	Child3	Other
Rearing	Release flock						
	Return flock						
	Clean barn						
	Milking						
	Mating/assist birth						
	Others (specify)						
Feeding	Land preparation						
	Forage development						
	Collect fodder						
	Chop fodder/hand feeding						
	Watering						
	Maintenance/others						
Health care	Care for sick goats						
	Take goats to clinic						
	Take goats to paravet						
	Others						
	Sale/purchase goats						
	Sale goat milk						
	Sale goat manure						
Others	Specify						

Appendix 3: Continuity of introduced technologies

Table 3.1: Frequency distribution of various crosses in study flocks

Breed class	Initial stock (n=171)	Final stock (n=158)
F1	31.0	21.5
F2	31.6	30.4
F3	9.1	9.5
75% AN cross	1.8	6.3
25% upgrade	21.1	19.0
12.5% upgrade	1.2	1.9
25% selfcross	0.0	0.6
62.5% backcross	0.0	0.6
25% backcross	1.8	8.2
12.5% backcross	1.2	1.3
6.25% backcross	0.6	0.6

Table 3.2: Flock dynamics at the Alemaya Dairy Goat Crossbreeding Station from 1992 to 1999

Year of operation	Breed of goat	Inventory		Birth	Purchase	Mortality	Culling	Distribution
		Begin	End					
1992	Somali	135	81	-	-	8	46	-
	Anglo-Nubian	28	23	3	-	8	-	-
	Crossbred	135	105	53	-	37	-	46
	Total	298	209	56	-	53	46	46
1993	Somali	81	48	-	-	12	21	-
	Anglo-Nubian	23	16	3	-	5	3	2
	Crossbred	105	73	39	-	8	5	58
	Total	209	137	42	-	25	29	60
1994	Somali	48	134	3	105	4	18	-
	Anglo-Nubian	16	24	12	-	1	-	3
	Crossbred	73	60	43	-	5	3	48
	Total	137	218	58	105	10	21	51
1995	Somali	134	157	9	42	14	14	-
	Anglo-Nubian	24	13	2	2	6	2	7
	Crossbred	60	76	59	-	9	3	31
	Total	218	246	70	44	29	19	38
1996	Somali	157	136	1	-	13	9	-
	Anglo-Nubian	13	14	6	6	5	2	4
	Crossbred	76	66	47	-	14	2	41
	Total	246	216	54	6	32	13	45
07/98 – 07/99	Somali	131	105	6	-	28	4	-
	Anglo-Nubian	12	11	7	2	10	-	-
	Crossbred	43	44	25	-	10	-	14
	Total	186	160	38	2	48	4	14

(The data for the period in 1997 is incomplete and hence not included)

Table 3.3: Description of private commercial goats producers around the study sites

Descriptors	Dire Dawa	Gursum	Alemaya	Kombolcha
Year of establishment	1993	1993	1995	1996
Initial stock:	(65)	(15)	(9)	(5)
- AN females	4	4	2	3
- AN males	1(temp.)	1 (temp.)	1	1
- Indigenous does	60	10	6	1
Flock size in June 1997:	(84)	(30)	(16)	(5)
- AN females	7	2	3	3
- AN males	4	2	1	1
- Indigenous does	43	20 + 1 buck	6	1
- Crossbred females	17	3	4	-
- Crossbred males	13	2	2	-
Improved goats supplied to the DGDP by June 1997:	(115)	(18)	(-)	(-)
- F1 doelings	79	1	-	-
- F1 bucklings	31	12	-	-
- AN doelings	2	4	-	-
- AN bucklings	3	1	-	-
Flock size in June 1998:	(15)	(26)	(6)	(3)
- AN females	2	-	2	2
- AN males	3	2	-	1
- Indigenous does	4	17	-	-
- Crossbred females	5	4	2	-
- Crossbred males	1	7	2	-
Flock size in July 1999	(23)	(16)	(5)	(-)
- AN female s	3	-	2	-
- AN males	3	-	-	-
- Indigenous does	4	11	-	-
- Crossbred females	11	1	2	-
- Crossbred males	2	4	1	-
Supplied stock during study period: (July 1998 – June 1999)	-	5 F1 female 1 F1 buck	-	-

Table 3.4: Assessment of components of the DGDP technology package by study households in June 1999 (%).

Components	Values	DGDP Participant households owning				Non-participants (n=31)	Total (n=141)
		Crossbreds only (n=27)	Mixed (n=54)	Indigenous only (n=29)	Total (n=110)		
Improved forage development	Not useful	0	1.9	-	0.9	0	0.7
	Impartial*	7.4	-	-	1.8	0.0	1.4
	Useful	92.6	98.1		97.3	100	97.9
Indigenous goat credit	Not useful	-	1.9	-	0.9	-	0.7
	Impartial	-	-	-	-	-	-
	Useful	100	98.1	-	99.1	100	99.3
Crossbred goats credit	Not useful	-	-	-	-	-	-
	Impartial	-	-	-	-	-	-
	Useful	100	100	100	100	100	100
Exotic buck stations	Not useful	-	-	-	-	-	-
	Impartial	81.5	35.2	10.3	40.0	40.5	40.4
	Useful	18.5	64.8	89.7	60.0	59.5	59.6
Women groups	Not useful	-	-	-	-	-	-
	Impartial	11.1	7.4	6.9	8.2	23.3	11.3
	Useful	88.9	92.4	93.1	91.8	76.7	88.7
Farmer training	Not useful	-	-	-	-	-	-
	Impartial	55.6	33.3	10.3	32.7	40.0	34.8
	Useful	44.4	66.7	89.7	67.3	60.0	65.2
Paravet services	Not useful	-	-	-	-	-	-
	Impartial	-	-	-	-	-	-
	Useful	100	100	100	100	100	100

* Impartial = The respondents could not give their opinion about the technology.

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All errors in the content of this work are the responsibility of the author.

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