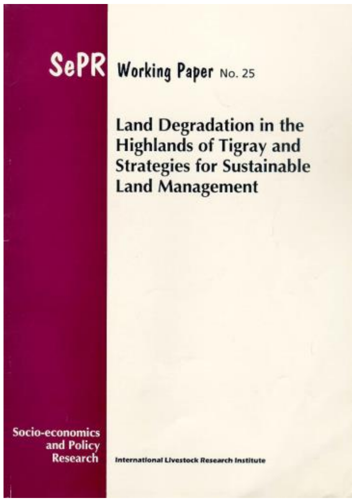
Land degradation in the Highlands of Tigray and Strategies for Sustainable Land Management



Socioeconomic and Policy Research Working Paper 25

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Background

The International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI) and Mekelle University College (MUC) have entered into a collabourative research agreement to undertake policy research on sustainable land management in the highlands of Tigray. This project is part of the ILRI/IFPRI Research programme of Policies for Sustainable Land Management in Mixed Crop-Livestock Systems in the Highlands of East Africa.

The primary purpose of the research project is to facilitate more effective policy and technological responses to the problems of poverty, low productivity, and land degradation in the highlands of Tigray. This goal is to be achieved by the research itself, as well as by strengthening the local capacity to conduct policy research and analysis. The other major objective of the research is to generate broader "international public goods" by testing a methodology for policy research on sustainable land management that can be applied in many other circumstances, and by generating comparative knowledge from Ethiopia[1] and other highland regions in East Africa.

1. IFPRI and ILRI are conducting similar research in the Amhara and Oromia regional states.

The present document is the result of the preliminary phase of the research project. The objective of this phase was to characterise the nature of the land degradation problem and its causes under the diverse circumstances of the highlands of Tigray based upon review of existing studies, interviews with key informants, and analysis of secondary data. This study was intended to help identify specific research hypotheses and areas of focus for a community survey of about 50 Tabias (lowest level of administrative unit in Tigray, equivalent to a Peasant association in other regions) that was launched in the fall of 1998. The main objectives of the community survey are to identify the main pathways of development existing in the highlands of Tigray and to suggest hypotheses about their causes and effects on natural resource management, agricultural productivity and poverty. Those hypotheses will be tested using data collected in a subsequent household level and plot level survey, and policy implications drawn.

The current document outlines the outcome of the review of existing knowledge and literature on the state and causes of land degradation, and the constraints and opportunities for more sustainable development in the highlands of Tigray.

Introduction

Ethiopia is one of the most environmentally troubled countries in the Sahel belt. The principal environmental problem in Ethiopia is land degradation, in the form of soil erosion, gully formation, soil fertility loss and severe soil moisture stress, which is partly the result of loss in soil depth and organic matter. Tigray contains many of the areas of greatest land degradation concern in Ethiopia's highlands. But Tigray is known not only for the severity of land degradation, but also, since the last few years, for the concerted efforts taking place there to redress these problems—including construction of stone terraces and soil bunds, area enclosure and afforestation.

However, in the face of these efforts, little quantitative information is available on the magnitude of the problem, the role of various factors in causing it, or the effects of on-going efforts to solve it. Most of the research conducted on land degradation in Tigray, with few exceptions, has focused on biophysical aspects of the problem—particularly on soil erosion—without much emphasis on the economic, social, or institutional factors that affect how farmers manage their land. Similarly, the policy response to land degradation in Ethiopia has focused on the technical aspects, promoting adoption of particular conservation technologies, particularly physical structures such as terraces and bunds. Although this has helped reduce erosion rates, some economic evaluations of these technologies have shown such technologies to yield low returns to farmers, in some cases actually reducing yields by reducing cultivable area (Sutcliffe, 1993; Catterson, *et al*., 1994) or harbouring rodents. On the other hand, there are also studies that indicate the positive effect of conservation in terms of both reduced soil loss and increased yield (see Berhanu 1998 and Yibabe *et al*., 1996). In any case, these returns haven't motivated farmers to widespread and spontaneous adoption of conservation technologies in the absence of continued public support for the costs of the investments.

If we want to address the problem of land degradation in Tigray and its linkages to agricultural productivity and poverty, we need to take a broader perspective; both in how the problem is defined and in the set of possible solutions considered. For example, it may be that despite reported high erosion rates, soil erosion is not the most important land degradation problem to farmers in many places, nor one that they are likely to take action to prevent. In a semi-arid area such as much of Tigray, farmers may be more concerned about conserving water than soil. For example, a study in Enderta woreda of Tigray has indicated that the majority of the farmers consider moisture stress as the most limiting problem to agricultural production (Fitsum, 1996). Furthermore, the net costs of soil erosion to agricultural production may be much lower than the problem of declining soil fertility (Sutcliffe, 1993). In addition, the nature of the land degradation problems and their causes likely vary from place to place.

This leads to consideration of a broader set of possible solutions than simply conservation programmes, though these have to be also considered. It may be that other areas of policy intervention, such as land tenure policy, infrastructure and market policies have much greater impact than conservation programmes, or largely condition the potential success of those programmes. Compared to the physical structures promoted by conservation programmes, alternative farming practices may be somewhat less effective in reducing the total amount of soil erosion per hectare where adopted but more cost effective per unit of erosion reduction, and thus likely to be more widely adopted. The potential for such alternative policy and programme responses should be investigated.

This approach is especially interesting because there is considerable variation in population density, market access, agricultural production potential and other factors within the region; likely calling for diverse responses in different situations. It is hoped that by accounting for this diversity the conclusions drawn from the research will have fairly broad applicability.

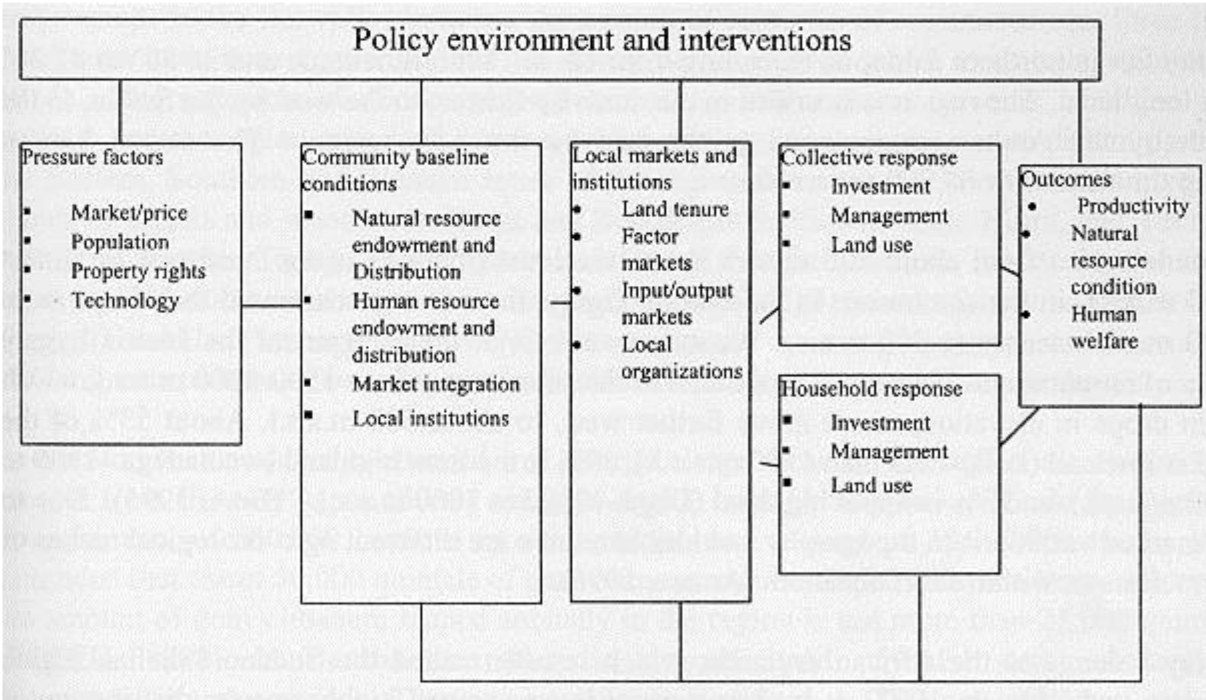
Conceptual Framework

The conceptual framework for the study draws principally from theories of agricultural intensification, which explain changing management systems in terms of changing microeconomic incentives facing farmers as a result of changing relative factor endowments, such as land and labour (Boserup, 1965; Binswanger and McIntire, 1987; Pingali *et al*., 1987; Lele and Stone, 1989; Templeton and Scherr, 1996). Additional variables that we believe are also important determinants of resource management have been included, inspired by theories of collective action (Olson, 1965; Ostrom 1990; Baland and Platteau, 1996), market and institutional development (North, 1990); rural organisation (Bardhan, 1989), and agricultural household models (Singh, *et al*., 1986; de Janvry, *et al*., 1991).

Figure 1 illustrates this conceptual framework. "Pressure" factors operating at a broader national or regional level (for example, population growth, changes in national market prices, development of new technologies, changes in official property rights) are assumed to induce, within individual communities, shifts in local market structure, prices and/or local institutions (for example, local labour or land tenure arrangements). The nature of these shifts will be conditioned by community characteristics that help to determine local comparative advantage (for example, their human and natural resource endowments, market linkages, and local knowledge of natural resource management). The shifts at the community level induce responses in natural resource management (NRM) at both the household and collective levels. At the household level, responses may take the form of changes in land use, product choice, investment, and/or land management (intensity, input mix, and conservation practices). At the community level, responses may take the form of collective land investments, collective self-regulation of private resource use, changes in management of communal resources, or changes in formal or informal rules of access to natural resources. The net results of these changes in NRM are changes in natural resource conditions, productivity and human welfare. Both the responses themselves, and changes in the outcome variables, can have feedback effects on community baseline conditions and local markets and institutions, thus contributing to further change and innovation at the local level.[2]

2. The aggregate effects (across communities) of local responses and outcomes also can have feedback effects on the pressure factors and public policies at a broader scale. We will not attempt to measure these aggregate effects in this project.

Figure 1. *Conceptual framework*



Source: Scherr, *et al*. 1996.

Public policies may influence this temporal process at various levels: through the pressure factors (*e.g.*, agricultural research programmes, sector price policies, resettlement policies); by directly influencing community conditions (*e.g.*, restrictions on natural resource use, infrastructure investment); by intervening in local markets or institutions (*e.g.*, land titling programmes, local credit programmes); by influencing household or community responses (*e.g.*, through technical assistance programmes); or by directly intervening in outcome variables (*e.g.*, nutrition programmes or direct forest management by the state).

Currently available information is not adequate to understand the dynamics of the process and does not provide policymakers with much guidance as to which of these intervention points will be most effective in promoting positive outcomes, key interactions to expect among policies, nor the most appropriate sequence for intervention. Most public action aimed at improving natural resource management in fragile land focuses on influencing household, and to some extent, community responses. Yet, it may be more effective to influence local markets and institutions or to invest in community infrastructure, since these may largely determine household and community response factors. However, we have very little empirical evidence that elucidates the relationship between these different levels of policy action, and their actual effects on the key outcome variables. Finding such empirical evidence is one of the main objectives of this project.

Setting

As discussed above, to understand the problem of land degradation in a given context, it is important to look at the community baseline conditions such as the natural resource base, human resources, existing institutions and infrastructure base, and how these conditions interact with policies and institutions to influence human responses and thereby affect productivity, livelihood and the natural resource base. This section thus considers the setting of the problem.

Natural Features

Tigray lies in northern Ethiopia, extending from 12 to 15 north latitude and 3630" to 4130" east longitude. The region is bounded to the north by Eritrea, to the west by the Sudan, to the south by the Amhara region, and to the east by the Afar region. The region has an approximate area of 80,000 square km.

Altitude varies from about 500 meters above sea level (m.a.s.l.) in the northeast to almost 4000 m.a.s.l. in the southwest. In the east of Tigray, there is an escarpment that drops from 2000 m.a.s.l steeply to 500 m.a.s.l. As we move west of the escarpment the area is largely made of mountainous plateaus. The altitude of this area ranges from 1500–3000 m.a.s.l, which again drops in elevation, as we move further west, to about 500 m.a.s.l. About 53% of the land is lowland (kolla—less than 1500 m.a.s.l.), 39% is medium highland (weinadega—1500 to 2300 m.a.s.l.), and 8% is upper highland (Dega—2300 to 3000 m.a.s.l.) (BoA, 1995). Due to the marked variations in topography and altitude, there are different agro-ecological niches or microclimates within short distances (Amare, 1996).

Tigray belongs to the African drylands, which is often called the Sudano-Sahelian region (Warren and Khogali, 1992). It is characterised by sparse and highly uneven distribution of seasonal rainfall, and by frequent occurrence of drought. The amount of rainfall increases with altitude and from east to west, and decreases from south to north. Average rainfall varies from about 200 mm in the northeast lowlands to over 1000 mm in the southwestern highlands. In the highlands close to the eastern escarpment the average rainfall is 450 mm. In the central part of the region near Axum and in southwestern Tigray average rainfall approaches 1000 mm. Rainfall declines again with altitude as we move further to the west.

Rainfall is highly variable temporally as well as spatially. The coefficient of variation in annual rainfall for the region is about 28 percent, compared to the national figure of 8 percent (Amare, 1996). Most of the rainfall falls during the "Meher" season from June to September (it is most intense during July and August). In some parts of Tigray, there is short rainy season called "Belg" which falls during the months of March, April and May.

Average temperature in the region is estimated to be 18C, but varies greatly with altitude. In the highlands of the region, during the months of November, December and January, the temperature drops to 5C. In the lowlands of western Tigray, especially areas around Humera, the average temperature increases from 28C to 40C during the summer.

Various studies identified 13 major soil types (Hunting, 1976; TAMS, 1974; FAO/UNESCO, 1971) in Tigray; namely, Cambisols, Rendzinas, Lithosols, Acrisols, Fluvisols, Luvisols, Regosols, Nitosols, Arenosols, Vertisols, Xerosols, Solonchacks, and Andosols. In the eastern part of the region the soils are mostly developed under arid conditions where the weathering process is slow and as a result very shallow lithosols are dominant on the steep slopes. Cambisols and vertisols are developed in the higher rainfall areas of the south on alluvium derived from basalt. In the western part of the region, the soil type varies according to the parent material (RCST, 1996). Generally, the soil of the region is highly eroded and with low fertility.

The highland plateau of Tigray is said to have been once covered by Junipers, Olea, and Cordia, alternating with montane Acacia - Andropogon Savannah, and by edaphic grasslands and swamps in the flat valley bottoms. As a result of centuries of continuous use, these lush conditions have been converted into the almost barren plateau which exits today (Hunting, 1974). The remnants of climax vegetation that are still existent in some localities also indicate that the region was once covered with lush vegetation, in the not so distant past. In the Eastern, Southern and Western zones of the region there are still some areas with good stands of forests and woodlands. Dessa and Boholeusot in Eastern zone, Hirmi, and Tekezze valley in Western Tigray, Hugumburda and Grat Kahsu in Southern Tigray are the main localities with substantial vegetative cover, accounting for 1.6 percent of the total land area of Tigray (Land Use Planning Team, 1996). The commonly occurring tree species in these areas are Juniperus procera, Olea europea, Cordia africana, Podo carpus gracilior and Acacia spp.

In addition to the above mentioned tree species, large areas of the region are covered by incense trees (Boswellia_papyfifera) and gum Arabic trees (Acacia senegal). In the Western Zone an area of 500,000 hectares is estimated to have a stand of 30,000,000 trees. It is estimated that about 50,000 quintals of gum olibanun can be tapped from the trees. However the amount of gum olibanum tapped annually in the region is not more than 25,000 quintals (BOPED, 1995). In Dansha area there is a good stand of solid stemmed bamboo (Oxytenanthera abyssinica) of potential economic significance. The gum olibanum and the gum Arabic obtained from the trees have demand in external markets, and are important commodities for earning hard currency. The bamboo found in western Tigray is useful for construction and paper manufacturing. The woodland of the lower Tekezze basin and the wildlife that are harboured in it can also be profitable assets as tourist attractions. Conservation based park establishment can help to protect and develop these resources.

About 90 billion MCU of water is drained from the region via the Tekezze basin. Studies indicate that about 300,000 hectares of land are suitable for irrigation from surface water sources (SAERT, 1994). Adjacent to the confluence of Tekezze and Giba rivers, there is a site suitable for a large dam envisaged to store about a half a billion MCU of water and capable of irrigating about 60,000 hectares of land downstream (BOPED, 1995). The potential of ground water is considered to be ample, although this has not been well studied[3].

3. According to sources in the Tigray Bureau of Agriculture and Natural Resources (TBANR) only minor exploration studies have been undertaken to identify ground water potential in the region.

Socioeconomic Features

The population of Tigray was 3,136,000 in 1994, 85% of which lived in rural areas (CSA, 1995). The annual population growth rate is estimated to be at least 3.2% (Amare, 1996). About 45 percent of the population is below the age of 15, indicating a high dependency ratio and the likelihood of continued rapid population growth as children reach child bearing age. The average population density of the region is 39 people per sq. km. (CSA, 1995). The average arable land holding in the region is 1.2 hectares per household (SAERT, 1994), varying from 0.5 ha in the eastern highlands[4] to 2.0 hectares in the lowlands (BOPED, 1995). More than 60% of households hold less than one hectare of farmland (SAERP, 1997).

4. Highland here refers to areas above 1500 m.a.s.l.

According to estimates from the Tigray Bureau of Planning and Economic Development (BOPED), about one fourth of the land area was cultivated and 40 percent used for grazing in 1992/93 (SAERT, 1994). The rest is mainly unused land. Only small areas of forest remain. It is estimated that about 500,000 hectares of cultivable land[5] has not yet been developed, mainly in the western lowlands (BOPED, 1995). There is an estimated 1.5 million ha of cultivable land in Tigray, of which about 1 million ha (67%) is presently cultivated by smallholder farmers (Mezgebe, 1996).

5. Currently commercial agriculture is emerging in those areas where there is extensive potential cultivable land, in the western lowlands.

There are three main farming systems in Tigray; namely, the pastoral system, the mixed pastoral and cereal production system, and the mixed crop–livestock farming system. Mixed crop–livestock farming is the dominant system in the highlands; pastoral systems are more common in the lowlands. Of the estimated 616,000 farmland holders in Tigray in 1996/97, more than three-fourths were mixed crop–livestock producers (CSA, 1997).

Almost all of the cropland is planted to annual food crops, including cereals (teff, wheat, barley, maize, sorghum, millet), pulses (beans, chick peas, lentils), and oilseeds (sesame, flax, noug).[6] A very small fraction of farmers (less than 1%) produce vegetables, fruits, or spices (SAERP, 1997). These crops are grown mainly in homestead gardens or where irrigation exists. Two thirds of farmers do not fallow, mainly due to the shortage of farmland. Manure and/or crop residues are used to maintain soil fertility by about 60% of farmers. Chemical fertilisers are used by only about 12% of farmers; high costs and lack of knowledge are the main reasons cited by those not using them (Ibid.). Uncertain rainfall is also an important factor limiting fertiliser use. The vast majority of farmers (90%) practice crop rotation, while less than half use intercropping. A large majority of farmers (87%) practice terracing on their own farmland; the main reasons cited by those who don't include the large amount of labour required and the fact that terraces harbour rodents. Improved seeds are used by only about one-fourth of farmers: high costs, unavailability and lack of knowledge are the main reasons cited by those not using them. One fourth of households use pesticides while only about 5 percent use herbicides: lack of knowledge and high costs are the main reasons cited for not using them. Given the low level of rainfall, lack of use of fallow and low level of input use, it is not surprising that crop yields are low. Cereal yields are typically less than 1 ton per ha, except under irrigated conditions.

6. Much of the information in this section is based upon a socioeconomic survey of 4000 households in Tigray conducted in 1996 by the Sustainable Agriculture and Environmental Rehabilitation Programme (SAERP), supported by the United Nations Economic Commission for Africa (SAERP, 1997).

Livestock are also very important to agriculture in Tigray. Two thirds of households in Tigray own at least one ox, and about half own at least one cow (Ibid.). Among households that own oxen or cows, average ownership is 1.5 oxen and 1.9 cows. About one third of households own goats and one fourth own sheep; these households average about 7 goats or sheep per household. Donkeys are the most common pack animal; owned by about one-third of households. About three-fourths of households raise some chickens; on average about 7 per household that owns chickens. Bee keeping is an activity of about 10% of households.

The availability of feed and water are serious constraints to livestock production in Tigray. Communal grazing areas, private pastures and crop residues are the principal sources of feed. Three-fourths of farmers in SAERP's survey reported lack of feed, particularly crop residues, to be a serious constraint to livestock production (SAERP, 1997). More than a third of farmers reported spending more than one hour per day to take their animals to a water source (Ibid.). Various diseases are also important constraints. For example, a substantial fraction (more than 10%) of sheep and goats are afflicted by pasteurellosis (Ibid.).

Poverty and food insecurity are very severe in Tigray. Several hundred thousand people died during the famine of the mid 1980s, and many are affected by food shortages on a regular basis. In 1996, nearly three-fourths of respondents in SAERP's survey reported being affected at least twice by famine since 1985 (SAERP, 1997). A survey by the Relief Society of Tigray (REST) in Central Tigray found that over 80 percent of households faced a food deficit in 1992/93 (REST, 1995).[7] The infant mortality rate is 123 per 1000 live births and average life expectancy is only 49 years (CSA, 1995).

7. REST was established in 1978 to provide relief assistance to the people of Tigray in the areas where the Tigrayan People's Liberation Front (TPLF) was active during the war. Currently REST has shifted its emphasis from wartime relief activities to rehabilitating the war-torn society and economy and achieving sustainable rural development and self-reliance.

Social services are very limited, particularly in rural areas. In 1994, only about 14% of rural adults were literate, while 57% of urban adults were (CSA, 1995). Only 11% of rural households had access to potable water (through piped water or protected wells) compared to 74% of urban households. Less than 3 percent of households in rural areas had a toilet, compared to 29% in urban areas. Almost half of urban households had access to electricity, compared to virtually none in rural areas. Only 14% of households had a radio.

The main source of energy in the region is biomass. According to studies conducted by the Bureau of Mines, Energy and Water, about 85–90% of the energy demand of the region is obtained from biomass (BOPED, 1995). In rural areas, the population's energy demand is met 66% from fuel wood, 12% from dung and 9% from crop residues. In urban areas, the source of energy is 50% charcoal, 40% fuel wood and 2% dung (Ibid). The sources of biomass are dwindling in the region as a result of deforestation, recurrent drought, limited tree planting (compared to the level of consumption and deforestation), and limited management of planted trees, causing low survival rates of the trees that are planted. Poverty and the lack of supply of alternative energy sources create pressure on the already dwindling biomass energy sources. The utilisation of modern energy sources (such as electricity and kerosene) is very low in the region and is limited to a few towns. Per capita electricity consumption is less than 2 kilowatts in the region[8] (Ibid.) Annual kerosene consumption is less than 4 litres per household (BOPED, 1995).

8. This will change with the introduction of hydroelectric supply lines, which is currently under extension.

The transport infrastructure is poor and underdeveloped. In Tigray there are 976 km. of gravel all-weather roads and 1,400 km. of rural roads. This amounts to only 0.31 km. of all-weather road per 1,000 people, less than half the average for Africa as a whole (BOPED, 1995). Much of the road network is in poor condition: 80–85% percent of the gravel road is in need of intensive maintenance, and the rural roads are mostly not fit for motor vehicle transport services (BOPED, 1995). As a result, walking and pack animals still remain the dominant modes of transportation in rural areas. Nearly half of households carry goods to the main market on foot and more than half by pack animal; the trip requires more than 2 hours for most households (SAERP, 1997). A survey in Central Tigray found that the average time to reach the nearest all-weather road was more than 4 hours (REST, 1995).

Land Degradation in Tigray

Soil erosion, soil nutrient depletion, and soil moisture stress are the major land degradation problems facing the region. Though soil erosion is prevalent throughout Ethiopia, this problem is particularly severe in Tigray. The early settlement and expansion of agriculture, together with the steep terrain and the erratic and intense nature of the rainfall has caused erosion to be a major problem. Quantitative soil loss estimates are rare in Tigray (Berhanu, 1998). Nonetheless, the persistent deterioration of the quality of the cultivated land, the ever expanding gullies, and the poor yields, partially explained by the poor water holding capacity of the soil, suggest that soil erosion is a critical problem. The available estimates give us a general picture of the magnitude of the problem.

The soil of the region is highly degraded. Hurni (1988) estimated that more than half of the area of the highlands of Tigray was severely degraded, with soils less than 35 cm deep (Ibid.). According to Hurni and Perich (1992), Tigray's soils are believed to have lost 30–50 per cent of their productive capacities compared to their original state some 500 years ago. REST's recent studies in seven woredas of the central zone of Tigray indicate that about 46 per cent of the currently cultivable land is exposed to severe soil erosion. Though two decades ago, about 30 per cent of the cultivated land is said to have required soil and water conservation measures (Hunting, 1975); now almost all the cultivable land needs treatment. At the present rate of conservation work, 20–25 years would be necessary to cover all of Tigray (Tekeste and Smith, 1989).

Estimates of soil erosion rates vary substantially, but are high in many areas. According to the Hunting Report (1975) the average rate of erosion in the central highlands of Tigray, the most densely populated area, was measured to be above 17 metric tones per hectare per year. Other studies in the 1980's reported estimates of erosion rates of more than 80 tonnes per hectare per year (REST, 1989a; 1989b; Tekeste and Smith, 1989).[9] A recent study of erosion in part of central Tigray near Adwa estimated that 18% of the area studied was eroding at rates exceeding 10 tons/ha/year, based upon the Universal Soil Loss Equation (USLE) (Eweg, *et al*. 1997). According to the Ethiopian Highlands Reclamation Study (EHRS), about 80 per cent of the erosion in the Ethiopian highlands was estimated to occur on croplands, and the remainder on overgrazed grasslands, wastelands and newly deforested areas (EHRS, 1985). The annual loss from cultivated land in the Ethiopian highlands was estimated to be 130 tons/ha, and this was expected to result in a loss of 7.6 million ha of cropland to productive use in Ethiopia by the year 2010 (Ibid.). Hurni subsequently estimated much lower erosion rates from cultivated land (42 tons/ha/year), though still much higher than the rate of soil regeneration (3–7 tons/ha/year) (Hurni, 1988). Based on Hurni's erosion estimates, Sutcliffe (1993) estimated that 0.5 million ha of cropland and 5.7 million ha of pastures would be lost by 2010.[10]

9. One needs to be cautious about the reliability of the information. Few thorough assessments have been made under various conditions.

10. The EHRS did not estimate the area of pastures expected to be lost to erosion.

There is also considerable variation in estimates of the production and economic impacts of soil erosion in the Ethiopian highlands. The Highlands Reclamation Study estimated that erosion would result in a reduction of crop production of 2.6 million tons by 2010, while Sutcliffe's (1993) estimates are only 13% of this. Estimates of the annual costs of erosion in the Ethiopian highlands range from EB 10 million to EB 135 million per annum (0.05% to 0.7% of agricultural

GDP); while the estimated gross discounted present value of cumulative losses caused by erosion ranges from EB 3 billion to EB 7 billion (Bojo and Cassells, 1995). Despite the debate over these magnitudes, it is clear that soil erosion is causing substantial costs to agriculture in the Ethiopian highlands. The relative impacts are probably greater in Tigray, where soil erosion is more severe than in much of the highlands.

Soil nutrient depletion poses a related and likely at least as critical a problem for agricultural production in Tigray. No estimates are available on the extent of the problem in Tigray specifically. For Ethiopia as a whole, estimated nutrient losses were more than 80 kg of nutrients per hectare in 1983 (including 41 kg of N, 13 kg of P_2O_5 , and 31 kg of K_2O), among the highest rates of depletion in sub-Saharan Africa, and are predicted to be even higher by the year 2000 (Stoorvogel and Smaling, 1990). The main cause of nutrient outflow in Stoorvogel's and Smaling's estimates is soil erosion (about 60 kg/ha), followed by removal of harvested products and crop residues; while inflows from manure and chemical fertiliser are very low (averaging less than 10 kg/ha). In Tigray, the use of chemical fertiliser is even lower than for most of Ethiopia, averaging less than 3 kg/ha (BOPED, 1995).

A major cause of the high removal of nutrients in crop residues and low addition of manure is burning of dung and crop residues to satisfy household energy needs. Sutcliffe (1993) estimated the impact of nutrient depletion due to burning of dung and crop residue in the Ethiopian highlands to be 465,000 tons of grain and 1 million tropical livestock units (TLU) of livestock production in 1990, valued at EB 580 million. Bojo and Cassells (1995) estimate the gross discounted cumulative loss due to this to be about EB 8 billion (compared to their estimate of EB 3 billion for cumulative losses due to erosion). Thus the costs of nutrient depletion due to burning of dung and crop residues may be larger than (though of the same order of magnitude as) the costs of soil erosion. Although these estimates are clearly subject to substantial uncertainties, and most are not specific to Tigray, they suggest that both soil nutrient depletion and soil erosion are major problems in Tigray.

Soil erosion and nutrient depletion are exacerbated by, and also exacerbate, the problem of moisture stress inherent in the semi-arid environment of Tigray. The amount of rainfall, even in a normal year, is not sufficient to sustain normal crop growth in most parts of Tigray, unless water harvesting mechanisms or supplementary irrigation is introduced. Under average conditions and presuming the moisture deficit is uniformly distributed over the growing season, yields will be 45% below potential (SAERT, 1994a). The problem is of course much worse in poor rainfall years, and where soils are thin and degraded. The very thin layer of topsoil and low organic matter content of the soil in many places as a result of erosion and limited recycling of organic matter limit the moisture holding capacity of the soil. Low soil moisture in turn reduces the ability of plants to utilise the nutrients that are available, leading to increased nutrient losses through leaching and volatilisation. It also reduces the return and increases the risk of applying fertiliser, thus reducing inflows of nutrients as well. Poor soil moisture and nutrient conditions lead to poor plant growth and low vegetative cover during erosive rainfall periods, leading to higher rates of erosion, and reduced availability of crop residues to recycle into the soil. The result is a viscous cycle of erosion, low organic matter content, low soil moisture, and poor soil and plant nutrition, contributing to worsening land degradation, low productivity and poverty.

Other major and related natural resource problems in the region include the degree of deforestation, causing a severe shortage of fuelwood and construction material, and overgrazing, causing a severe shortage of feed resources. These problems are also of course related to soil erosion and soil nutrient depletion. Both contribute directly to soil erosion and to the general shortage of biomass in Tigray, which limits the ability of farmers to recycle nutrients from dung and crop residues into the soil.

The implications of all these processes are lower and less reliable crop yields, reduced grazing and browsing for livestock, decrease in availability of fuelwood, decrease in soil water holding capacity, declining dry season water flow and thereby low irrigation possibility. These all mean a decrease in the potential for sustained crop production. Crop production in most areas of Tigray does not reach the subsistence level, even in times of adequate rainfall. For example, according to the survey done by REST and NORAGIC (1995) in the central zone of Tigray, the number of households that can feed themselves for about 4–6 months of the year amount to 42 per cent against 17 per cent that are food self-sufficient.[11] The situation is worse in the eastern zone as the zone is more severely affected by drought and moisture stress.

11. About 82 per cent of the households are classified as food insecure.

The consequence has been a series of both localised and regional disasters, characterised by drought, famine, and associated population displacements. Among the recent regional calamities are the famines of 1971–75 and 1984–85. Famine as a natural and social phenomenon induces loss of animal and human life, disposition of meagre household assets, and more pressure on natural resources to compensate for lost incomes (e.g. sale of firewood). These in turn affect farmers' ability and willingness to invest in conserving their land. Studies in very similar conditions elsewhere in Ethiopia have indicated that poor farmers living under stress with severe material or cash needs have very short time horizons and are thus less able to plan or invest for the future (Holden *et al*., 1998). The cumulative effect has been profound socioeconomic and resource stress. Although there has been some improvement in socioeconomic conditions in recent years, alleviating land degradation and its impacts on food insecurity and poverty remains an issue of highest priority in the region.

Causes of and Responses to Land Degradation

The natural resource management problem is characterised by a widening gap between actual land uses and those dictated by the capability and sustainability of particular ecosystems. The natural resource management challenge emanates from a basic conflict between two sets of imperatives: the biophysical, political and socioeconomic imperative of sustainable utilisation of ecosystems on the one hand; and the political and socioeconomic compulsions that determine the current unsustainable patterns of resource use on the other (Shanmugaratanam, 1994). Hence, the cause of this disjunction resides not only in the natural world but also in the political economy of the society.

The direct causes of land degradation are apparent and generally agreed. These include production on steep slopes and fragile soils with inadequate investments in soil conservation or vegetative cover, erratic and erosive rainfall patterns, declining use of fallow, limited recycling of dung and crop residues to the soil, limited application of external sources of plant nutrients, deforestation and overgrazing (Figures 2 and 3). Underlying these proximate causes include many factors, e.g. population pressure, poverty, high cost and limited access to agricultural inputs and credit, low profitability of agricultural production and many conservation practices, high risks facing farmers, fragmented land holdings and insecure land tenure, short time horizons of farmers, and farmers' lack of information about appropriate alternative technologies. Affecting many of these factors are government policies relating to infrastructure development, market development, input and credit supplies, land tenure, agricultural research and extension, conservation programmes, land use regulation, and local governance and collective action.

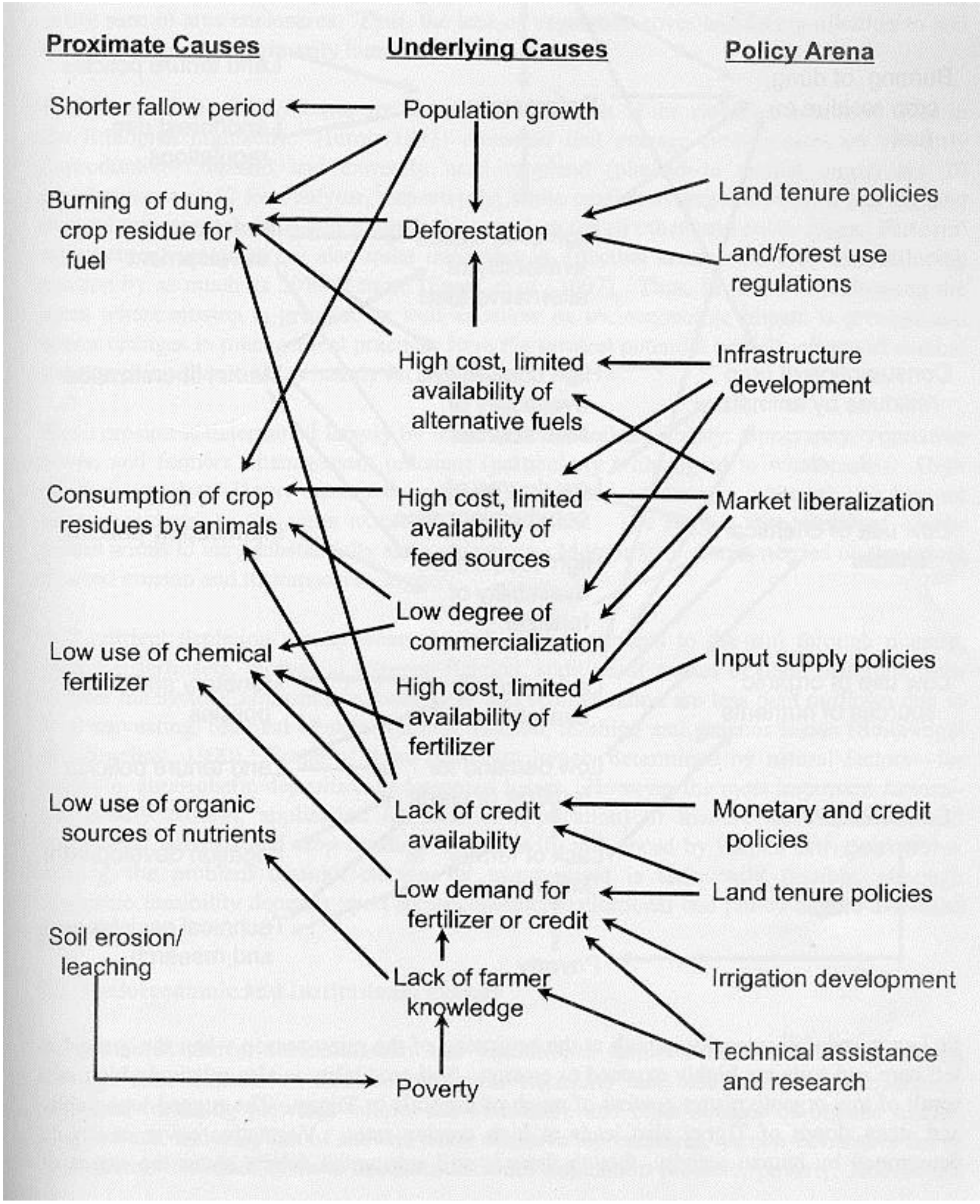


Figure 2. *Causes of soil erosion.*

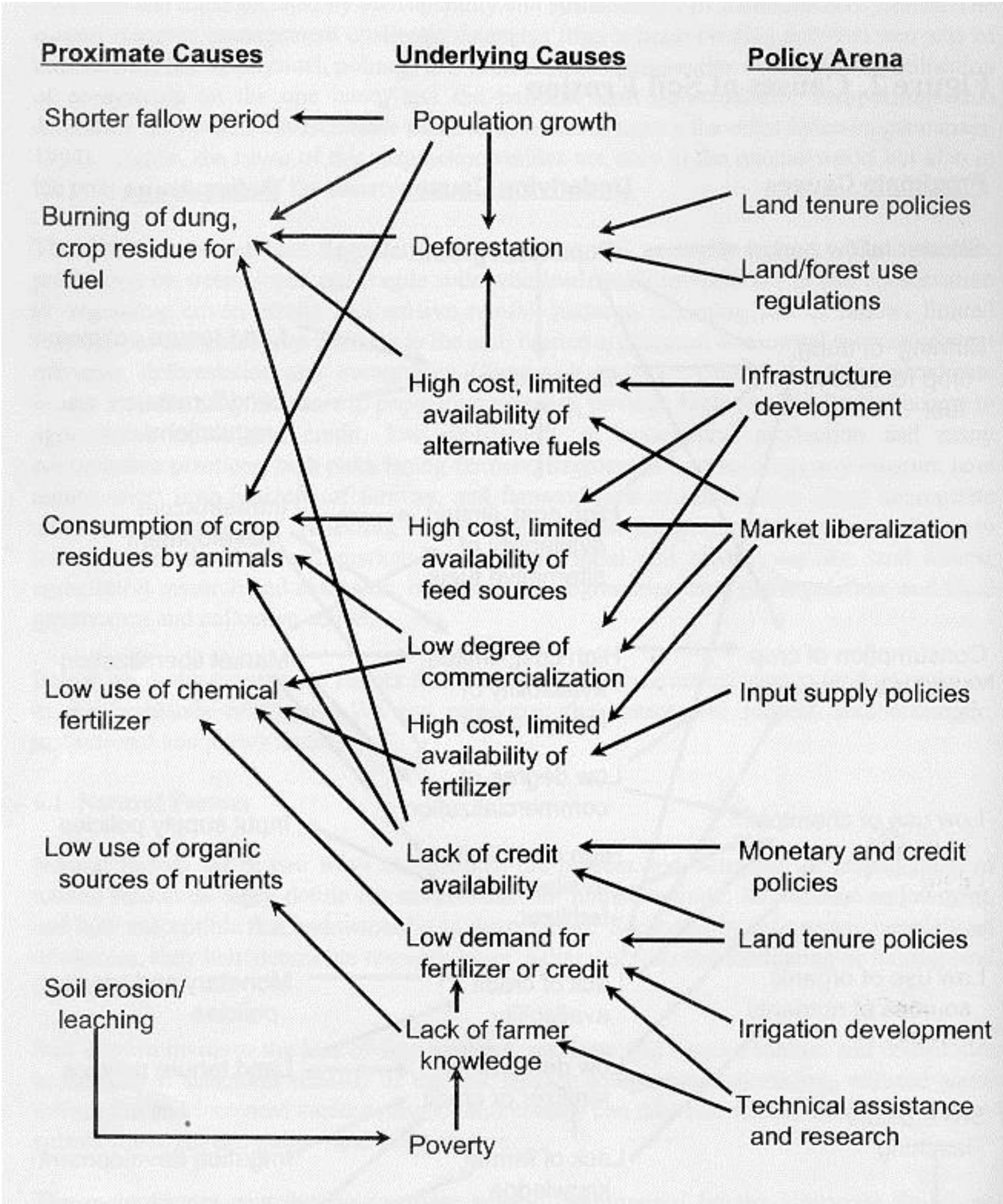


Figure 3. *Causes of nutrient depletion.*

Below we discuss numerous factors that are believed to have contributed to land degradation in the highlands of Tigray. We can categorise the causes into natural, socioeconomic, institutional and policy factors.

Natural Factors

Natural factors act in two ways to influence the process and outcomes of management of natural resources. They define the environment for human activity, its resource endowment, and how susceptible that endowment is to degradation. Secondly, by influencing people's set of choices, they help determine resource users' behaviour, thereby facilitating or halting land degradation.

Soil erosion involves the loss of fine particles, nutrients and organic matter, and contributes to the loss of structural stability of the soil, surface compacting and sealing, reduced water infiltration and increased surface runoff. Soil erosion can take two forms: erosion by water—splash, sheet, rill and gully—and wind erosion.

The main factors contributing to water erosion, summarised by the Universal Soil Loss Equation (Wischmeier and Smith, 1978), are rainfall erosivity, determined by the energy, intensity and duration of rainfall; the erodibility of the soil, determined by soil type, texture, and organic matter content; the slope gradient and length, determined by topography; the type and density of vegetative cover (particularly during peak rainfall events); and farmers' management practices, such as plowing and the presence of conservation structures such as terraces, grass strips, field bunds, etc. Except for farmers' management practices and vegetative cover, these are largely naturally determined factors, although human activities do influence soil texture and organic matter content to an important extent.

In Tigray, rainfall intensity is high at the beginning of the rainy season when the ground is left bare and soils are highly exposed to erosion. Soil erodibility is also relatively high as a result of low organic matter content of much of the soils in Tigray. The rugged topography and steep slopes of Tigray also leads to high erosion rates. Vegetative cover is largely determined by human activity, though there is still substantial debate about the extent of natural vegetative cover in northern Ethiopia. Although an estimate that 40% of Ethiopia's land area was covered by forest at the turn of the 20th century is commonly cited (e.g., Berhanu, 1998), recent archeological work has found evidence of heavy deforestation in the northern Ethiopian highlands as long as 500 years ago (Hans Hurni, personal communication). Nevertheless, there may have once been natural vegetation covering much of Tigray, even though the deforestation may have occurred much further in the past than many people currently believe. This is consistent with the vegetation still observed in protected areas and churchyards in Tigray and with the rapid regeneration of vegetative cover being seen in area enclosures. Thus, the lack of vegetative cover and its contribution to soil erosion appear to be primarily human-induced.

Differences in vegetative cover are responsible for much of the variation in erosion rates in the Ethiopian highlands. Hurni (1988) estimated that average erosion rates on currently unproductive cropland and currently used cropland (planted to annual crops) are 70 tons/ha/year and 42 tons/ha/year, respectively; while erosion averages 8 tons/ha/year on land planted to perennial crops and 5 tons/ha/year or less for all other land cover types. Farmers' management practices are also quite important in affecting erosion on cropland, reducing erosion by as much as 50% or more (Eweg *et al*., 1997). Thus, in terms of addressing the areas where erosion is greatest, as well as where its socioeconomic impact is greatest and where changes in management practices have the greatest potential benefit, efforts to combat water erosion should focus mainly on cropland.

Wind erosion is determined largely by wind velocity, soil erodibility, topography, vegetative cover, and farmers' management practices (particularly with regard to windbreaks). High winds in much of Tigray cause wind erosion to be a serious concern, although this has not been considered to the same extent as water erosion. The rugged topography of Tigray causes winds to vary substantially across locations. More information is needed on the extent of wind erosion and its impacts in Tigray.

Soil nutrient depletion results when the inflows of nutrients to the soil through manure, chemical fertilisers, biological nitrogen fixation, addition of wastes or plant materials from outside the system, atmospheric deposition, and sedimentation are less than outflows due to crop harvesting, removal of crop residues, erosion, leaching and gaseous losses (Stoorvogel and Smaling, 1990). Some of these flows are largely determined by natural factors—for example, atmospheric deposition and gaseous losses. However the most important factors—particularly erosion, application (or lack of application) of manure and fertilisers, and removal of harvests and crop residues—are heavily influenced by human activities. Thus, solving the problem through changes in management is technically feasible, although economic feasibility depends upon socioeconomic, institutional and policy factors discussed below.

Socioeconomic and Institutional Factors

As discussed above, socioeconomic and institutional factors influence land degradation through their impacts on farmers' decisions regarding land use and land management practices, including plowing, fallow, use of manure and other sources of organic matter, fertiliser use, and adoption of soil and water conservation measures. A non-exhaustive list of such factors influencing these decisions includes population pressure, poverty, land tenure relationships, the nature of local markets, local institutions and organisations, and farmers' perceptions and attitudes. We consider each of these below, in the context of the highlands of Tigray.

Population Pressure

As discussed earlier, the population of Tigray is growing rapidly and, although the average rural population density is only 33 persons per square km, the population density per unit of arable land is much higher (138 persons per square km). As a result, farm sizes are very small and the use of fallow is rapidly disappearing, causing problems of declining soil fertility and erosion. Population growth increases the demand for land and contributes to farming on steep and fragile soils, also leading to erosion problems. It increases demand for biomass as a source of fuel, leading to deforestation and increased burning of dung and crop residues, thus increasing the problems of erosion and nutrient depletion. Population growth increases demand for livestock products and therefore leads to increased livestock numbers, causing overgrazing and consumption of crop residues by animals.[12]

12. The impact of livestock consumption of crop residues on soil nutrient depletion is offset to the extent that manure is recycled to the soil; however, burning of dung removes much of these potential soil nutrients.

Population pressure also can contribute to other socioeconomic problems, which themselves contribute to land degradation. Poverty may be worsened by population growth as a result of resource constraints and decreasing returns to capital and labour in agriculture (Pender, 1998). Land tenure may become more insecure and landholdings more fragmented as a result of population pressure, particularly if (as in the past in Tigray) land is redistributed by the government to make room for new landholders. Local institutions and organisations for collective action may break down as a result of population pressure, particularly if population change is rapid and large migration is involved, thus undermining the stability and homogeneity of communities (Pender and Scherr, 1998; Baland and Platteau, 1996).

Not all of the impacts of population pressure are necessarily negative, however. By increasing the value of land relative to labour, population growth may induce farmers to make labour intensive investments in land improvement and soil management, such as constructing terraces, composting or mulching (Pender, 1998; Tiffen *et al.,* 1994). In Tigray, we do see large investments in soil and water conservation taking place, although much of this is stimulated by government policies and development programmes (more on this below). Population growth may also induce beneficial changes in markets and institutions or investments in infrastructure that would otherwise not occur (Ibid.). For example, population growth is commonly held to induce development of more privately-held property rights, which may favour investments in land improvement and better soil management, though this is much debated in the African context (Platteau, 1996). It may also induce development of infrastructure and markets, by allowing the fixed costs of these developments to be spread over a larger number of beneficiaries (Pender, 1998; Tiffen *et al.*, 1994; Boserup, 1965).

Poverty

The extreme poverty existing in Tigray likely contributes to land degradation for many reasons. Population pressure on the land is worsened because people lack access to alternative sources of livelihood. Deforestation and burning of dung and crop residues are increased by people's inability to afford or lack of access to alternative fuel sources. Poverty similarly limits farmers' ability to purchase feed or livestock products, contributing to overgrazing, and their ability to purchase chemical fertiliser, contributing to soil nutrient depletion. Poor farmers may lack access to draft animals, implements, or other capital items needed to make major investments in land improvements. Poverty tends to increase farmers' short-term perspective, limiting their interest in investing in soil and water conservation measures that yield benefits only in the longer term (Holden *et al* 1998; Pender, 1996). The lack of education or access to information associated with poverty may cause farmers to be less aware of land degradation problems, or to attribute such problems to causes beyond their control, and thus may reduce their efforts to address such problems (Ervin and Ervin, 1982).

As with population pressure, however, there are also reasons to believe that poor people may be more likely to conserve their land. Since they may "own" little else than the land they occupy[13], poor farmers may have more incentive than wealthy ones to manage what they have carefully. Furthermore, they may have few alternative investments available to them, so they may give high priority to investing in the land. Finally, the opportunity cost of poor farmers' labour time may be very low at certain times of the year, encouraging them to make labour intensive investments in land improvement and soil management.

13. All land in Ethiopia is owned by the state. Nevertheless, farmers in Tigray have permanent rights to use and bequeath land, and thus may develop a strong sense of land ownership. This is discussed in more detail in the next subsection.

Land Tenure

Several aspects of land tenure arrangements influence farmers' decisions with regard to land management, including tenure security, whether land is managed privately or communally, landholding size and fragmentation, the ability to mortgage land, and the ability to transfer land by sale, lease, or bequest. We consider each of these briefly.

Tenure security determines the extent to which farmers may benefit from investments made to improve the land. In the extreme case in which farmers expect to hold land for only the current season, they will have no incentive to invest; rather, their incentive is to get the maximum that they can from the land, even if that means undermining its future productive capacity. More generally, farmers may expect to use land for an undetermined period of time, but consider that there is some risk that they will lose this right in the future. The greater the risk of losing the right, the less likely they are to invest, or to conserve the productive capacity of the land (Feder, *et al*., 1988).

It is important to recognise that tenure security does not require private land title, or even private ownership. There is substantial evidence from elsewhere in Africa that farmers can be secure in access to a given piece of land and make investments on it without having title, and even where land is communally owned (Otsuka, 1998; Platteau, 1996; Place and Hazell, 1993). What is required is recognition and respect of the right of an individual or well-defined group to continue to use a given piece of land over a long enough term for investments to be viable. This may exist under communal or private tenure, and whether or not such rights are officially sanctioned by the state through titling or other means.

Communal tenure may undermine incentives to manage land in a sustainable manner for other reasons. Where land is managed collectively, "free rider" problems may undermine the incentive of individuals to contribute to successful collective action (Olson, 1965; Hardin, 1968). There is ample evidence that such problems can be successfully overcome in developing countries (Baland and Platteau, 1996; Ostrom, 1990), but the ability to do so may be undermined by many factors, such as instability of community membership (for example, as a result of migration), breakdown of social norms, short time horizons, a large group of beneficiaries, etc. (Rasmussen and Meinzen-Dick, 1995). On the other hand, communal tenure may allow community members to take into account the costs of one farmer's management decisions on other community members, or social or equity considerations that may not be adequately accounted for under private tenure (Platteau, 1996).

Small landholdings and land fragmentation may undermine farmers' interest in undertaking some types of land improvements, regardless of tenure security or private management. For example, farmers may find the costs of hauling manure or other organic materials to distant and small plots not worth the considerable effort required. In addition, investments that can be easily damaged by free ranging livestock or subject to theft (such as trees) are less likely to be made far from the household where it is difficult to protect them.

The ability to mortgage land may affect farmers' access to credit, which may in turn affect their ability to make land-improving investments (Feder *et al.*, 1988). Evidence from elsewhere in Africa suggests that this may not be a serious constraint where formal credit markets are not well developed and farmers rely primarily on their own savings or informal sources of credit (Place and Hazell, 1993; Gavian and Fafchamps, 1996). Nevertheless, the absence of this option may limit the development of formal credit markets, particularly where commercial agriculture is developing.

The ability to transfer land can have several impacts on land management. Land sales and leasing allows land to be used by farmers who are able to earn the highest return from it, perhaps because of greater access to scarce factors of production (such as draft animals, farm implements, labour, or management ability) or greater interest or ability to invest in land improvement (Pender and Kerr, 1997; Besley, 1995). The ability to transfer land may provide greater incentive to invest in land improvement, since this increases the farmer's ability to recoup the value of such investments (in the case of sales or leasing) or extends the time period during which investments may yield meaningful benefits (in the case of bequests) (Pender and Kerr, 1997). In addition, mixed leasing arrangements such as sharecropping may increase farmers' access to scarce factors of production such as labour, credit, or draft power, or may help farmers to cope with risk in the context of imperfect information and contract enforcement (Braverman and Stiglitz, 1982). These effects may in turn influence whether farmers are able to manage land in a sustainable fashion.

The systems of land tenure that have developed in Tigray have had various impacts on these tenure characteristics and thus on land management. Prior to the fall of Haile Selassie in 1974, there were three dominant tenure systems in Ethiopia, *Risti*, *Gulti*, and church land. The Risti system was prevalent in most parts of Tigray. Under this system an individual had usufruct rights to land (risti rights) in a given community if he/she was able to establish descent from someone recognized as an original holder of land or the founder of the community (Bruce, 1976; Dessalegn, 1984). The individual's usufruct right to land could not be transferred to others through sale or mortgage, although he/she could lease them temporarily. The right to land did not imply a right to any specific parcel; and land redistributions were periodically undertaken to ensure that every member of the family was granted access. The principle of equal division governed land redistribution, with land divided into sections according to quality and then allocated by lottery. This system led to land fragmentation and deterioration in the quality of land. Since a holder in this system (especially in diessa[14]) was entitled to use the land for only a short time (usually up to 7 years), it limited the farmers' incentive to invest in improvement or even preservation of the land.

14. Defined as the village ownership system. In contrast to the Risti system which entitles people of access to land based on their kinship, any individual living in a given village, regardless of whether his ancestors belong to the pioneers of the community or not, had use rights.

The Gulti system of tenure emerged with the strengthening of the central Imperial power, particularly during the time of Emperor Menelik at the end of the 19th century, when large parts of southern Ethiopia were claimed by the northern armies. The original occupants of the land became tenants, and worked as sharecropping tenants of the Gulti-holding landlords. The prevalence of tenancy arrangements was much lower in northern Ethiopia. Nevertheless, holders of Risti rights were required to pay tribute to local church and secular authorities that administered communities under Gulti rights. Church officers (clergy, priests, etc.) were entitled to cultivate land as compensation for their service for the church.

The "Derg" (the name given to the military government) proclaimed the land reform legislation of March 1975 with the aim of transforming the nature of agrarian relations and agricultural production in the country. Land was proclaimed to be the collective property of the Ethiopian people and redistributed to the tillers, thereby doing away with land tenancy. There emerged free-holder subsistence producers having only usufruct rights. From this reform, though tenants and the landless benefited, owner-cultivators were in most case net losers (Dessalegn, 1984). Ten hectares was fixed as the maximum land holding. Large holdings were confiscated and converted into state farms, settlement schemes, and cooperatives. Any type of land transfer (mortgaging, leasing, selling, or bequests) was outlawed. Hiring of labour was also prohibited. The local peasant association (PA) was made responsible for further land redistribution and management of common pool resources. Based on the decisions made by the PA, grazing lands were used either collectively or redistributed for use by individual farmers. There were no formal use regulations regarding forest areas. In most cases, they demonstrated a classic case of open access resources, leading to overexploitation. Moreover, there was no formal policy defining ownership or use rights of trees that grow on cultivated land.

In an attempt to promote equity of tenure, redistribution of plots within a short period of duration (in some cases as short as 1–2 years) was a common practice under the Derg (Dessalegn, 1984). This led to diminution of plot sizes, disruption of production activity, and increased tenure insecurity, rather than solving it (Ibid.). In this context, lack of secure tenure was not merely due to the absence of private ownership as such, but rather to the fact that existing social structures allowed those who controlled usufruct rights— in this case the government — to grant or withdraw these rights at will.

This feeling of insecurity was exacerbated by the military government's drive for collectivisation. The government saw state farms and producers' cooperatives as the vehicle of development in agriculture. Hence, most resources for agriculture (including good quality land by evicting farmers) were directed towards this end. Forced villagization and resettlement also were pursued to promote collectivisation, although these programmes could not be implemented in most parts of Tigray due to the war. The consequences of the Derg's land and other policies included reduced agricultural production, conflict, famine, and increased land degradation and impoverishment, despite huge publicly-sponsored conservation efforts (Cohen and Isaksson, 1988; Kidane, 1991).

During the time of the Derg, the Tigray People's Liberation Front (TPLF) introduced important elements of land reform (Berhanu, 1998). The TPLF-pioneered land distribution also gave farmers usufruct rights to land, based on two principles: (1) a farmer needs to reside as a farmer in a given *tabia* to get land from the *tabia* and (2) land will be allocated to individuals, not to households, entitling every member of a household, both female and male.[15]

15. A *tabia* is the lowest administrative unit in Tigray, usually consisting of several villages. The administrative structure is discussed in a subsequent section.

In most communities, land was redistributed until 1991 to accommodate young families and returnees from settlement areas. This resulted in further fragmentation of holdings. In 1994/95, more than three-fourths of respondents in SAERP's survey reported that land fragmentation was a problem, in almost all cases because it caused plots to be too far apart to be able to look after them sufficiently (SAERP, 1997). In more than half of cases, the two most distant plots were more than one hour's walking time apart (Ibid.).

Since 1991, land redistributions have stopped in Tigray, and the current land policy in Tigray formally prohibits further land redistribution, except where public irrigation or other major infrastructure investments are being made, and allows land leasing for up to ten years.[16] The impact of this policy is not yet known. Based on historical experience, however, it is plausible to expect it to reduce land degradation and promote farmers' investments in land improvement, to the extent that tenure security is enhanced and land fragmentation reduced by the policy.

16. Current policies are discussed in more detail in a later section.

Local Market Development

The nature and development of markets for factors of production (e.g., land, labour, draft animals, credit), inputs and outputs can play a major role in determining patterns of land use and land management. Where markets are well-developed and competitive, farmers can be expected to respond largely to the profitability of alternative land uses and management options, and the outcomes are likely to be relatively efficient (though not necessarily equitable or resource conserving) (Singh *et al*., 1986; de Janvry *et al*., 1991). Where some markets are poorly developed or missing, however, farmers' production decisions cannot be separated from their consumption preferences and constraints, and as a result farmers' responses may depend greatly upon their preferences and endowments (Ibid.). For example, where credit is unavailable, poorer farmers may not be able to use purchased fertiliser even though it may be highly profitable to do so. Where hired labour is a poor substitute for farm family labour or labour markets are undeveloped, households with more family labour available relative to land will be more likely to adopt labour intensive practices or make labour intensive land improvements. Where high transportation costs cause households to produce cereals for subsistence purposes, farmers' response to increased cereal prices at the national level may be negligible.

In much of Tigray, local markets are poorly developed. Most households in Tigray produce crops only for subsistence. Crop sales are very limited—for example, while more than half of SAERP's respondents planted teff in 1994 and 1995, less than 9% sold any teff (even smaller fractions of producers sold other crops). Less than one-fourth of SAERP's respondent households purchased cereals. Livestock sales are much more common as a source of income—nearly half of SAERP's respondents sold livestock in 1994/95, and most of these sales were to finance purchase of food, clothing or other expenses. The most commonly purchased consumer items are coffee, sugar, edible oil and spices (98% of SAERP respondents purchased items in this category). Land sales are illegal, though some sales may occur without being officially sanctioned. Land leasing is relatively common—nearly one-fourth of households in SAERP's survey leased out land in 1994/95, while another one-fourth leased in land (SAERP, 1997). Use of hired labour is limited—while three-fifths of SAERP respondents reported insufficient family labour to carry out agricultural activities, less than one-fifth of those used hired labour. Credit use is relatively limited in rural areas—only about one-fourth to one-third of respondents in SAERP's survey reported using credit during each of three years. Use of purchased inputs is similarly limited, as noted earlier.

As a result of such limited market development, most producers in Tigray probably have minimal response to changes in national market prices of cereals or inputs. They are probably more responsive to livestock and livestock product prices, or to local variations in supplies of cereal grains or feed materials. The limited development of labour and credit markets may result in large variations across villages and households in local wage rates and rates of return to different types of investments. Thus, many farmers may be encouraged to make investments in soil and water conservation measures or other labour intensive investments that yield relatively low returns, while farmers facing tight cash constraints may be unable to purchase fertiliser, improved seeds or other productive items even when they might yield potentially high returns.

This suggests there may be many opportunities for market development to increase agricultural productivity and sustainability; though further research is needed to identify where such opportunities exist.

Local Institutions and Organisations[17]

17. Following other social scientists, we define "institutions" as "complexes of norms and behaviors that persist over time by serving collectively valued purposes", and distinguish them from "organizations", which are defined as "structures of recognized and accepted roles" (Uphoff 1986). This definition differs from common use of these terms, which often confounds the two terms.

As with market development, institutional and organisational development may have a major impact on land management.[18] The nature and evolution of local rules and norms (institutional development) and the organisations established to make decisions about or to enforce such rules (organisational development) set the context and constraints within which land management decisions are made. For example, almost 97% of the rural people of Tigray are Orthodox Christian (CSA, 1997), and subject to the norms and rules of the Ethiopian Orthodox Church. Among the most important of these norms, from the standpoint of land management, is the large number of religious holidays during which manual labour is prohibited. Although the number of religious holidays observed differs from area to area, Berhanu (1998) found an average of 8 holidays per month (excluding weekends). This obviously affects the availability and cost of labour during the rest of the year, and hence the ability of farmers to make labour intensive investments in land improvement or to adopt labour intensive practices such as mulching or composting.

18. Based on the definition of institutions given in the preceding footnote, institutional development includes market development as well as changes in land tenure relationships. In this subsection we focus on other aspects of institutional development.

Also affecting land management are official policies and informal rules and norms of behaviour requiring or encouraging households to devote labour to soil and water conservation or other promoted activities. Since the 1980's households have been expected to contribute labour to annual "voluntary" work campaigns, which heavily emphasise construction of soil and water conservation structures. Originally households were expected to contribute four months worth of labour during the dry season, but since 1992 the contribution has been reduced to 20 days. As a result of these efforts, a large fraction of Tigray has been treated with various soil and water conservation measures.[19]

19. These measures are discussed in more detail in a subsequent section.

Local rules also have important bearing on the management of grazing lands, particularly on common lands. In recent years, many tabias and kushets have established area enclosures, where grazing is restricted to allow natural vegetation to recover. Although leadership in establishing these enclosures has been provided by the Tigray Bureau of Agriculture and Natural Resources (TBANR), REST, and other organisations, decisions about whether to establish such areas and how to manage them are up to the local tabias and their baitos, according to various officials. However, based upon a small number of field interviews, it appears that some local communities may be unclear about what their rights and responsibilities are with regard to management of such areas, and are waiting for guidance from the regional authorities. Perhaps in part because such confusion has limited the benefits farmers have received from the enclosures, as well as the near term costs caused by loss of access to enclosed areas, some farmers do not favour the concept of enclosed areas.

Local communities may also regulate the use of uncultivated hillsides and wastelands. In Eastern Tigray, for example, the leaders of one village (Echmare, in the Gulomakeda woreda) decided to allow private tree planting on a degraded hillside beginning in 1992. Very small plots approximately 20 square meters in size were allocated to each household in the village, and the households were expected to plant trees and provide good management. The penalty for not doing so was to lose access to the plot, and potentially to future plots that may be allocated as well. In contrast to management of community woodlots, private management has been highly intensive, with large labour investments in clearing rocks and constructing stone bunds around the plots, and even hand irrigation of the seedlings during critical dry periods. As a result, the survival rate of seedlings on the private plots has averaged about 80%, according to village residents, compared to as low as 10% in community woodlots. The village has continued to allocate parts of the unused hillside almost every year since 1992. Households are now beginning to harvest the mature eucalyptus trees planted in the first years, which are worth about EB 30 to 50 ($5 to $8) per tree. Visual observations suggest that each household has about 20 trees surviving per plot allocated, representing a substantial increment to household income and wealth. The success of this experience has led the regional government to adopt a new directive allowing all tabias to allocate unused hillside wastelands for permitted uses, included tree planting, forage production, horticulture, and bee keeping. However, despite the success of the Echmare experience and the new directive, it appears that other tabias are not yet adopting this approach, in part because the TBANR prefers to implement the approach cautiously, by first testing it in several pilot study communities.

Associated with institutional development is organizational development. Tigray is divided into four administrative zones: central, eastern, southern and western, with a total of 36 woredas and 550 tabias. A reorganisation in 1996 reduced the number of woredas and tabias from 81 woredas and 1089 tabias existing previously. This reorganisation may have affected the ability of local governments to reach and implement agreements. Research on the impacts of the reorganisation on local decision making could yield useful insights.

A tabia, which consists of several kushets (villages), constitutes the basic administrative unit in the region. At the local level, the most important organizational structure is the tabia and its baito, which is where most local collective decisions are made. Baitos are the community council elected by the people, and are responsible for administrative and socioeconomic functions within the community jurisdiction. The baito plays a decisive role in terms of local governance, including identifying problems; designing areas of intervention; setting goals for community actions such as soil and water conservation activities; developing regulations related to resource use; identifying target groups for food aid, food for work, rehabilitation schemes and credit; regulating tax collection and credit repayments; ensuring security and resolving minor legal issues. Local collective decisions are codified in bylaws established by the baitos.

Since the fall of the Derg, the regional government of Tigray has sought to increase the authority and responsibility of the tabia baitos, based on its philosophy of local participation and self-determination. However, as illustrated by the reluctance of many tabias to develop their own policies with regard to enclosed areas or management of wastelands without guidance from regional authorities, a substantial amount of authority and leadership still resides with the regional government.

Other important organisations at the local level include churches, service co-operatives, schools, informal credit groups, and various social and religious groups (like mahber, elders' council, etc.). The church plays a very important role in the social (and of course religious) life of the people, but is not prone to rapid change. Service co-operatives were established under the Derg, and as a result of becoming an instrument of political control, fell out of favour with many communities. As noted previously, there has been rapid growth in the number of schools in Tigray, and this may be exerting important dynamic influences on many aspects of life, in addition to its direct impacts on children's education. More information is needed on this and other aspects of organisational development and its implications in rural Tigray.

Farmers' Perceptions and Attitudes

Farmers' perceptions and attitudes can have a major bearing on land management. Although farmers are often more acutely aware of the condition of their land than is sometimes assumed by experts, they may not be fully aware of land degradation, its causes, or consequences (Ervin and Ervin, 1982). Soil degradation is often a very slow process and may be almost invisible. Farmers thus may not observe ongoing erosion or nutrient depletion problems, or perceive them as immediate problems. While they do observe low or declining yields, farmers often attribute deterioration of crop yields to declining rains. But soil degradation may also have affected the water holding capacity and thereby reduced the soil's ability to overcome situations of water stress, thus contributing to the decline of yields. As long as farmers do not perceive soil degradation as a major determinant of decreasing yields this trend will certainly not be reversed.

Even if farmers do accurately perceive land degradation as a problem, they may not be induced to act to reverse it. They may attribute the problem to natural or divine causes beyond their control. On the other hand, they may understand that the problem is affected by their own actions, but the alternatives that they are aware of to address the problem may be too costly relative to the perceived near term benefits. In some cases, conservation measures reduce farmers' yields in the near term by reducing cropped area or harboring pests (Herweg, 1993). These problems are compounded if farmers discount the future heavily as a result of poverty and/or credit constraints (Holden *et al*., 1998; Pender, 1996). Thus, many farmers require food-for-work to voluntarily participate in soil conservation programmes.

On the other hand, some farmers may have attitudes favouring conservation; that is, they may obtain positive psychic benefits from taking actions to conserve the land, regardless of the economic benefits (Lynne *et al*., 1988). If such attitudes can be effectively promoted, promotional efforts could be more effective in the long run than using subsidies or compulsory approaches to promote conservation. Such attitudes may be playing an important role in promoting adoption of conservation measures by farmers in Tigray, though the extent of this or the potential for promoting them is not yet known.

Government Policies and Programmes

Government policies and programmes play a crucial role in affecting farmers' decisions with regard to land management. They influence most of the factors discussed above in crucial ways, as well as having other direct effects on land management in many cases. We consider here the past and current policy strategies as they have been implemented in Tigray and their possible impacts on land management. First we consider the broad development strategy, and then specific policies and programmes implemented within those strategies relating to agricultural research, extension, inputs, credit, irrigation, land tenure, marketing, infrastructure, and farmers' organisations.

Development Strategy

The development policies of Ethiopia during the last half-century gave emphasis generally to the so-called modern sector. During the Imperial government's first and second Five-Year Development Plans (between 1957–62 and 1963–1968), manufacturing, mining and infrastructure development were given greatest priority. In the last phase of the Imperial government, during the Third Five-Year Development Plan (1968–1973), the important role of agriculture in development was finally recognised. But even then it was private modern commercial farms that were seen as the engine of development in the country. Therefore, small holder agriculture received little policy attention.

During the Derg, the development of co-operative agriculture and state farms got the highest attention of policy makers, while policy discriminated against peasant agriculture. State farms and co-operatives took the lion's share of the limited resources (government budget, skilled labour, input supply, credit service, output pricing, etc), while small holder agriculture received little. Small farmers suffered greatly as a result of low controlled prices, required delivery of production quotas to the Agricultural Marketing Corporation (AMC), limitations on private grain trade and the policy of promoting collective agriculture by giving preferential prices to state farms and co-operatives.[20] This policy environment exacerbated the pressure on degraded land resources, by deepening rural poverty and limiting farmers' incentive and ability to invest in agriculture generally or in land improvement specifically. During the first six years of the military regime, food production declined by 6 percent (Lanz, 1996 quoted in Berhanu, 1998). Despite the disincentives to small holder agriculture, the productivity of small farms was still higher than that of the agricultural co-operatives (Stahl, 1990 as quoted in Berhanu, 1998).

20. The AMC has since been dissolved.

As the civil war intensified, increasing amounts of resources were shifted from development to the war effort. The defence share during the military regime rose from 18 percent at the beginning of the 1970's to 50 percent in 1988 (Dejene, 1990 as quoted in Berhanu 1998). Forced enlistment of farmers became a routine practice. Land degradation intensified as land and forest resources were literally left without an owner, and the incentives for farm productivity diminished (Berhanu, 1998).

Since the end of the war, the ruling Ethiopian People's Revolutionary Democratic Front (EPRDF) has placed great emphasis on agricultural development, particularly in the small farm sector. The current development strategy of the Ethiopian government is called Agricultural Development-Led Industrialization (ADLI). The development strategy of Tigray builds upon this strategy, taking into account the agricultural constraints and potentials of the region, and the extent of environmental degradation in Tigray. This strategy is called Conservation-based Agricultural Development-Led Industrialization, and focuses on conservation of natural resources and popular participation as the basic principles for agricultural development. It is now in its third year of implementation and aims to attain food self-sufficiency and fast economic growth through:

- Developing and promoting use of improved agricultural technologies such as improved seeds, fertilisers and pesticides through agricultural research, extension services, input supply and credit schemes;
- expanding small-scale irrigation schemes in drought prone areas;
- development of livestock resources;
- conservation of natural resources;
- implementation of an enabling land policy;
- expansion of marketing services;
- enabling private investors to play their proper role;
- expanding economic and social infrastructure that supports development; and
- Ensuring that all activities are centered on farmers' organizations and their decisions.

Below we consider policy efforts in many of these areas.

Agricultural Research

The need to improve agricultural productivity in Ethiopia has been recognised for some decades now. The Ethiopian Agricultural Research System was established in the 1950s with the primary objective of fostering the generation and dissemination of agricultural technologies to enhance productivity and efficiency. Currently the research system consists of the Ethiopian Agricultural Research Organisation (EARO), Regional Research Centres, higher learning institutions and several specialised centres. The overall contribution of these research centres should not be underestimated. But several criticisms of the research system have been raised in recent years.[21]

21. The criticisms discussed are taken mostly from the proceeding of a workshop on "Research and Development in Dryland Areas of Ethiopia" held in January 1997 in Weldia, Amhara Region.

In the past, the agricultural research budget fluctuated significantly from year to year. External grants in terms of bilateral aid, government loans, special projects, etc. were the major sources for research capacity building. This led to the development of donor driven and non-sustainable projects. This issue seems to be addressed at present through the government allotment of 1.5 percent of the agricultural GDP for agricultural research. This compares favourably with other African countries; expenditures for agricultural research in 19 countries of sub-Saharan Africa have averaged only about 0.8% of agricultural GDP since the early 1970's (Pardey *et al*., 1997).

The dominant approach to agricultural research in Ethiopia has been the organization of research centers on a commodity basis. There are many centers specializing in specific commodities, crops and animals, mostly regarded as high potential, without giving due attention to solving constraints based on agro-ecologies. Establishment of research centers was mainly based on proximity to urban areas, rather than addressing the constraints to agricultural production focused on agro-ecological zones. A systems approach to research has been poorly appreciated in Ethiopia. Research on watershed management was either neglected or only narrowly focused on single disciplines.

Despite the large area coverage of the arid and semi-arid areas (55% of the land area of Ethiopia) research in these areas has been marginalized. This contributed to a negative attitude not only among the research establishment but also negatively influenced policy on research. Previous attempts to concentrate research effort only in the higher potential areas has denied the necessary support dryland agriculture needed from research results. This is reflected in the low focus given to research centers in dryland areas, which, in turn, is reflected in their poor capacity which caused them to serve only as adaptation trail centers. As a result, no technologies were generated in the dryland research centers that could be of use to these regions. This leaves the farmers and technology promotion centers, primarily the Bureaus of Agriculture, limited to technologies released by national centers, which are often not suited to dryland conditions.

These problems are particularly acute in Tigray. Tigray is one of the least researched regions in Ethiopia. The research centre in existence is limited in capacity, both in terms of manpower and facilities. The role of the centre in generating technologies for dissemination has been very minimal. Until recently, it has served only as a trial station for the national research centres. The research centre is now reorganised and in collaboration with Mekelle University College conducting variety trial, screening, observation, and yield trials of different crops. All technologies currently being promoted by the Tigray Bureau of Agriculture and Natural Resources (TBANR) are packages released from other research centres and, hence, less relevant to the agroecological and socio-economic setting in Tigray.

According to some surveys conducted on adoption of technologies in Tigray, farmers' adoption rate and performance of promoted technologies has been very low. In one case, of the 80 farmers interviewed, only about 15 percent indicated that they use improved varieties and about 1 % herbicides and pesticides (Fitsum, 1996). One of the reasons mentioned by farmers was the poor performance of the packages. According to farmers' views, the improved varieties supplied by the Bureau could be high yielding but risky, particularly given uncertain rainfall conditions. As a result farmers have more confidence in local varieties than the exotic ones. According to the Bureau of Agriculture, the average fertiliser application for the whole region amounts to only 2.75 kg/ha (BOPED, 1995). The low demand for fertiliser is conditioned by farmers' attitudes, poverty and weather conditions, among other things.

Research on natural resource management (soil, water, forestry, dry land agriculture and agro-climatology) and irrigated agriculture is fragmented and uncoordinated. Organizations or departments that are not integrated with the research system have handled efforts that need to be coordinated at a national level.

Research programme development and the methodology followed has been a mixture of top-down technology development, farming systems research and farmer participatory research. The farming systems research programme is not broad in scope, does not adequately utilize participatory approaches and lacks consolidation of results by agro-ecologies. The review process lacks involvement of stakeholders and emphasizes the responsibility of team leaders rather than collective responsibility through a multi-disciplinary approach. For example, there is a lack of recognition of team members other than plant breeders when releasing new varieties of crops.

Agricultural Extension

An ambitious extension programme has been launched in all regions of Ethiopia including Tigray, with the overall objectives of attaining food self-sufficiency and improving the living conditions of the people. The programme has two major components: simple technology transfer and human resource development. The technology transfer component is designed to suit three dominant situations: moisture reliable, drought prone and nomadic pastoralism. In the areas where there is adequate rainfall the extension package follows the standard Sasakawa-Global 2000 approach. Sasakawa-Global 2000 (SG 2000) is a project initiated in 1993 by the Sasakawa Africa Association and the Global 2000 programme with the cooperation and support of the Ethiopian government (Sasakawa-Global 2000, 1996). The emphasis is on increasing the productivity of food crops. The package includes chemical fertiliser[22], improved seeds, agronomic practices like improved seed rates and planting dates, and chemicals (herbicides and pesticides). Farmers are expected to devote a one-half hectare plot to the programme as an extension management training plot. The intent is to use a commercial size plot to test the packages, so that farmers will quickly recognize the significance of the results and reap substantial benefits. The programme provides inputs to farmers and requires that the input recommendations be followed to participate in the programme. Farmers are expected to pay 25% of the cost of inputs in advance and the remaining balance after harvest at an annual interest rate of 12.5%.[23] The extension agents also demonstrate the use of manure (compost) in combination with chemical fertilisers.

22. The fertiliser component of the package recommends use of 100 kg of DAP and 100 kg Urea per hectare

23. Dedebit and other micro financial institutions are currently lobbying to raise the interest rate to 15.5%

In the areas that are highly stressed with lack of moisture but with good agricultural potential, the extension approach aims to work in combination with efforts to expand irrigation through construction of micro dams and river diversions, improvements in traditional irrigation schemes, and development of ground water irrigation.

The extension programme has shown some impressive results so far. In 1995, average maize yields on SG-2000 programme plots in Western Tigray were triple those using conventional methods, while wheat yields in Central Tigray nearly doubled and teff yields in both zones increased by 40 to 60 percent (Sasakawa-Global 2000, 1996). An assessment of yields in the moisture stressed areas of eastern Tigray in 1996 showed that the average yield increase due to the extension package was more than 280% higher than without (Yohannes, 1996). In many parts of Tigray where this team visited, farmers have reported yields that are three- to-four folds higher than without the modern inputs. During 1997 the region was able to produce a record 6.7 million quintals of crops, in part because of adoption of the extension package.

Despite the early success of the new extension package where it has been adopted, there are problems in attaining more widespread adoption in Tigray. The programme is criticized by some farmers for use of the same recommendations for all agro-ecological conditions. A case in point is the uniform fertiliser application rate recommended by the Bureau of Agriculture, irrespective of the availability of moisture. In moisture-stressed conditions, high applications of chemical fertiliser (particularly nitrogen) can be very risky, particularly given the relatively large size (compared to farmers' landholdings) of the plots devoted to the programme. In some areas farmers complain of problems with weeds and pests when they combine fertiliser with manure. Distance of plots from the homestead and lack of alternative sources of fuel also seem to impede the widespread adoption of composting. As a result of such problems, there are diverse impacts of the programme in different locations, with successes more common in higher potential parts of central and western Tigray, but failures more common in the lower potential parts of eastern and southern Tigray (except where irrigation is available).

There are also criticisms of the agricultural extension system more generally. As with agricultural research, the extension system is plagued by capacity constraints in terms of resources such as skilled manpower, means of transport, inputs, and materials, etc. A common criticism is of the poor extension-research linkage that exists in Ethiopia in general, as well as in Tigray in particular. Collabouration between the TBANR and EARO is not strong enough to speed up the process of technological changes necessary to bring about food self-sufficiency in the region (Eyasu *et al.*, 1996). The working relationship among research, extension and other organisations that has been formulated through the former Research and Extension Liaison Committee (RELC) can hardly be considered as operational at various levels at present (Workshop on Research and Development in Dryland Areas of Ethiopia, 1997).

Agricultural Inputs Supply

The principal organisation involved in the provision of agricultural inputs to farmers in Tigray is the TBANR, while REST is involved in some cases, particularly in the supply of oxen. The TBANR provides farmers with inputs such as fertiliser, improved seeds, herbicides, and insecticides, either on credit or cash basis, in collaboration with the Dedebit credit programme and the Agricultural Inputs Supply Corporation (AISCO), a state-owned enterprise. AISCO is presently the only distributor of fertiliser operating in Tigray. Two other private fertiliser distributors, which operated previously in the region, have withdrawn recently due to lack of adequate demand and high transport costs. The total demand for fertiliser in the region has grown from 20 thousand quintals in 1992/93 to 250 thousand quintals in 1997/98. Even so, the demand is too low compared to other regions to attract additional suppliers (Tesfay, personal communication). According to sources at the TBANR, suppliers, and farmers, there is generally no scarcity of inputs. This is supported by the results of SAERP's survey, in which only 11% of households not using chemical fertilisers reported that this was because they were not available, and 77% of households reported that fertilisers were available at the right time (SAERP, 1997). The most serious constraint is considered to be high fertiliser prices (Ibid., Fitsum, 1996). Most farmers feel that the inputs supplied are too expensive to afford, and fear that this will contribute to their indebtedness. A study by Mulat *et al*. (1997) showed that with the removal of subsidy and deregulation of prices in 1997, farmers could face a price which is 21 to 39 percent higher in 1997 than in 1996.

Considering the inefficiency and high operating costs typical of state-owned enterprises, the removal of subsidies from fertiliser, the successive devaluation of the Ethiopian Birr, the risk of crop failure due to unreliable rainfall, the fall of output prices during years of good harvest, and increasing interest rates, it is imperative that the input market efficiency be improved. Otherwise, farmers' desire to adopt and sustain the use of such inputs will remain limited in Tigray. The efficiency of the input delivery system needs to be improved by attracting private businessmen in both wholesale and retail trade of inputs by providing incentives like credit, storage facilities etc., and improving the condition of roads.

Credit

One of the potential constraints to farmers' adoption of modern technologies and inputs is the shortage of capital. It is difficult to increase productivity of the agricultural sector in the absence of an efficient credit facility, given the fact that the majority of farmers are resource-poor.

In Tigray, rural credit has been provided by the Dedebit Rural Credit and Savings Scheme since 1994. Dedebit is an affiliate of REST. The rural credit scheme was initiated with the goal to "attain food security through income generation and diversification, saving and investment by stimulating the local economy" (REST, 1997). Dedebit extends short-term credit for agricultural input purchases as well as credit for petty trading to enable creation of self-employment, especially among unemployed young people and women. Loan sizes range between Birr 50 and 5,000 and the loan period is a maximum of one year.

The dominant form of credit provided by Dedebit is credit in kind. This is due more to the desire of the programme than to farmers' preferences. In fact, many farmers believe that cash credit would allow them to act more flexibly in improving their livelihood. Dedebit follows the eligibility criterion of "the household being able to pay back." In principle all productive loans that enable the borrower to generate income so that he/she can repay the loan are eligible (Berhanu *et al.*, 1996). This is usually measured by whether the household is male-headed, or at least has adult male members, whether the household has land and its willingness and capacity to cultivate the land. There are no material collateral requirements to credit; security is in the from of peer group pressure and support (Ibid.). Though women and the poor are expected to benefit from the service, the eligibility criteria seem to exclude both and favour the relatively less poor.

Lending activities, including loan eligibility assessment, loan approval, collection, etc. are undertaken through the community and tabia *baitos*, the local administrative bodies. Dedebit employs a group collateral system when extending loans. Borrowers form groups of seven people and bear collective responsibility and will have to repay collectively in case one of them defaults.

Dedebit has 120,000 regular clients and in 1997 it extended agricultural input loans to 220,000 farmers. Women are the main beneficiaries of the credit for petty trade. About 60% of the loan volume is targeted for women. In Abergelle, central Tigray, about 95% of the farmers have built their own houses with loans obtained from Dedebit. Dedebit claims a loan repayment rate of 99%.

The sustainability of any credit scheme is to be ensured not only by a low default rate, determined in part by the clients' success in generating income, but also by incorporating a workable saving programme into the scheme. Dedebit has advocated this philosophy in its credit scheme, and it was able to mobilise savings of Birr 30 million in 1997. But few farm households are aware that such a saving scheme exists, so more needs to be done. In the future it plans to make saving a prerequisite for eligibility to borrow.

Though Dedebit has expanded its coverage very quickly, it will need time and effort until farmers develop the confidence to make greater use of it. Results of a survey conducted by Mekelle University College show that only about 55 per cent of the farmers in the survey area are aware that the TBANR and REST offer a credit service. Based on their present experience and future expectations, only 32 per cent of our interviewees are very interested in making use of the service. The reasons are related to farmers' fear of indebtedness, which is conditioned by the unreliable nature of agricultural production and perceived high interest rates.

Despite limitations on the demand for credit, Dedebit appears to be liquidity constrained, and has difficulty meeting the demand for rural credit in general and large loans for fixed investments in particular. This is apart from the legal upper limit on loan size established by the National Bank Directive. The National Bank of Ethiopia has recently issued a directive liberalising interest rates and allowing inter-bank loans to overcome the liquidity problems of small banks using the idle resources of the state-owned commercial banks[24]. But it is not yet clear whether this arrangement is applicable also to rural financial institutions. If so, this could provide a substantial source of additional liquidity to help finance investments and working capital in rural Tigray.

24. The Commercial Bank of Ethiopia (CBE) alone, which is the largest bank in the country, has excess liquidity of 53%, which is much higher than the statutory liquidity requirement of 15% (CBE, 1996).

Irrigation

In 1995, the regional government of Tigray initiated an ambitious plan to construct 500 dams within ten years with a capacity of irrigating 50,000 ha in the moisture stressed and drought prone areas. To this end, it established a commission mandated to increase crop production through construction of microdams and irrigation infrastructure, Sustainable Agriculture and Environmental Rehabilitation of Tigray (SAERT). The plan, however, had to be scaled back because of lack of suitable sites for dam construction and resource constraints. By the end of 1997, 25 dams with a nominal capacity of irrigating 2,500 ha of land were completed. But most of the completed dams are operating much below their capacity due to a shortage of water. Only about 300 ha of land was actually being irrigated in 1998. SAERT has recently adopted a strategy of "area based development", which focuses on whatever opportunities for exploiting water resources may exist—whether it be through dams, ponds, river diversions, wells, or other water harvesting structures—rather than focusing only on construction of dams as originally envisioned.

Farmers have started growing some cash crops such as maize, onions, potatoes and tomatoes in irrigated areas. Participation in the extension programme and use of inputs such as fertiliser and improved seeds is reportedly high in these areas, and farmers' yields and incomes are substantially higher from irrigated plots. For example, in the Gum Selassa microdam site in southern Tigray near Adigudum, farmers reported that typical teff yields on irrigated plots were 2 metric tons per ha, compared to 1 ton per ha under rainfed conditions. Maize yields are typically 7 to 8 tons per ha on irrigated plots (maize is not grown in this area under rainfed conditions). With a local price of about Birr 200 per quintal, this translates to a gross revenue of about Birr 14,000 to 16,000 per ha for irrigated maize. Farmers estimated a similar return to onions. Even after deducting the cost of fertiliser doses recommended by the Bureau of Agriculture (100 kg/ha of DAP and 50 kg/ha of urea, together costing less than Birr 400 per ha), the return to irrigated maize or onions is much higher than rainfed teff or wheat, which may yield about Birr 5,000 to 6,000 per ha.

The benefits of such microdam projects could be quite substantial, particularly if they are able to eventually irrigate close to the nominal capacity of 100 ha. Considering a dam that irrigates 100 ha of maize and onions during two seasons, the annual net income generated would be close to Birr 3 million (Birr 15,000 / ha x 100 ha x 2). The annual income that would be generated from the command area and the land displaced by the dam (assuming this to be an additional 100 ha) would be about Birr 1 million under rainfed conditions (Birr 5000/ha x 200 ha), for a net increase in annual income of Birr 2 million.[25] Of course, these estimates are based on the nominal irrigation capacity of the microdams, and as noted previously, the actual level of irrigation so far has been much less than this in most cases.

25. Estimates of the costs of constructing and maintaining such microdams were not available, so benefit–cost analysis was not possible.

Selection of the beneficiaries of the irrigation projects is up to the affected communities, in consultation with SAERT and the Bureau of Agriculture. Generally, priority is given to farmers with land already in the command area, as well as to farmers whose land has been displaced by development of the dam. Allocation and management of the irrigation water is the responsibility of a committee of five members elected from the beneficiaries. It decides who uses how much water when, and penalizes transgressors. Communities do not appear to have major problems handling these responsibilities, though this observation is based only on informal interviews in a few cases. More in-depth research on these irrigation projects, their implementation and impacts would be useful.

Based on the limited information we have from informal interviews, some other issues have been identified that may be of concern. One is the possibility that many farmers may be suffering losses as a result of the dams that have been constructed. Because land in the command area is generally expected to be allocated to households whose land was displaced by the dam, as well as to original holders of land in the command area, the size of plots allocated to beneficiaries may be quite small. For example, in the Gum Selassa dam site near Adigudum, the average plot size allocated to beneficiaries is 0.2 ha. With the limited availability of irrigation water so far, many of the expected beneficiaries have not yet benefited from the dam. Some have likely lost income as a result of being allocated less land than they had previously. In addition, there appear to be some problems in ensuring access to irrigation or compensation to households whose farmland was displaced by the dam. In the case of one recently completed dam near Axum, farmers whose land was displaced had not yet been allocated any land in the command area by May 1998, even though the dam had been completed for more than a year.

Another important issue relates to the treatment of catchment areas to reduce siltation of the dams. A study by SAERT has shown that about 1000 m^3 of sediment is accumulated annually in the dams (Leul, personal communication). SAERT is mandated only with building the dams, while the treatment of the catchment and coordination of management of the irrigation is the responsibility of TBANR. Ensuring adequate coordination between the efforts of these different agencies thus is quite important. It appears that the problem is well recognized and now efforts are being made to treat the catchment before construction of dams.

Other key issues relate to the need for complementary infrastructure and institutional development to support production and marketing of the products being (or capable of being) produced under irrigated conditions. As local production of maize and other products increases, there is a substantial risk that local prices for these products will collapse, particularly if there has not been adequate investment in transportation infrastructure, storage, processing facilities, etc. Lack of credit to facilitate orderly marketing can also contribute to this problem, particularly for storable commodities. Farmers' will need much more information about profitable non-traditional products that become possible as result of irrigation (such as many horticultural crops), appropriate management practices, prices and marketing, requiring additional investments in technical assistance and market information. Demand for agricultural inputs will increase in such areas, placing greater emphasis on the importance of the development of competitive input markets. A final concern relates to the increased risk of malaria and the appearance of new migrant birds which damage crops as a result of accumulation of surface water in reservoirs and ponds, requiring increased efforts towards prevention and/or treatment. Most of these factors are already of concern where irrigation development has occurred, but will become increasingly important to address as the programme expands to much larger areas over the next several years.

Studies are being conducted to assess the potential for groundwater irrigation in Tigray. The Raya valley development feasibility study has indicated that there is a potential to irrigate 12,000 ha of land. The Tekezze basin master plan project has also identified places with good potential for groundwater irrigation development. Associated with the use of groundwater for irrigation, however, is the problem of salinization of the soil. This has been a serious limitation in the use of aquifers for both agriculture and for human consumption.

Livestock Development

The livestock development strategy of the region is based on improvement of animal breeds, better delivery of animal health services, and improvement of animal feed production. The five-year development strategy of the region indicates that artificial insemination service is expected to grow by more than seven fold and the veterinary service is expected to grow by more than 28% during the plan period. Recognizing shortage of feed as one of the key constraints for livestock development, the regional government plans to increase the number of feed trial and seed multiplication sites from 4 in 1996 to 14 by the year 2000. The five-year development strategy of the region (BOPED, 1995) indicates that it also plans to increase the number of farmers who will benefit from forage seed distribution for production on their farm plots by more than 89% during the plan period of 1996–2000.

Resource Conservation

To reverse the land degradation process, large efforts to promote soil and water conservation have been undertaken in Tigray since the 1970's. Terracing and afforestation programmes started in 1970 under a USAID sponsored food-for-work programme. In the four years following this programme about 1500 ha were terraced and planted at 11 sites (Hunting, 1975). The UN/FAO world food programme later complemented this. The initial stage of implementation had technical failures in the alignment of terraces, poorly organised nurseries, incorrect spacing and inappropriate choice of species (TFAP, 1996).

Since the early 1980's soil and water conservation activities have become one of the major preoccupations of the people and the authorities. This has involved mass mobilisation of labour during the dry season, as well as food-for-work and cash-for-work programmes. Originally every dry season, for four months, the farmers in Tigray were mobilised to treat catchments by building stone bunds over entire catchments, starting with higher level fields. This required the equivalent of 2.5 to 5 months of part-time work per hectare of terracing work for a farmer and his family if tools were supplied. Each family was expected to give 90–180 man-days per year spread over 90–120 days of the year (Tekeste and Smith, 1989). This had a serious cost implication to the household. After critical assessment, the present government substantially reduced the number of days allocated for "voluntary" unpaid involvement in soil and water conservation activities, to twenty days. Food-for-work and cash-for-work programmes are used to mobilise additional labour for such activities.

The conservation strategy focuses mainly on the construction of physical structures, depending on the topography and land use pattern. For steep uncultivated lands, contour stone bunds, cut-off ditches and contour furrows are used. For cultivated lands, contour stone bunds, soil bunds, or grass strips, complemented by check dams for gully control are used. To complement these physical structures, biological measures, such as tree planting and enclosures for natural regeneration are used (Tesfay, 1998). Since 1991/92 about 600,000 ha of land has been terraced and 4,600 km of gullies treated. An average of 7–8 million person-days/year of labour was utilized (Tesfay, 1998).

The soil and water conservation measures are showing good results in terms of harvesting soil and water behind the stone bunds. Consequently it has been possible to obtain higher crop yields and biomass (Yohannes, 1996). The conserved areas show accumulation of soils and develop into bench terraces, minimizing rill damage and harvesting water. Evidence indicates that yield is higher in the treated than in the untreated plots and is better near the bunds due to retention of moisture and soil (Berhanu, 1998; Yibabe, *et al*., 1997). However, the increase in yield due to such conservation structures appears to be insufficient to stimulate widespread spontaneous adoption outside of the programmes and mass mobilization.

Despite their positive impacts, the soil and water conservation (SWC) programmes have been criticized for not considering farmers' indigenous SWC measures, which are based on long years of experience and intimate knowledge of their environment. Yohannes (1996) reports that some farmers criticize the standardized and fixed technologies, which are unlike the traditional site-specific, semi-permanent structures and combinations of technologies used by farmers. They complain that the new structures sometimes negatively affect the productivity of the land and create favourable conditions for the breeding of rodents.

In addition to programmes promoting adoption of soil and water conservation investments, there have been efforts to promote regeneration of degraded grazing areas by establishing area enclosures (as discussed in a previous section) and to promote reforestation. So far, about 305,000 ha has been protected in area enclosures. As part of the reforestation programme, more than 603 nurseries have been established and 199 million seedlings of various tree species have been raised. The seedlings are distributed to farmers at nominal prices for private use and are given freely for communal plantations and were planted on 98,600 ha of land until 1996 (BOPED, 1995). However, as noted earlier, the survival rates of seedlings in communal plantations have generally been low, and there is now increased interest in promoting reforestation by allocating sloping areas and wastelands to private individuals for tree planting and other conserving uses.

Alongside the already indicated measures, there are also attempts to promote changes in the farming practices of farmers by encouraging contour ploughing, strip cropping and crop rotation. The extension system strives to promote technologies which can have immediate impact on yield and biomass, and greater emphasis is being given to integrating soil and water conservation measures into general land management and productivity enhancing practices. For example, in drought-prone areas of the southern and eastern zones of Tigray, farmers are using various mechanisms to conserve moisture such as diverting floods and using water retention structures on their plots.

The planning and implementation process of soil and water conservation is done with the active interaction of the people and the local baitos. Mass mobilisation and the involvement of grass-root institutions are the main strategies for implementing the process, which depend very much on farmers' motivation to participate. Thus "the continuation of such motivation will determine the success or failure of any future soil and water conservation programme" (Tekeste and Smith, 1989).

Land Policy

As discussed previously, the land tenure system in Tigray has long historical roots. However it is also substantially affected by current land policy, which is based on the new Ethiopian constitution. Under the constitution, all land is the property of the state, and it may not be sold or mortgaged. The right of peasants and pastoralists of free access to land is guaranteed. The constitution also guarantees the right of individuals to improvements they make to land, including the right to bequeath, transfer, remove, or claim compensation for such improvements if the right of use expires. Although the constitution has resolved some issues, it seems to create other ambiguities and does not address some important issues. Given the scarcity of land, it is not clear how peasants' right of free access to land can be assured in practice, and what effect this may have on tenure security of those currently possessing land. Nor is it clear how much land peasants are entitled to. These issues have been left to the regional governments to resolve, and there have been important differences across the regions.

In Tigray, a new land policy was issued in 1997 stating that there will be no further redistributions of land except where major infrastructure investments such as irrigation projects necessitates it. The people and the regional government seem to have reached a consensus on the issue; in the view of many people, "distributing land is distributing poverty". The policy allows leasing of land for up to 10 years if the lessee uses "modern technology" and for only 2 years if the lessee uses "traditional technology". However, it fails to define what the modern and traditional technologies are. It clearly indicates the obligations of farmers, among which is undertaking SWC measures on both communal and private holdings. The policy also prohibits farmers from planting eucalyptus and cactus trees on cultivable land.

Currently the region is undertaking a land inventory survey and issuing land registration certificates. From informal discussions with some farmers we have the impression that farmers feel more secure in their tenure now than before as a result of the new land policy. Nevertheless, some farmers indicated that they would feel more secure once they have registration certificates. Research is needed to provide more evidence on this issue.

The restrictions on leasing may constrain efforts to reduce land fragmentation, limit farmers' ability to obtain sufficient income from farming, limit incentives to invest in land improvements, and constrain peasants' ability to take advantage of better economic opportunities outside of farming or in other locations. The prohibition on land mortgaging in the constitution reduces farmers' collateral and hence reduces the possibility of collateral-based credit, though alternatives such as peer group monitoring are being used. More research is needed on these issues as well.

The government has envisaged long- and short-term strategies to reduce the pressure on land and land fragmentation. Among the short term strategies are providing technical and vocational training to the landless youth to enable them to find off-farm employment and encouraging emigration to urban centers and to other parts of the region for resettlement. On the other hand, it aims to curb the high population growth in the region in the long-term through expansion of education and family planning programmes.

Infrastructure Development

Substantial investments in physical and social infrastructure improvement have occurred in recent years, though more is needed and expected. Both the central and regional governments have given emphasis to the construction of new roads and rehabilitation of existing road networks. The regional government allocated 17.5% of the total regional budget outlay for rural road construction in 1995 (BOPED, 1995). Extensive road construction was undertaken from 1993–1995, which raised the road density from its 1993 level of 8 km/1000 kms^2 to 12.9 km/1000 km^2. Between Adua and Mekelle 187 km of all-weather road have been completed since 1993. Roads connecting towns such as Shire and Sheraro, Korem and Soketa, Tembien and Sekota, Zalanbessa and Alitena are near completion. Road building, however, is not integrated with other development projects such as construction of microdams (apart from the access roads that are paved to facilitate the construction of the projects), which may limit the economic impact of both types of projects.

Large investments are being made in other types of infrastructure as well. Air transport is being improved with expansions at Axum and Mekelle airports. Similar improvements are occurring in the telecommunications and power supply sectors. Electric power lines providing power from a hydroelectric dam in southwestern Ethiopia are being completed, and will substantially increase electricity availability in major towns. The number of primary schools has increased from 551 in 1993 to 696 in 1996, while the number of hospital beds increased from 769 to 959 (RECC, 1996).

Development of Local Participation and Farmer Organisations

As mentioned previously, under the new federal government system administrative authority is being devolved from the centre to regions and local communities as well. The people participate in all stages of the planning process from problem identification, project formulation, implementation, monitoring and evaluation. The tabia *baito* and residents discuss problems of their area, prioritise problems according to their severity and prepare an action plan and budget at the woreda level with the assistance of line departments. The plan is then sent to the zonal level and compiled and presented for the regional council's approval and budg*et al*location. The regional council, after reviewing the plans, allocates the budget, while implementation occurs at the local level. The local communities now have greater authority than before, although in many cases it seems that they still expect ideas to be initiated from the top, even though the final decisions are theirs.

Cooperatives are almost non-existent in Tigray, unlike in the other parts of the country where the past government was able to organize farmers for the attainment of its ideological objectives. But the importance of cooperatives is being increasingly recognized and efforts are underway to organize farmers into cooperatives. To this end the regional government has established an office to oversee the development of cooperatives, and has been taking farmers to other parts of Ethiopia on experience sharing visits. The Federal Government of Ethiopia has issued an agricultural cooperative societies proclamation (Proc. No. 85/1994), with the objective of improving the living condition of peasants through increasing productivity and production, collective action, and improving supply of industrial products and modern technologies at fair prices, etc.

Development Pathways: Opportunities for Sustainable Development[26]

26. The remainder of this paper draws heavily from the analysis originally developed in Pender, Place and Ehui (1998).

Considering the nature and causes of land degradation as discussed in the previous sections, we seek in our research programme to identify policy, institutional, and technological strategies for more sustainable, productive, and poverty-reducing development in the highlands of Tigray. Given the complexity of factors influencing land degradation and the diversity of situations existing in Tigray, we expect that no "one-size-fits-all" strategy will suffice in all situations, though there will be common elements to any successful strategy, including physical security, economic stability, a competitive market environment, land tenure security, and investments in physical, human, natural and social capital. Much of what distinguishes different strategies in different situations will be differences in the portfolio of such investments.

In this section, we take some initial steps towards identifying such strategies, based on the limited information available and hypotheses about the key constraints and opportunities for development in the different types of situations in the highlands of Tigray. Our principal hypothesis is that the prospects for sustainable development in any given situation depend largely on the comparative advantage of alternative livelihood strategies in that situation.[27] For example, in areas where commercial crop production is feasible and economic, the potential to address soil nutrient depletion using large inputs of inorganic fertiliser will be much greater than where subsistence production of food crops is likely to remain the dominant activity. A corollary to our principal hypothesis is that the strategy to promote more sustainable development must be based on the comparative advantages that exist or that may be developed in different locations.

27. Support for this hypothesis is provided by similar IFPRI research conducted in Honduras (Pender et al., 1998).

Many factors determine comparative advantage and the appropriate response to it. We will focus on three factors that reflect much of what distinguishes the opportunities for agricultural development: agricultural potential, access to markets, and population pressure.

Agricultural potential is an abstraction of many factors—including rainfall, altitude, soil type and depth, topography, presence of pests and diseases, and others—that influence the absolute (as opposed to comparative) advantage of producing agricultural commodities in a particular place. There are of course variations in potential depending upon which commodities are being considered. Furthermore, agricultural potential is not a static concept but changes over time in response to changing natural conditions (such as climate change) as well as human-induced conditions (such as land degradation). For simplicity of exposition, however, we will discuss agricultural potential as though it was a one dimensional and fixed concept. In reality, the multi-dimensional and dynamic nature of agricultural potential should be considered when developing more specific strategies of development than will be possible in this paper.

Access to markets is critical for determining the comparative advantage of a particular location, given its agricultural potential. For example, a community with an absolute advantage in producing perishable vegetables (i.e., total factor productivity in vegetable production is higher there than anywhere else), may have little or no comparative advantage (low profitability) in vegetable production if it is far from roads and urban markets. As with agricultural potential, market access is also a multi-dimensional and dynamic concept (distance to roads, condition of roads, distance to urban centres, degree of competition, access to transport facilities, etc.), but we will treat it as a single predetermined variable (though subject to change through investments in roads, for example).

Population pressure affects the labour intensity of agriculture by affecting the land/labour ratio, and may also induce innovations in technology, markets and institutions, or investments in infrastructure (Boserup, 1965; Ruthenberg, 1980; Hayami and Ruttan, 1985; Binswanger and McIntire, 1987). Population pressure thus affects the comparative advantage of labour intensive strategies of development, as well as returns to various types of investments.

These three factors interact with each other in complex ways. Population density tends to be higher where there is greater agricultural potential or greater market access, since people have moved to such areas in search of better opportunities. On the other hand, population pressure may have contributed to land degradation in many cases, reducing agricultural potential from what it once was. Market access tends to be better where there is higher population density, since the per capita costs of building roads are lower and the benefits higher in such circumstances. Market access also tends to be better where agricultural potential is higher, since the returns to developing infrastructure are greater. Despite these interrelationships, it appears that there is still substantial independent variation of these factors in the highlands of Tigray. Given such variations, and the fact that these factors change relatively slowly over time, it is useful to consider how different combinations of these factors influence possible development pathways.

We can classify the situations of the highlands of Tigray into a maximum of eight types, considering two levels of each dimension. We recognise that there is an unavoidable element of arbitrariness in defining these categories. "High agricultural potential" refers to areas with relatively assured rainfall of around 1000 mm or more, or access to irrigation; with a temperate climate (less than 3000 m.a.s.l. elevation); and with soils suitable for agricultural production with minimum investment (excluding very thin soils, highly acidic soils, and those which are highly P-fixing). High potential areas in Tigray are limited to higher rainfall parts of central and southwestern Tigray and to irrigated areas. "High market access" refers to areas relatively close to a city or large town, with access to an all-weather road and to transport facilities. Areas close to major towns such as Mekelle, Adigrat, Adwa, Axum and Shire fit this description. Although relative to other parts of Africa, population density is high in all of the highlands, we consider "high" population density to mean greater than 100 persons per square kilometre. This mainly includes parts of central Tigray. Other areas are viewed as "medium" population density.

Examples of these categories are presented in Table 1. For each category in Table 1, we present hypotheses about what opportunities exist for various pathways of development. The pathways we consider include:

- intensification of cereal production using relatively high levels of external inputs, such as improved seeds and fertiliser (the approach being promoted by the extension programme of the Bureau of Agriculture);
- intensification of cereal production using labour intensive investments and organic sources of soil fertility in combination with limited use of external inputs;
- commercial production of perishable cash crops, such as fruits and vegetables;

- commercial production of non-perishable perennial cash crops, such as nuts, coffee, tea or chat;
- commercial production of dairy or other intensive livestock, such as poultry;
- improved and intensified livestock production through increased forage and fodder production, use of improved breeds, disease prevention and health services, etc.;
- bee keeping;
- planting of woodlots or trees for other purposes (e.g., agroforestry);
- non-farm development, such as through development of agricultural processing, mining, manufacturing, or other industries; and
- emigration to areas with greater economic opportunity.

Table 1. *Development Opportunities in the Highlands of Tigray*

Agricultural Potential	Market Access	Population Density	
		High	Medium
High	High	Areas Close to Axum, Shire High input cereals Perishable cash crops Dairy, intensive livestock Non-perishable cash crops Rural non-farm development	Irrigated Areas Close to Mekelle High input cereals Perishable cash crops Dairy, intensive livestock Livestock and grazing improvement Non-perishable cash crops Rural non-farm development
	Low	Irrigated Parts of Central Tigray Far from Towns High input cereals Non-perishable cash crops Beekeeping	Other Irrigated Parts of Tigray Far from Towns*** High input cereals Non-perishable cash crops Livestock and grazing improvement Beekeeping
Low	High	Rainfed Parts of Central Tigray Close to Towns Low input cereals Rural non-farm development	Rainfed Areas Close to Mekelle, Adigrat Low input cereals Livestock and grazing improvement Woodlots Rural non-farm devt.
	Low	Rainfed Parts of Central Tigray Far from Towns Low input cereals Limited livestock intensification Beekeeping Emigration	Rainfed Areas Far from Towns in Much of Tigray Low input cereals Livestock and grazing improvement Beekeeping Emigration

*** This includes areas with great potential for irrigated agriculture, such as the Raya Valley in the Southern Zone.

As will be evident in the exposition below, we hypothesise that most of the variation in comparative advantage in Tigray is due to variation in agricultural potential and market access, with population density an important factor conditioning some of the opportunities that are primarily determined by these other factors. We thus discuss the four possible categories of agricultural potential and market access under major headings, and discuss how variations in population density are hypothesised to condition the opportunities within these major categories.

High Potential with Good Market Access

Areas with high agricultural potential and good market access—such as areas near Axum and irrigated areas near Mekelle—represent the greatest potential for agricultural development. Most agricultural strategies are feasible in such circumstances, but the more commercial strategies linked to high value products, such as production of perishable cash crops and dairy production, likely offer the greatest economic potential in the long run.

In the near term, intensified cereal production using high levels of external inputs is a high priority to farmers in such areas, allowing rapid improvement in food security and incomes and facilitating their ability to invest in producing riskier but more profitable perishable commodities. This is particularly the case in high population density settings where markets are not yet well developed, since land scarcity may limit farmers' willingness to devote significant portions of their land to even very profitable commercial crops. Increased cereal productivity can also facilitate intensified livestock production by increasing the supply of crop residues available for feeding and freeing up land for fodder or forage production. Conversely, production of cash crops can facilitate increased food crop and livestock production, by providing significant income from a small amount of land (and during the dry season when dry season irrigation is available) which can be used to finance purchasing external inputs or purchase of improved livestock breeds.

In lower population density settings as in southern Tigray, the potential to saturate local markets with increased food grain production will be greater than in higher population density settings, at least until development of regional and national infrastructure and grain marketing systems facilitate increased trade of local surplus production. Opportunities for improved livestock production by improving management of communal grazing lands are likely to exist. Taking advantage of such opportunities will require effective collective action at the community level to protect and improve management of area enclosures.

Non-farm development opportunities are also likely to exist in high potential, high access areas (both low and high population density), particularly through growth linkages to commercial farming activities. For example, employment in input supply, agricultural trading and processing industries will be stimulated by development of commercial farming. Growing demand for construction, financial services and other non-farm sectors will also stimulate non-farm growth linked to growing commercial agricultural activity.

High Potential with Poor Market Access

In areas with high agricultural potential that are more remote from market centres—such as irrigated areas in southern and eastern Tigray that are relatively far from the main road—opportunities for commercial agricultural development are more limited, at least until substantial improvements in road and transport infrastructure are made. Commercial agricultural production may need to emphasise non-perishable high value (relative to volume) crops, livestock (particularly small ruminants that can be readily transported to market), and/or bee keeping. There may also be good opportunities to reduce the perishability and increase the value to volume ratio of some commodities through local processing, such as by drying fruits or meats. In the near term, such processing efforts probably will need to focus on activities that require little capital (but may be labour-intensive) and that do not involve large economies of scale (otherwise such activities are more economical in larger urban processing facilities).

Opportunities for selling surplus cereal production from such areas are likely to be limited by high transport costs relative to the value of the products. A similar argument applies to importing cereals, and suggests that farmers will seek to be self-sufficient in food production in such remote areas. Intensifying cereal production using external inputs is likely to be important in achieving this objective (particularly high population density areas), since using imported inputs is likely to be cheaper than importing food in high potential remote areas. For example, one study estimated that one quintal of fertiliser produces three to seven quintals of additional cereals in high potential areas of the Ethiopian highlands (Mulat *et al*., 1997).

Without improvement in the productivity of food crop production, farmers' ability to take advantage of profitable opportunities to produce cash crops or livestock may be constrained by the need to allocate scarce land to producing food crops, particularly in high population density settings.[28] However, high transport costs and low incomes may limit farmers' ability to improve food crop productivity by purchasing inputs, suggesting that credit and possibly near term subsidies on the transport costs of inputs may be critical in enabling farmers to get out of the poverty trap that they are facing.

28. For example, the Technical Committee for Agroforestry in Ethiopia (1990) reported that forest coffee production was declining in high potential areas of Ethiopia as a result of population pressure and expanded food crop production.

Bee keeping is less affected by land and cash constraints and thus may be a good opportunity even in densely populated and low-income areas. The main constraints limiting bee keeping may be the limited flora in most of Tigray (except near remaining forest areas such as in eastern Tigray near the escarpment), and farmers' lack of familiarity with this activity. In less densely populated areas, improved management of grazing areas and livestock may be a good opportunity to generate increased incomes and increase the sustainability of resource use.

Low Potential with Good Market Access

In lower potential areas, such as the rainfed highlands of most of Tigray, adoption of more input-intensive cereal production is still very limited, and likely to remain so due to moisture stress, except where irrigation investments are being made. There may be potential to build upon the soil and water conservation investments that exist in most of Tigray by promoting targeted and limited use of fertiliser and improved seeds to the parts of the fields where soil moisture is greatest. However, such a limited and adaptive approach is not presently being pursued. For this approach to be economically feasible, sources of income to finance input purchases are needed.

This will be most feasible closer to urban areas where off-farm sources of income are available, where industries such as mining or manufacturing are developing, or where seasonal migration (or remittances from permanent migrants) is common. Despite opportunities for some agricultural improvement, non-farm development is likely to be the driving force for development in such areas, provided sufficient investments in infrastructure, education and training are made.

Rainfed areas close to the major towns of Mekelle, Adigrat and Adua are examples of such a situation.

In low potential areas with good market access and low population density, expansion of livestock production may be a good opportunity. Achieving this potential may require the strengthening of collective action institutions which would encourage investments in improvements of grazing lands, perhaps by planting and managing fodder grasses and trees in area enclosures. Tree planting activities in degraded lands may also provide opportunities for significant incomes and welfare improvement where market access is relatively good. The example of Echmare village in eastern Tigray (discussed earlier), may be replicable in similar situations elsewhere in Tigray.

Low Potential with Poor Market Access

The most difficult case for which to identify development opportunities are areas with low agricultural potential and no irrigation which are far from roads and markets, particularly where there is high population density and no significant off-farm sources of income. In some cases, particularly close to forests (such as in parts of Eastern Tigray), bee keeping is an economic activity. Small ruminants can be efficient users of available fodder resources, and can be transported long distances to market, though intensification of their use will be limited by grazing resources (especially in high population density settings). Tree planting on degraded lands, as mentioned above, and continued investment in soil and water conservation structures (particularly given relatively low opportunity costs of labour and the greater benefits of such technologies in drier areas) also may have significant potential to improve land productivity. Despite the existence of such opportunities, these seem unlikely to solve the long term poverty problem facing such communities. Emigration (seasonal or permanent) is likely to be an important element of the people's livelihood strategies in these areas.

In summary, despite the many constraints facing agricultural development in the highlands of Tigray, there appear to be many opportunities to achieve more productive and sustainable agriculture. Nevertheless, there is a continuing need to develop the non-farm sector as well.

In the long term, such balanced development of both the farm and non-farm sectors will be the key to achieving more sustainable use of the land, economic growth, and elimination of poverty.

Strategies for Sustainable Development

Having developed hypotheses about pathways of development that may be economically feasible in different types of circumstances in the highlands of Tigray, we now develop hypotheses about the policy, institutional, and technological strategies needed to exploit these comparative advantages. We must be clear at the outset that we are only suggesting hypotheses at this point. Development of recommendations for actual strategies must await further policy research at the community and household level; first, to identify whether the pathways of development that we have hypothesised are actually feasible and desirable in the circumstances suggested, and second, to illuminate the constraints and opportunities to achieving more sustainable, productive, and poverty-reducing development through the development pathways considered above.

High External Input Intensification of Cereals

The first requirement of this strategy is the availability of food crop varieties that will respond well to fertiliser and other inputs in the conditions of the highlands of Tigray. The initial success of the Sasakawa-Global 2000 programme and the government extension programme in higher potential areas of Ethiopia (Quinones *et al*., 1997; SG 2000, 1996), demonstrate the availability of such varieties, especially for maize. However, potential yield increases from such varieties likely will be more limited in the moisture-stressed conditions existing in most of Tigray.

To have the broadest and most sustainable economic impact, promotion of such technologies should account for local potentials and economic conditions as much as possible. As discussed previously, small farm sizes and uncertain rainfall (especially in moisture-stressed areas) can make allocation of half-hectare plots to new technologies a very risky strategy. This is less of a concern where rainfall is relatively assured or irrigation exists, but many farmers even in these circumstances still may prefer to adopt a more gradual or diversified approach, which may be precluded by a fixed package approach. In addition, adaptive and participatory research is needed to develop more targeted recommendations for integrated nutrient management practices; taking into account available sources of organic matter, local sources of soil nutrients, and potential for leguminous crops or trees (Quinones *et al*., 1997; Sanchez *et al*., 1997). The priority for such research in the near term should be high potential areas where this strategy is most feasible. For the longer term, continued basic research is needed to develop varieties that are suitable under lower potential conditions, such as in moisture-stressed and drought-prone environments.

Even without targeted nutrient management recommendations based on adaptive research, agricultural extension programmes can improve the usefulness of their efforts by allowing a more flexible approach and learning from farmers. Although the fixed extension package being promoted by the Bureau of Agriculture has demonstrated some impressive results, even more impressive results might be possible if farmers are given more opportunity to experiment with alternative mixes of inputs, and the results of such experiments are used to inform the development of more site-specific recommendations.

The availability of inputs (especially seeds and fertiliser) must also be assured. Although distribution of inputs by the extension programme is attractive as a way of demonstrating the benefits of using such inputs, this is something that can be as or more effectively provided by competitive input markets, at least to places with good market access. The longer-term goal should be to promote development of such markets. This is largely a matter of removing obstacles to such development, such as eliminating foreign exchange and import restrictions, deregulating prices, and avoiding interventions by local authorities in private marketing of inputs, as reportedly has occurred in other parts of Ethiopia. Mulat *et al*. (1997) estimate that improvements in the competitiveness of the input marketing system in Ethiopia resulting from such changes could reduce the average farm level price for fertiliser (relative to unsubsidised prices) by nearly 20 Birr per quintal (about 8 percent).[29] Other positive efforts that can help develop such competitive markets include investments in road construction and improvement and facilitation of the availability of credit to private wholesalers and retailers to finance purchase of storage and marketing facilities and working capital stocks.

29. One quintal equals 100 kg.

In remote areas where substantial improvements in market access are not likely in the near future, consideration of the most effective means to address poverty and food security should include consideration of subsidising the cost of transporting inputs to these areas (perhaps by continuing government provision to these areas). Since one ton of fertiliser can yield three to seven tons of additional grain in higher potential areas (Mulat *et al*., 1997), it is much cheaper to subsidise fertiliser imports than grain imports (through food aid) to such areas as a means of addressing food deficits. The longer term solution for such areas is to invest in improved infrastructure and education, but people still must be able to feed themselves in the near term.

Of course, exporting substantial quantities of grains from remote areas is not likely to be economical due to high transportation costs, and should not be promoted through subsidies. For example, it may require a two-day round trip for a farmer to take a quintal of grain by donkey to the nearest market from remote areas in Tigray. The opportunity cost of this trip (including the farmer's time and additional feed) could easily be 20 Birr, approaching 10 percent of the value of the grain sold. Probably more important, most farmers in remote areas may simply be unable to sell substantial amounts of grain, even if they produced a surplus, due to limited ownership of pack animals and carts. Thus it is not a good idea to subsidise fertiliser imports to areas that already produce sufficient food for local consumption, since the impact will be to produce a local surplus and depress local prices.

These considerations suggest that the priority for a transport cost subsidy for inputs, if it is used, should be remote areas that are food deficit with relatively high potential to use the inputs profitably. An example of such a situation might be in areas such as southwestern Tigray where production of non-perishable tree crops may be profitable, but may be limited by the need to produce food crops. In this situation, subsidised inputs for a limited period of time may enable farmers to intensify production of food crops and invest in increased perennial crop production, eventually being able to sustain use of inputs without subsidies through sales of high value products. In the near term, a subsidy on the transport costs of inputs may not be sufficient to overcome the subsistence constraint if incomes are very low, given the time lags in earning returns from producing high value perennials. In such cases, longer-term credit or a subsidy on the cost of the inputs (not only on transport costs) may be necessary in the near term, until farmers are able to meet food needs and earn sufficient income to buy such inputs, or until substantial improvement in market access occurs.

In areas with high potential and good market access, subsidies for inputs should be avoided. Such areas are likely capable of producing and marketing sufficient surplus production to pay for inputs purchased without subsidies. The main constraint to increased input use in such areas are likely to be limited access to credit and perhaps limited information where farmers have not yet participated in the extension programme.

In moisture-stressed areas with otherwise suitable soil conditions (particularly areas close to roads and markets), high priority should be given to irrigation investments where irrigation potential exists. The drought prone areas of southern Tigray close to Mekelle are a good example of such a situation, and in fact this is where SAERT is focusing much of its investment in constructing microdams. In more remote areas with irrigation potential, priority should be given to investments in roads as well as irrigation, since marketing constraints may otherwise undermine the ability to reap the full benefit of irrigation investments.

In low potential remote areas, the returns to fertiliser and other inputs may be too low or risky for farmers to use substantial amounts of them. Thus food aid may still be needed in the near term to address food deficits in such areas. In the longer term, alternative sources of income are needed.

In all areas where a high external input strategy is pursued, development of rural credit institutions is critical to the long run sustainability of the effort. As discussed earlier, rural credit institutions are poorly developed in Tigray. Efforts to develop such institutions should focus on areas where there is good potential for a high input strategy. The greatest immediate need is of course for short term credit simply to finance the input purchases. However, where surplus production and trade is possible, marketing credit to allow farmers to store and market grain during the dry season is also very important. Related to that, credit to finance investment in grain storage and facilities is needed where inadequate capacity exists. Adequate regulation of private grain warehouses, for example through licensing and bonding, is also needed to assure quality and reliability of the grain stored. Given such regulation, private warehouse receipts can serve as reliable collateral for marketing or other kinds of loans. Consumption credit can also be very helpful in promoting increased input use, since it can act as a form of insurance. In areas with sufficiently large production and good market access to support grain milling, credit or equity to finance such investments will also be needed. The development of equity markets in Ethiopia may be helpful in this regard, as is maintaining a policy environment favourable to domestic and foreign investment in industry.

The high external input strategy may facilitate more sustainable land management. Investments in soil and water conservation will be more attractive to private farmers since the value of land and the need to minimise losses of valuable inputs through erosion and runoff will be increased. In addition to direct benefits where such intensification occurs, indirect benefits in other areas can also result, as increased supplies of biomass reduce pressure on forests and grazing areas, and increased incomes provide alternatives to expansion of production onto marginal lands.

The impacts of this strategy on restoring soil fertility are not assured however. Soil fertility can be restored through increased use of fertiliser together with greater production of organic material. However, a net increase in soil mining may occur even with greater use of fertiliser, as a result of increased losses through erosion, leaching and quantities harvested. For example, recent estimates from western Kenya show greater nutrient mining on farms where there was more commercial orientation in food crop production (de Jager *et al*., 1998). Less nutrient depletion was found in cash crop production (e.g., in coffee and tea), suggesting that the profitability of using fertilisers in food crops may be insufficient to prevent such depletion (Ibid.). Further research is needed on this issue.

In summary, to fully realise the potential benefits of a high external input strategy of increasing food production, adequate attention must be paid to factors affecting the feasibility and profitability of input use, including infrastructure, extension, input availability, credit, and marketing facilities. In some cases where persistent food insecurity exists, subsidies on the costs of using inputs should be considered as a lower cost alternative to food aid, until these other constraints can be overcome (IFPRI, 1995).

Low External Input Intensification of Cereals

In lower potential areas without irrigation, the return to using external inputs, particularly fertiliser, is likely to be much more limited. The strategy for intensifying food crop production therefore must rely on a low (not zero) external input approach. In moisture stressed areas, a critical need is to conserve and use the available soil moisture as efficiently as possible, in combination with integrated use of limited amounts of inorganic fertiliser with organic nutrient sources.

In Tigray, where the moisture stress problem is severe, soil and water conservation structures such as stone bunds and terraces are very common, and there may be good potential to increase production through better management of nutrients where these structures exist. For example, it might be possible to significantly increase production with limited risk by targeting use of fertiliser and manure in the vicinity of conservation structures, where soil moisture is greater. However, the fixed package approach of the current extension programme has not encouraged such site-specific experimentation. In addition, little adaptive research has been conducted to explore the potential of such integrated approaches to conservation and productivity improvement.

Research is also needed to better understand the potential for improving soil productivity through integrated use of organic and inorganic fertilisers in different settings (Palm *et al*., 1997). Organic sources vary greatly in terms of their biomass productivity and nutrient content, their interactions with soil moisture and inorganic sources of nutrients, and their impacts on productivity; and these issues are not yet well understood in sub-Saharan Africa (Ibid.). For example, application of organic materials may reduce nutrient availability to crops by immobilising nitrogen or increase nutrient availability by reducing phosphorus fixation. It is also important to recognise that many organic "sources" of nutrients (such as crop residues or manure produced from grazing crop residues) only recycle nutrients within the farming system, and do not add to the stock of nutrients in the system. As important as such recycling is to help slow the rate of nutrient depletion, it cannot restore soil fertility. Biological nitrogen fixation by leguminous plants, uptake by trees of nutrients that are unavailable to crops, and transfer of biomass from outside the farm do increase the stock of nutrients available to the farming system, and can be very important components of a low external input strategy. However, these strategies cannot adequately restore phosphorus where it is depleted (Sanchez *et al*., 1997). Thus, some use of inorganic fertiliser is an essential component of strategies to restore soil fertility and increase agricultural productivity, especially where phosphorus depletion is a major problem.

A critical constraint on increased use of organic material in low potential areas is the shortage of such material and high demand to use it for other purposes (particularly in high population density areas) such as burning of dung and grazing of crop residues. It is thus difficult to address the soil fertility problem in such areas without addressing the larger problem of a shortage of biomass. One way to address this issue is to make better use of degraded lands and communal grazing areas to produce biomass. As the experience in the village of Echmare in Eastern Tigray discussed earlier indicates, there is substantial potential to increase production of trees on degraded lands, helping to relieve local shortages of wood for fuel and construction materials, as well as generating substantial income and wealth. The key to success seems to be to provide the right set of incentives. The community approach to planting woodlots has yielded limited benefits in Ethiopia, whereas allowing individuals to receive private benefits from tree planting (with secure tenure) shows promise of achieving impressive results.

The impact of the new land policy, allowing private use of degraded and sloping lands for tree planting and other conserving uses, remains to be seen and should be investigated. If it does result in a substantial increase in tree planting and harvesting from wastelands, more manure and crop residues can be recycled into crop production, as fuelwood becomes more available. As the general biomass shortage is reduced, the need for the most rapidly growing species (generally eucalyptus) will decline, and other kinds of trees, such as fruit trees, legumes, and fodder producing trees may become more attractive to plant. This will increase opportunities for improving soil fertility and intensifying livestock production, as well as generating income directly from tree products.

Improved management of pasture and grazing areas also could yield substantial benefits. For example, area enclosures are showing good results in terms of regeneration of natural vegetation, but there are common complaints from farmers that they are not benefiting from the biomass being produced (where cut and carry or controlled grazing systems have not been established). In addition, enclosures tend to increase pressure on other unprotected areas, so the net impact on resource degradation is not necessarily positive. To help ensure that positive benefits are achieved and felt by farmers, more intensive management of grazing areas, such as planting and managing improved grasses and trees, is needed. This could be approached by allocating such lands for private grazing use or through better collective management of enclosures.[30]

30. More productive pasture areas are often allocated to private individuals in Tigray.

Because of economies of scale in protecting grazing areas and risk spreading advantages of using them collectively, privatisation of such lands may not be optimal (Otsuka, 1998; Baland and Platteau, 1996). However, attaining the benefits of collective management requires effective institutions at the local level. Such institutions do not necessarily arise spontaneously, even when the net benefits of effective collective action are large (Ibid.). Government or other external intervention can help to catalyse the development of such institutions, though this requires a cautious approach that respects local autonomy and concerns. Heavy-handed intervention from external agents can undermine the development of such institutions, causing increased dependency on the regulatory role of such external agents, and possibly increased conflicts in the community (Pender and Scherr, 1998). Research is needed to better understand the conditions under which effective institutions for managing grazing lands arise and become sustainable in the Ethiopian highlands, and how the government and non-governmental organisations (NGOs) can help to promote rather than undermine this development. Where this does occur, intensified livestock production, improved soil fertility management, and increased incomes will also likely occur.

Organic sources of crop nutrients can also be generated on cropland. Many practices have been developed for this purpose, such as hedgerow intercropping, improved fallow, green manures, composting, and planting of fodder or multi-purpose trees (Cooper *et al*., 1996). High population density and remoteness from markets favours more labour intensive practices (such as hedgerow intercropping or composting) since opportunity costs of labour are lower in such circumstances (Ibid; Ehui *et al*., 1990). However, the potential of such approaches is limited by the scarcity of water in the low potential highlands. High population density and small farm sizes will limit more extensive practices, such as improved fallow and planting trees. In land scarce settings, planting of trees may be most feasible in particular niches, such as in the homestead plot, on bunds and on plot boundaries. However, planting on boundaries and bunds can create problems by competing with crops for water and light on the owner as well as neighbours' fields (Ibid.).[31] There are also possibilities of temporal niches, such as improved fallow during the short rainy season.

31. These problems are particularly acute for eucalyptus, which has led the government of Tigray to ban planting of eucalyptus in farmland.

Despite these possibilities, the potential for increasing flows of organic nutrients into food crop production from such sources is probably lower than the potential offered by better management of grazing lands and wastelands, at least in lower population density settings as in much of Tigray. In very high population density, low potential (non-irrigated) areas, the options for increased organic matter production are probably relatively limited. In such cases, development of woodlots, even on farmland, may be a better option for sustainable land use and reducing poverty (particularly where market access is relatively good and farmers have access to off-farm sources of income). The ban on planting eucalyptus trees in farmland recently adopted in Tigray may eliminate this as a feasible option, however, since eucalyptus is by far the preferred tree because of its ability to grow rapidly, produce valuable products, and regenerate even in very dry conditions.[32]

32. It's not clear how well this ban is being enforced. One can readily observe eucalyptus trees planted in farmlands in various parts of Tigray.

Tenure insecurity on farmland may also undermine investments in tree planting, manuring, soil and water conservation structures, and other land improvements. This issue appears to be more of concern in other regions of Ethiopia where land redistributions are still a threat. Nevertheless, some farmers in Tigray do express a desire to have registration certificates to their land, because of the increased sense of security this would provide. As mentioned previously, this demand is being met through current land registration efforts. Restrictions on long-term leasing may also reduce such investments where leasing is common. Land fragmentation, as is common throughout much of the highlands, is likely a major constraint to investment in manuring, mulching, or other approaches requiring transport of bulky materials to distant fields. Fragmentation may also prevent investments in land improvements such as planting fruit trees or constructing soil bunds, since these may be subject to theft or damage by neighbours if not easily supervised. For example, Olson (1995) reports cases of farmers in the Kabale district of southwestern Uganda surreptitiously undermining terraces on plots of their upstream neighbours, thus "harvesting" some of the fertile soil that had accumulated in the terrace. Restrictions on land sales and leasing, as exist in Tigray, may contribute to the land fragmentation problem. However, the example from Uganda, where such restrictions do not exist, suggests that change of land policies would not necessarily solve it.

Livestock grazing practices also can have a significant impact on the feasibility of some kinds of land improving investments. For example, free grazing on farmland after the harvest is common in much of the highlands of Tigray. This likely limits the ability of farmers to invest in planting many kinds of biological measures to control erosion and restore soil fertility, since grazing or trampling may destroy such measures. Thus, improvements in management of farmlands may depend upon changes in the grazing system and improvements in the management of grazing areas.

Other issues such as fertiliser and credit supply are less important where a low external input strategy is pursued than where a high input strategy is pursued, since such areas will have lower demand for these inputs. Nevertheless, these areas should not be neglected in this regard since the small amounts of inputs and credit they use may be very important. Other kinds of credit, particularly credit for productive non-agricultural purposes (such as petty trading) and for consumption purposes may also be very important in addressing problems of poverty and food insecurity. Development of road infrastructure, storage facilities and the output marketing system will be less important to such areas as suppliers of food, but critical to them as net importers of food.

Commercial Production of Perishable Cash Crops

Where there is very good access to markets and irrigation or sufficiently reliable rainfall, intensive commercial production of perishable fruits and vegetables can be very profitable. The ability to pursue this strategy likely will depend first upon the success of increased productivity of cereal production. Risk averse farmers with very little land are usually reluctant to gamble on new and highly risky crops, however potentially profitable, unless their food security is assured (von Braun *et al*., 1991). Such assurance need not depend only on local food production though. For example, small farmers in western Kenya are adopting vegetable crops and importing maize from Uganda. Open trade policies thus can be very helpful in allowing such commercialisation to occur. Non-farm income can also provide sufficient food security to allow commercialisation to occur (Ibid.). But in cases where a potential comparative advantage in cereal production exists, realising that potential can be an important first step towards enabling farmers to diversify into higher value products. Thus the requisites of high-external input intensification of cereals also likely help to promote intensive production of perishable cash crops in such cases. At the same time, income earned from such cash crop production can help farmers intensify food crop production, by enabling them to purchase more inputs. Thus increased cash crop production and increased food crop production may be mutually reinforcing strategies.

One important constraint may be lack of knowledge about such products, especially about their market potential. Technical assistance, emphasising market opportunities for different crops as well as crop management, can be very important. With fresh horticultural products, local markets can quickly become saturated, causing dramatic price declines.[33] It is critical for farmers to be aware of the potentials and problems of alternative crops, so that they can diversify their production. Information on prices in local markets, announced over radio, could also be helpful.

33. On a recent field trip to a microdam site near Axum in Tigray, farmers recounted how the price of tomatoes fell from 8 Birr/kg to 2.50 Birr/kg and the price for peppers fell from 6 Birr/kg to 3 Birr/kg after the previous harvest.

Such technical assistance need not come only from government extension agents however. In other parts of the world, farmers often obtain advice from other farmers, input suppliers or traders. As the input marketing system develops, local suppliers will become more knowledgeable and able to provide advice to farmers. Providing training to suppliers as well as farmers could help this process. For some things, however, technical assistance probably must be provided (or at least financed) by governments, due to incentives facing private suppliers. For example, integrated pest management and organic farming methods may not be adequately promoted (relative to their potential benefit) by private input suppliers, since these methods may reduce sales of agrochemicals. Training is also needed on proper use and disposal of pesticides, which are likely to be much more widely used where horticultural development is occurring. Taxes on pesticides, so that their private cost reflects their social cost accounting for negative externalities, would help to promote safer and more efficient use of pesticides, while generating revenue for governments.

Where irrigation is used in production of cash crops, conflicts may arise over access to water and management of irrigation systems. Well functioning institutions are needed to allocate use rights and enforce responsibilities. As with institutions to manage grazing lands (discussed below), such effective institutions may not arise spontaneously, but may be catalysed by appropriate interventions by external agents (Baland and Platteau, 1996). On the other hand, external intervention may undermine the effectiveness of local management and increase the potential for conflict (Ibid.). Thus a careful approach to promoting development of such institutions is warranted, taking full account of local conditions and concerns before investing in irrigation schemes or identifying the strategy to address issues of rights and responsibilities. For example, the fact that some farmers have lost access to land as a result of microdam construction in Tigray without yet being allocated land in the command area (discussed previously), could lead to conflicts that undermine confidence in the overall effort, which otherwise appears to be achieving impressive results. In other cases in Tigray, local community councils (tabia baitos) have been very involved in such decisions from the outset, and land in the command area has been allocated to all affected households; resulting in broad support for the effort.

Available input supply and credit to finance input purchases are of course important for producers of horticultural crops, as they are for high input production of cereals. Given the high expected returns to such inputs, linking future credit to repayment of past loans can provide a strong incentive to repay. However, since such crops are highly risky (particularly price risk), lenders may be reluctant to lend as much as farmers desire where collateral is limited. This problem is exacerbated by the prohibition on land mortgaging in Ethiopia. However, even when farmers have adequate collateral, they may be reluctant to borrow due to the risk involved, even if the expected profits are high. Alternative institutional arrangements, such as sharecropping and contract farming, can be used as a means of reducing risks and obtaining access to short term capital.[34]

34. The use of these arrangements to obtain capital and reduce risks has been observed in recent research in Honduras (Pender et al., 1998; Bergeron et al., 1996).

Tenure insecurity, restrictions on leasing, and land fragmentation may limit commercialisation of perishable cash crops for the same reasons cited earlier in discussing factors affecting investments in land improvement. These factors are particularly important with respect to planting fruit trees, which of course require long term tenure security, and protection against theft or being cut for fuelwood. Where such security is lacking, investments in fruit trees are likely to be limited to plots near the homestead.

Where there is potential for selling processed products and/or export of cash crops, the availability of cold storage, processing and transport facilities may be critical constraints. The availability of electricity is one key constraint affecting the development of such facilities. Commercial credit or equity capital also will be needed. Provision of infrastructure and lines of credit for such purposes and maintaining a policy environment that facilitates private investment are thus likely to be very important to achieve this potential. Development of processing can also promote contract farming or cooperatives, since processors will seek to assure themselves a reliable supply.

There is good potential for more sustainable land management where horticultural production is occurring, but there are also risks. Such high value, labour intensive production may reduce pressure on marginal lands by providing farmers' sufficient income on a smaller area of land. It can contribute to agro-biodiversity and help to reduce pest problems if used in rotations with primary staple crops (Pingali and Rosegrant, 1995). Horticultural production can encourage investment in soil conservation by increasing returns to such investments. For example, Tiffen *et al*. (1994) found a strong association between adoption of horticultural crops and construction of bench terraces in the Machakos district of Kenya. The cash income generated by horticultural production also provides incentive and ability to purchase fertilisers, which may restore soil fertility. This effect is not assured, however, since multiple cropping of horticultural crops can rapidly deplete soil nutrients even when increased fertilisers are applied. Education and extension efforts can help to address such problems, though farmers may simply find it too risky or costly to apply sufficient amounts of fertiliser to avoid this problem. Other potential problems include contamination of soil and water and human health risks caused by agrochemicals, and increased conflicts over water. Applied research and extension related to integrated pest management, integrated nutrient management, and water management are critical to minimise such risks and attain the greatest possible benefits from this development strategy.

High Value Non-Perishable Perennial Crops

Given the time lags required to receive the benefits of investment, expansion of production of high value perennial crops such as nuts, coffee, tea and chat where land is scarce depends upon first assuring food security. Since areas with a comparative advantage in such non-perishable crops will tend to be further from markets than dairy or horticultural areas, relying on imported food is likely to be more costly than local production. Increased food production therefore must be high priority for such areas, with the goal being elimination of local food deficits and freeing up of scarce land for the production of higher value crops. The policy and institutional requisites thus include those discussed earlier to achieve high input intensification of cereal production, including consideration of subsidies on the transport cost of fertiliser in the near term until food deficits are eliminated and income from perennial crop production is growing.

Many of the requirements for other commercial strategies mentioned earlier are also important for high value perennials. Investment in roads, land tenure security, and land transactions (to reduce fragmentation) are critical. Research and extension to promote use of improved varieties and improved management is needed. Promotion of private nurseries (for example, through availability of credit) can be helpful. Credit to finance inputs and purchase of tree seedlings can also be helpful. Development of processing facilities and assuring adequate capacity utilisation of such facilities is important, especially for tea (von Braun *et al*., 1991). The need to assure a sufficient quantity and reliability of supply to make such facilities profitable contributed to the attractiveness of large plantations established by colonial settlers in Kenya. Development of alternative institutional arrangements more appropriate to smallholder production, such as cooperatives or contract farming, can help to achieve the same goals. Large processing facilities are less necessary for coffee than tea if coffee is sold in unwashed form, but the value-added in the local economy is reduced. To be able to tap this potential, substantial investments in coffee washing facilities are now occurring in coffee producing areas of Ethiopia (Ethiopian Herald, May 7, 1998). Maintaining a policy environment conducive to development of cooperatives and such investments in processing are key to attaining the potential of this strategy.

The benefits of development of high value perennial crops for the sustainability of land use can be substantial. As with annual horticultural crops, the income generated can help reduce pressure to continue producing or expanding onto marginal lands and allow greater use of inorganic fertilisers, while the increase in land values encourages investments in land improvements.[35] In contrast to annual cash crops, high value perennials are a less erosive land use. Where coffee is grown in shaded conditions, there is good potential to plant other kinds of trees for soil fertility management, fodder and/or fruit production, increasing the benefits for land management and farm incomes. There is evidence from western Kenya that soil fertility depletion is lower where perennial cash crops such as coffee and tea are grown than where annual food crops are grown for commercial purposes (De Jager *et al*, 1998). As with horticultural crops, however, there are risks posed by increased use of agrochemicals in the production of such crops. Thus, extension and training will play an important role in promoting appropriate practices of integrated soil nutrient management and integrated pest management.

35. For example, coffee has played a key role along with horticultural crops in promoting more profitable and sustainable land use in the Machakos district of Kenya (Tiffen et al., 1994).

Intensification of Livestock Production

The most widespread technical constraint to intensified livestock production in sub-Saharan Africa is the availability of feed (McIntire *et al.*, 1992; Winrock International, 1992). In the densely populated highlands, the prospects for relaxing this constraint through increased forage production in farmlands is limited (except where high value dairy production exists), given the scarcity of land and food (McIntire *et al.*, 1992). Except in less densely populated parts of the highlands, the potential for increased fodder production in communal grazing areas and wastelands is also limited, as discussed above. Imported feed and feed concentrates are likely to be of limited use, except in very commercialised systems such as urban and peri-urban dairy production. Thus, the prospects for livestock intensification (especially in mixed crop–livestock systems common in Tigray) may depend significantly upon the success of intensification of cereal production, which can greatly increase the quantity and quality of crop residues available as a feed source, as well as freeing up land to be used for increased forage production. This implies that the policy and institutional requisites of cereal crop intensification discussed above are also critical to livestock intensification.

Other important constraints to intensified livestock production in the East African highlands include animal diseases, limited stock of improved breeds, limited availability of veterinary services and other inputs, poor infrastructure, and limited market and institutional development (Winrock International, 1992). While it is desirable to address all of these constraints wherever they are binding, priority should be given in the near term to places where there is substantial commercial potential and where the feed constraint is not binding. For example, improved dairy breeds are not likely to be used where adequate feed cannot be assured or only limited commercial potential exists, given their cost and greater demand for feed. Returns to investment in veterinary services, infrastructure and marketing facilities will be much greater where commercial potential exists and feed is adequate than elsewhere. Thus, such efforts should be targeted in the near term to areas close to urban markets, particularly where dairy potential exists, since the returns to this activity are relatively high (McIntire *et al.*, 1992; Jahnke, 1982).

Development of dairy cooperatives may be a critical component of a strategy to develop dairy production in areas of high market access. Because of the bulky, highly perishable, and easily contaminated nature of fluid milk, the transaction costs and risks involved in marketing milk are very high (Staal, *et al*. 1997). Dairy cooperatives help to reduce risks and transactions costs facing individual producers by pooling risk, reducing unit costs due to economies of scale in collection and transport, making inputs available, and enhancing their bargaining power. They reduce costs faced by processors by reducing milk acquisition costs and assuring the quality and reliability of the supply. In addition, dairy cooperatives may contribute to the development of social capital; for example, by investing in education and health facilities.

Dairy cooperatives are not yet common in Ethiopia. For example, almost all milk is marketed through informal channels in the Addis Ababa milkshed; only 12 percent is sold to the parastatal Dairy Development Enterprise (DDE) (Ibid.). As a result, substantial differences in prices received by different producers and paid by different buyers exist. Large producers receive higher prices than smaller producers, urban producers higher than peri-urban, and all producers are willing to accept lower prices if selling to larger and more reliable customers (Ibid.). Controlling for these differences, farmers with more capital are able to obtain higher prices than poorer ones. These findings suggest that development of cooperatives could help promote smallholder dairy development in Ethiopia, by helping to reduce transaction costs and achieving economies of scale. The Smallholder Dairy Development Project, funded by FINNIDA, has begun to promote development of milk groups for processing and marketing in peri-urban areas of Ethiopia.[36] Preliminary results from a recent survey of such groups suggest that there are substantial variations in their performance and viability, influenced by many factors (Nicholson *et al*., 1998). One factor that appears to be particularly important is economies of scale; the largest group studied obtained the highest prices for dairy products and was the most profitable (Ibid.). Thus, changes in farmer attitudes towards participation in cooperatives are likely to be an important determinant of their success in Ethiopia. Removal of bureaucratic obstacles to cooperative development and availability of credit could help facilitate cooperative development.[37] Availability of crossbred cattle also must be assured. Government provision of information about market opportunities and prices and capacity building in cooperative management could also be very helpful.

36. Perhaps because of the negative impression farmers have of cooperatives from the politicization of service cooperatives under the Derg, dairy cooperatives are called "milk groups" in Ethiopia.

37. For example, government agencies in Ethiopia are reputed to have claimed ownership of dairy processing equipment purchased by groups of producers under dairy development projects (Ibid.).

Development of other intensive commercial livestock enterprises such as beef fattening and poultry and pork production is constrained mainly by the need for low cost feed, though religion also plays a strong role with regard to pork consumption. Where domestic feed supplies are limited, avoiding restrictions on imported feed concentrates could help such enterprises to develop. Once demand for such concentrates becomes sufficiently developed, and domestic production of cereals increases sufficiently, local production of feed concentrates may become profitable. Ensuring a policy environment attractive to foreign and domestic investors could be an important element in facilitating such development.

Development of such commercial intensive livestock industries would greatly enhance the availability of manure. Given the high cost of transporting manure, the direct impacts on soil fertility would be limited mainly to areas close to the urban markets where these industries develop. However, the increase in supply of such organic material might be used to develop domestic industries supplying more concentrated fertiliser or fuel, which could have a significant impact even in areas further from the urban market. An attractive policy environment could also help facilitate investment in this type of venture.

In more remote areas, focusing on increased fodder production (though increased cereal production, forage crops and/or fodder trees) may be the greatest opportunity in the near term. Given improved fodder production, there will be opportunities to promote increased productivity in small ruminant production, particularly in lower population density settings, together with improved grazing land management (discussed above). Public measures to control or eliminate animal diseases are justified in remote areas as well as commercial areas for both efficiency reasons (due to the public goods nature of the investment) and to address rural poverty and food insecurity.

Beekeeping

The primary constraints to expanded beekeeping in Tigray are the availability of vegetation, farmers' knowledge and training in this activity, and the availability of infrastructure and facilities for marketing the honey. Given the limited availability of forests in Tigray, expansion of beekeeping could be linked to establishment and management of area enclosures and to tree planting efforts on degraded lands, increasing the benefits achieved by such efforts. The policy and institutional requirements for increased beekeeping thus include the same requisites as those to promote improved management of area enclosures and tree planting in degraded areas (discussed above).

Other requisites include training and technical assistance in beekeeping and honey marketing, and facilities for canning, storing, transporting and marketing honey. Honey is already being exported from Tigray to other regions of Ethiopia, so some of the market infrastructure already exists.

Rural Non-farm Development

In areas close to roads and markets, rural non-farm activities are usually an important source of employment and income (Delgado *et al.*, 1994; von Braun *et al.*, 1991). Where commercial agricultural production is expanding, linkages to agricultural input supply, processing, and trading are particularly important. For example, off-farm income exceeds half of total income for farmers in western Kenya (the proportion is higher for lower income farmers), and much of this comes from small enterprises engaged in such agriculturally related activities (Crowley *et al*., 1996). Thus many of the requisites for this strategy are the same as those discussed above for the commercial agricultural development strategies.[38]

38. Other kinds of rural non-farm development may be related to development in mining, manufacturing (e.g., textiles and leather goods), and construction (related to development in other sectors). These types of development have some of their own requirements, which will not be discussed in detail here.

Beyond development of commercial agriculture, the key requirements for this strategy include development of infrastructure (especially roads and electricity) and transportation facilities, education and vocational training, availability of credit and savings to help finance small start-up enterprises and equity capital for medium and larger enterprises (access to credit usually not a problem for larger enterprises). It is important to maintain an environment conducive to investment; for example, by reducing delays in licensing procedures, facilitating purchase or long-term leasing of land and buildings by enterprises in urban and peri-urban areas, reducing taxes and broadening the tax base. Restrictions on labour mobility caused by restrictions on land sales or leasing or tenure insecurity in rural areas can also be an important constraint inhibiting migration of workers to areas where employment demand is high. However, shortages of skilled workers resulting from low education and inadequate training facilities is probably a more critical constraint. High priority should be given to improved education in all areas, and to establishing training facilities where potential for non-farm development exists.

The impacts of non-farm development for sustainable land management are less direct than the effects of the agricultural development strategies, but may be larger and more profound in the long run. Non-farm income enables households to save and to overcome capital market imperfections that may cause households to discount the future heavily and limit their ability to invest in commercial crop production, inputs or land improvements (Crowley *et al.*, 1996; Reardon *et al.*, 1996; Pender and Kerr, 1998; Clay *et al.*, 1998). Such development can provide farmers an alternative to continuing depletion of soil, forests and other resources (Pinstrup-Andersen and Lorch, 1995). On the other hand, non-farm development may reduce farmers' incentive to invest in land improvement, by increasing the opportunity cost of their time (Pender and Kerr, 1998; Clay *et al*., 1998). It is thus important to promote less labour-intensive strategies of land management (such as planting trees rather than annual crops and hand-built terraces) in areas where non-farm employment opportunities are increasing the value of labour. Land policies that limit farmers' ability to plant trees—such as the periodic land redistributions, restrictions on land sales and leasing (limiting ability to reduce fragmentation) and the ban on planting eucalyptus trees in farmland in Tigray—may thus have a particularly onerous impact where rapid non-farm development is occurring.

Emigration

Related to non-farm development is the strategy of emigration, both seasonal and permanent. Areas with low agricultural potential and low market access are likely to be particularly large sources of emigrants, though emigration from all areas of the rural highlands is likely given the high population density and small farm sizes. The feasibility of this strategy depends largely upon commercial agricultural development and non-farm development; thus the requisites of the strategy include the requisites of those strategies. There is likely potential for seasonal rural–rural migration within the highlands from low potential areas to higher potential or irrigated areas during the dry season, and in some cases there may be potential for permanent rural–rural migration to reduce disparities in across locations (though generally high population density throughout the highlands makes this difficult).

The need for education and training for people in areas of emigration should be emphasised. Land tenure is also a key issue affecting migration. People without secure tenure are unlikely to risk losing their land by taking jobs in the city. The scope for permanent rural–rural migration is affected by host area tenure policies affecting opportunities for land purchasing or leasing. This will be less important with regard to seasonal migration, although availability of land to establish housing for seasonal immigrants is important. Education policies also can affect possibilities for inter-regional migration: for example, different languages are now being taught in different regions of Ethiopia, which will likely increase barriers to inter-regional migration.

Summary and Conclusions

In this paper we have examined the available evidence regarding land degradation in the highlands of Tigray and its causes, and suggested hypotheses about opportunities for various pathways of development in Tigray and strategies to achieve more productive, sustainable and poverty reducing development via such development pathways. Although the evidence on land degradation and its causes is limited in Tigray, it appears that the interrelated problems of soil erosion, soil nutrient depletion, and limited soil moisture are the most critical land management problems facing the region, and are inflicting substantial costs in the region.

The proximate causes of these problems are relatively well known, and include natural factors such as the rugged topography, thin soils, low and uncertain rainfall (subject to highly erosive rainfall events) in the highlands of Tigray; as well as farmers' decisions regarding land management, including land use, crop choice, adoption of soil and water conservation measures, soil fertility management practices, grazing practices, use of agricultural inputs, etc. Underlying these decisions of farmers are many socioeconomic and institutional factors. Among the most important appear to be population pressure, poverty, land tenure, local market development, local institutional and organisational development, and farmers' perceptions and attitudes. Affecting many of these socioeconomic and institutional factors (as well as often affecting farmers' decisions directly) are many government policies and programmes, particularly policies affecting distribution and leasing of land, agricultural research and extension, input marketing, credit, irrigation development, road and other infrastructure development, development of farmers' organisations and local institutions, and soil and water conservation programmes. Clearly soil and water conservation programmes, though important, are not the only, nor necessarily the most important, policy factor affecting whether land is managed in a sustainable manner. Further research is needed to determine the impact of these other policy areas (as well as the impact of conservation programmes) and to identify policy strategies to promote more sustainable and productive development.

In order to identify effective policy strategies, we have argued that it is useful to start by considering the comparative advantage of various potential pathways of development under different types of situations existing in Tigray. In areas with relatively high agricultural potential and good market access, there is strong potential for commercially oriented agricultural development strategies, such as intensified production of cereals using high levels of external inputs, commercial production of perishable cash crops such as fruits and vegetables, and/or intensive production of commercial livestock products such as dairy and poultry. There is also strong potential for rural non-farm development linked to agricultural development in such areas. We have argued that the priority initially should be on intensified cereal production in these areas, since the need for food security is likely to constrain farmers' ability to expand production of other (perhaps more profitable) products until cereal production is adequate. In the longer term, increased production of higher value commercial products is likely to bring greater incomes and development in these areas. Development of credit, input and output marketing systems will be critical to the success of these pathways.

In areas with high agricultural potential that are more remote from markets, the comparative advantage is likely to be greater in production of high value (relative to volume) non-perishable cash crops such as nuts, coffee, tea, or chat, and/or intensified production of easily transportable livestock such as small ruminants. Even more than in areas of good market access, farmers' ability to produce sufficient food is likely to constrain their ability to expand production of such products. Thus, we have argued that high priority should be given to increased cereal production in such areas with food deficits through the use of imported inputs (particularly seeds and fertiliser). This may require subsidising the cost of transporting inputs in the near term, as well as medium or long term credit to allow farmers to finance investments in perennial crops. In the longer term, investments in transportation infrastructure and increases in farm income will make transport cost subsidies unnecessary.

In areas with low agricultural potential but good market access, development opportunities are likely to be related to investment in irrigation where feasible and profitable; intensification of cereal production using limited amounts of inputs integrated with soil and water conservation and organic fertility management measures; intensification of livestock production through improved management of grazing lands (especially in lower population density settings); development of private woodlots (especially in lower population density settings); and rural non-farm development. Increased cereal production using limited inputs is likely feasible in such areas, though there needs to be more flexibility and adaptation of the extension approach to farmers' situations. Development of the capacities of local tabia baitos to manage common lands (including grazing areas, area enclosures, and degraded and sloping areas) more profitably will also be critical in these areas. These areas are likely to remain deficit producers of food, and food aid may be needed in the near term in many such areas, until the development potentials are more fully realised.

In areas with low agricultural potential and poor market access, the opportunities for agricultural or rural non-farm development are even more limited. Irrigation development may be a driving force for development where large potential exists, as in the Raya Valley, though generally the returns to such development may be much lower than in areas of higher potential or higher market access. Development of woodlots may also be limited by lack of market access. Intensified cereal production using limited amounts of inputs integrated with soil and water conservation practices and intensified livestock production is likely to be important. Beekeeping may also be an attractive option in some areas, and could be linked to vegetative regeneration in area enclosures (especially in lower population density settings). Despite the opportunities that still exist for agricultural development in such areas, food aid and emigration are likely to be essential to the livelihoods of people in these circumstances. Thus policies with respect to food aid, agricultural extension, education and training in non-farm activities, and land tenure will be of particular importance for these areas.

The opportunities for addressing land degradation, while achieving more productive and poverty reducing development, will differ depending upon which pathways of development are pursued. Where commercial agriculture is feasible and profitable, there is strong potential to increase incomes and sustainability through use of high levels of inputs integrated with organic soil fertility management practices and conservation investments. Where commercial agriculture is less feasible, improved soil and water management will depend greatly on development and adoption of integrated resource management practices, linking tree planting, improved grazing land management, and integrated use of soil and water conservation and organic fertility management measures with limited use of inputs. The success of these efforts likely will depend greatly on adoption of a more integrated, flexible and responsive approach to agricultural extension and soil and water conservation.

Consideration of the key constraints likely to be binding in these different situations discussed suggests a number of hypotheses about where public policy and investment priorities should be placed:

1. The highest priority for road development should be areas relatively close to urban markets where there is high agricultural potential or high irrigation potential. The highest priority for irrigation development is also in these areas; particularly dryer areas, although supplemental irrigation in higher rainfall areas can also be very valuable. Such development could enable intensive production of food crops, high-value perishable cash crops, and dairy products. Where irrigation investment is occurring, adequate attention must be given to institutional issues, such as how water will be allocated and how losers will be compensated, prior to physical construction.
2. Where such commercial potential exists, food security is a key to allowing farmers to exploit the opportunities available. Where farmers have substantial off-farm income, they may be willing and able to specialise in cash crop production. However, where such opportunities are more limited (or for more limited income farmers), the risks associated with cash crop production may require increases in food productivity to enable greater cash crop production. Increased cash crop production may also help promote increased food crop production (by enabling purchase of inputs), so that both food and cash crop production may increase for some time before greater specialisation occurs. Similar complementary growth of food crop and dairy production may occur in the early phases of development. Research and extension programmes should recognise and exploit such complementarities.
3. Assuring adequate provision of inputs and credit, and development of the marketing system are critical to all commercial strategies. Development of processing facilities and marketing institutions (such as cooperatives and contract farming), facilitated by a supportive policy environment, are needed. Research and extension programmes will need to take a broader focus, emphasising market opportunities for new commodities, management of animal health, integrated pest management, and integrated soil nutrient management.
4. Second priority for road development should be high potential areas further from markets, especially where population density is high. There is good potential for intensified production of high value perennial crops in these areas if roads are adequate. However, achieving this potential first requires assuring food security, which is likely to be most economical by increasing productivity in food crop production. For the near term, subsidies on the cost of transporting fertiliser and other inputs to such areas (if they are food deficit) should be considered as a lower cost alternative to food aid. As food deficits are eliminated and increased income from perennial crops generated, such subsidies should be eliminated. A high priority for such areas is also land registration and avoidance of restrictions on long-term land leasing, to reduce problems of tenure insecurity and land fragmentation.
5. For low potential areas without good potential for irrigation (especially with lower population density), priority should be placed on promoting increased productivity of all land, including grazing lands and wastelands. Cautious efforts by governments and NGOs to catalyse development of local institutions to better manage grazing lands are needed. Contingent upon improved grazing land management, some intensification of livestock production is possible. Increased production of small ruminants may be a particularly profitable strategy. Private allocation of wastelands and sloping lands for tree planting has potential to substantially reduce the biomass shortage in some areas, as well as increasing household wealth and incomes, though the potential for income generation is greater closer to markets. In the near term, food aid may be needed in such areas, though priority should be given to developing alternative sources of income as well as increasing land productivity.
6. For low potential areas with good market access, good opportunities for rural non-farm development may exist, though these may depend upon non-agricultural activities, such

as manufacturing and mining, given low agricultural potential. Priority should be on investment in infrastructure (especially electricity), availability of credit to finance startup enterprises, and education and training of the labour force.

7. For low potential areas with poor market access (especially with high population density), emigration should be facilitated. High priority should be placed on education and training. Allowing long term land leasing could also help to facilitate emigration and less intensive use of the land.

It is important to emphasise that these are only hypotheses, based upon theoretical considerations and a very limited amount of empirical evidence. Furthermore, there is certainly substantial variation within the types of situations discussed, and across households having access to different resource endowments. Addressing problems of poverty, low agricultural productivity and resource degradation will therefore require strategies that address the needs of the poor as well as the more well-endowed. Nevertheless, identifying the broad strategies of development that are feasible can help to identify more targeted strategies for more specific situations. Much research is needed to validate the development pathways and associated strategies that have been hypothesised, or to identify other appropriate strategies. That is the objective of the research IFPRI–ILRI–MUC research programme that will be conducted in Tigray, building upon the hypotheses developed in this paper.

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