AG/ETH/82/010
TECHNICAL REPORT 1

MASTER LAND USE PLAN

ETHIOPIA

MAIN REPORT

Report prepared for
the Government of the Peoples
Democratic Republic of Ethiopia

based on the work
of
B.L. Henricksen

in collaboration with

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ABSTRACT

This report summarizes the findings of a 6-man consulting mission charged with the responsibility of preparing a draft Master Land Use Plan (MLUP) of Ethiopia, an original objective but uncompleted output of the Phase I, FAO/UNDP Assistance to Land Use Planning Project, ETH/78/003. The draft MLUP prepared by the mission provides a concise articulation and quantification of current land use, land potential and of the constraints and possible solutions to development. Much of the detail is presented in graphic form to assist higher level planners and decision makers, as requested in the consultant's terms of reference. A total of 5 Technical Reports comprise the MLUP. The Main Report is supported by 4 Technical Annexes, and 1:2 million scale maps on constraints and potentials for development are attached. The analysis of land resources, agriculture, population and socio-economics contained in the MLUP relies heavily on the data base produced during the Phase I, Assistance to Land Use Planning Project. The backbone of the MLUP is an analysis of the projected food demand and population supporting capacity (PSC) in Ethiopia, in the short (1985), medium (1995) and long term (2010). The PSC was estimated using a computer model which optimizes the land requirements for food, fuel and forage production sufficient to meet the subsistence needs of a typical farm family in each Awraja of the country. Results indicate that food demand will outstrip production by 2010 at current levels of production and consumption, even if all potentially arable land is cultivated. Development is concluded to be constrained by physical, policy related and institutional problems. Recommedations include the immediate reallocation of resources towards achieving increased agricultural output, decreased population growth, and increased nutrition and welfare levels.

AKNOWLEDGEMENTS

The Food and Agriculture Organization is greatly indebted to all those who assisted in the implementation of the project by providing information, advice and facilities. In particular, the Master Land Use Plan preparation mission wishes to aknowledge the special assistance provided by the following agencies of the Government of Ethiopia: the Fourth Livestock Development Project, the Forestry Department, the Soil Conservation and Community Forestry Department, the Land Use Planning and Regulatory Department and the Agricultural Development Department, the Project Planning Group and the Special Land Resource Studies group of the Ministry of Agriculture, the Agricultural Marketing Corporation, the Ministry of Coffee and Tea, the Water Resources Development Authority, the Relief and Rehabilitation Commission, the National Meteorological Services Agency, the Agricultural Inputs and Supplies Corporation, the Institute of Agricultural Research, the Ethiopian Mapping Agency, the Nationalities Commission and the Central Statistics Office. Special thanks are also directed to the offices of the following International Agencies in Ethiopia: the International Livestock Centre for Africa, the World Bank, the World Food Program, the United Nations Development Program, the office of the FAO Representative, and the national and international staff of the FAO/UNDP Assistance to Land Use Planning project, ETH/82/010.

TABLE OF CONVERSION FACTORS

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LIST OF ABBREVIATIONS

AEZ	Agroecological zone
ADD	Agricultural Development Department
AIDB	Agricultural and Industrial Development Bank
AISCO	Agricultural Inputs and Supply Corporation
AMC	Agricultural Marketing Corporation
CBE	Commercial Bank of Ethiopia
CMC	Coffee Marketing Corporation
CSO	Central Statistical Office
DAP	Diamonium Phosphate
EHRS	Ethiopian Highland Reclammation Study
EPID	Extension and Project Implementation Department
ESC	Ethiopian Seed Corporation
FAO	Food and Agriculture Organization of the United Nations
FLDP	Fourth Livestock Development Project
GDP	Gross Domestic Product
GoE	Government of Socialist Ethiopia
IAR	Institute of Agricultural Research
ICRISAT	Internation Centre for Research in Semi-Arid Tropics.
IDA	Internaitonal Development Association
IFAD	International Fund for Agricultural Development
ILCA	International Livestock Centre for Africa
LUPRD	Land Use Planning and Regulatory Department
MoA	Ministry of Agriculture
MPP	Minimum Package Program
N	Nitrogen
ONCCP	Office of the National Committee for Central Planning
P	Phosphorous
PA	Peasant Association
PADEP	Peasant Agricultural Development Program
PC	Producer Cooperative
PDRE	Peoples Democratic Republic of Ethiopia
RRC	Relief and Rehabilitation Commission
SC	Service Cooperative
SCCFMD	Soil Conservation and Community Forestry Main Department
UNDP	United Nations Dvelopment Program
WFP	World Food Program

1. INTRODUCTION

1.1 BACKGROUND

The Land Use Planning and Regulatory Department (LUPRD) of the Ministry of Agriculture (MoA) in Ethiopia has been receiving UNDP/FAO assistance since 1979, in the form of the Assistance to Land Use Planning Project, ETH/78/003 (Phase-I) and, more recently, ETH/82/010 (Phase II). The preparation of a draft Master Land Use Plan (MLUP) was one of the objectives of the Phase-I project but, due to time and manpower constraints, it was not completed during either phase of the project.

A draft MLUP synthesized from the vast quantity of data generated during the Phase-I project life - concerning both physical and socio-economic aspects of agriculture in Ethiopia - would have represented a logical conclusion to this phase of the project. A 5-man consulting mission was subsequently given the task of completing the MLUP between August 1987 and February 1988, based primarily on the data produced during Phase-I and subsequent phases of the Assistance to Land Use Planning project .

1.1.1 Definition and scope of the MLUP

The draft MLUP envisaged under the Assistance to Land Use Planning project is defined as a summary document containing a simple expression of the distribution of land potential and current land use in the country; and a concise and comprehensive articulation of the constraints and their possible solutions in a language understandable to higher level decision makers and planners at national and regional levels. It is an abstraction of the resource maps and information on land use and land suitability, and the integration of the analysis and findings of the various studies undertaken at the exploratory level of 1:1,000,000 scale during the Phase-I project.

The small-scale character of the original data base used to compile the MLUP dictates that the conclusions from the data are only applicable for large areas and should not, therefore, be used for compiling detailed land use plans that can be laid down on the ground. The MLUP is, however, designed to help planners and decision makers at higher levels identify areas of the country requiring state intervention, areas requiring more detailed studies to fully assess the potentials or constraints to development, and to assist the development of policies at national and regional levels for rational use of land. The MLUP also integrates the findings of the Phase-I project with more recently gathered agricultural statistics, livestock data, and land use information to provide an improved basis from which appropriate land use policies can be formulated.

1.1.2 Summary of activities suggested in the terms of reference:

a) Identify, characterize and quantify the current land use in the country;

b) Identify the problems and potentials associated with current land use practices;

c) Identify, characterize and quantify the land resources in the country suitable for:

i. rainfed crop production;
ii. mechanized rainfed crop production;
iii. perennial crop production;
iv. extensive livestock production;
v. semi-intensive livestock production, including dairying;
vi. production of wood for fuel and timber;
vii. irrigated agriculture, both small scale and large scale.

d) Identify and quantify areas requiring preservation including:

i. unique ecosystems;
ii. natural forests;
iii. areas of wildlife concentration

d) Identify areas which are degraded or threatened by degradation.

e) Identify the physical, institutional and infrastructural constraints to realizing potentials, and suggest policies to overcome these.

f) Match the land resources with the demand for these resources in the short, medium (1995) and long term (2010).

g) Quantify the land resources and their current use, including potentials and constraints at national and regional levels.

1.1.3 Composition of the consultancy team

The following consultant inputs were made to the MLUP:

- Land Use Planner/Team Leader	7	months
- Agricultural Economist (macro)	1.7	months
- Agricultural Economist (micro)	1.7	months

- Range Ecologist 2 months
- Agronomist 2 months
- Agroclimatologist 1 month

1.2 THE COMPONENTS OF THE MLUP

The MLUP consists of a number of reports which together constitute the draft master plan. The list of components is as follows:

Technical Report 1

Main Report

Annex 1 - Population Supporting Capacity Analysis Summary of Results

Annex 2 - Regional Profiles of Land Resources

Annex 3 - Regional Profiles of Land Use and Crop, Livestock and Forest Production

Annex 4 - Atlas of Maps

Technical Report 2

Agricultural Economics Consultancy

Technical Report 3

Range/Livestock Consultancy

Technical Report 4

Potential Farming Systems

Technical Report 5*

A Summary of the Agricultural Ecology of Ethiopia

Much of the information presented in the technical annexes is in the form of bar graphs and charts to improve the ease of comprehension for higher level decision makers and planners. Technical Report 1 summarizes the findings detailed in the other technical reports referred to above. Technicians wishing to probe for detailed analysis of the various subjects treated in the MLUP will find that information available in the remaining technical reports.

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*Prepared in collaboration with NMSA and CSO: FAO/TCP/ETH/6658.

1.3 GENERAL SETTING

Ethiopia lies wholly in the tropics, between 3°N and 18°N latitudes, and 33°E and 48°E longitudes in the Horn of Africa (see Figure. 1). The land area is approximately 1.24 million km², and is bounded in the northeast by the Red Sea and the Gulf of Aden, the Republic of Djibouti and Somalia in the east, Kenya in the south and the Sudan in the west. Ethiopia is unique physically because of the high proportion of its landmass over 2000 m altitude, where the climate is more temperate than tropical. Over 80% of the 45 million inhabitants live in these highlands, 90% of them rural and relying on subsistence agriculture.

Temperatures vary widely throughout the country, from the hottest on earth to those found in the frost prone, Afro-alpine zone. This variation is mainly due to extremes in altitude. Rainfall is also quite variable in both amount and extent, ranging from a few hundred mm per year in the semi-arid zone to more than 2000 mm in the western highlands. The highlands in general are surrounded by hot, semi-arid lowlands in the north, east and south, and by hot humid lowlands in the west.

Soils used for agriculture are predominantly formed on volcanic materials. This, coupled with temperate highlands and adequate rainfall, suggests a rich agricultural potential, but climatic variability, outdated farming practices, and limited incentives for farmers inhibit productivity. The dramatic famine of 1984/85, following just 10 years after similar problems in 1974, highlighted the fragility of the existing subsistence agricultural system in relation to the food demand of the rapidly rising population.

1.4 OUTLINE OF METHODOLOGY FOR THE MLUP

The MLUP aims at providing planners and higher level decision makers with an objective assessment of the major constraints and potentials of the agricultural resources of Ethiopia, with a view to identifying appropriate policies and interventions to stimulate food production over the next 25 years.

The backbone of the MLUP is the quantification of land resources from the Phase-I project, the population census and agricultural statistics. These are presented in an easy to use graphic form in the annexes listed in section 1.2. Data on land resources were fed into a population supporting capacity model developed during the MLUP activity. This provides an assessment of the ability of available land resources to provide a satisfactory level of subsistence for rural farmers and the population as whole. Various analyses using the model test the benefits of interventions to the land use systems in terms of the population supporting capacity. Potential farming systems which may help to realize the benefits simulated in the population supporting capacity model are discussed in later chapters. Potentials and constraints to agricultural development are also discussed, along with suggestions on of policies which may help to realize potentials or to overcome constraints.

Figure 1. Location map

2. THE ECONOMY, POPULATION AND FOOD DEMAND

2.1 AGRICULTURE AND THE ECONOMY

Agriculture is the mainstay of the Ethiopian economy, accounting for approximately 50% of the GDP, 85% of employment and the major share of exports. The share of GDP, however, fell from around 58% to 41% between 1965 and 1985, and agricultural GDP growth averaged 1.1% over the last decade, while the economy grew at around 2.5% during the same period. Recent economic indicators show a declining trend, with the drought of 1984/85 having a strong negative influence (World Bank 1987). The contribution of different sectors to GDP in 1984/85, and the relationship between GDP and Agricultural GDP in the period 1979/80 and 1984/85, are shown in Figures 2 and 3.

Ethiopia has an estimated GNP per capita of around US$140, making the country one of the poorest in the world (World Bank 1983). This has resulted in a declining spiral of subsistence, exacerbated by two serious famines in the last 25 years. Some 95% of the food produced is by peasant farmers whose primary objective is to meet survival needs before any consideration of generating cash income for consumer goods. Where surpluses of grain are produced, these amount to some 20% of a subsistence farmer's production and are sold for cash or traded. However, income disparity between the agriculture and non-agriculture sectors is more than 1 to 6. Cereals make up the bulk of the food production, with pulses, oilseeds, enset (Ensete ventricosum), roots and tubers accounting for the remainder. These are supplemented by livestock products.

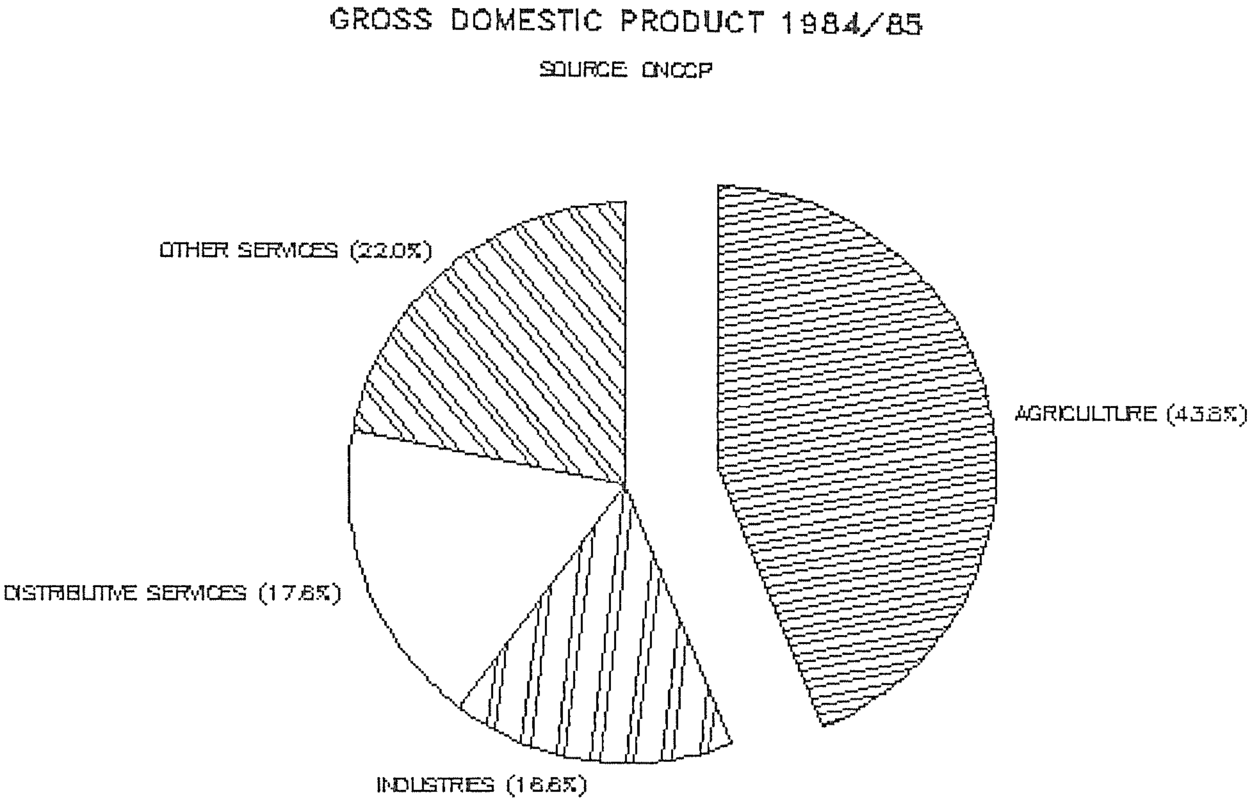
2.2 TRADE

2.2.1 The nature of imports and exports

In the export sector, coffee is by far the most important agricultural commodity in Ethiopia, accounting for some 60% of total export earnings (EHRS 1986). Livestock products and live animals are also important export earners. Exports accounted for approximately 13% GDP during the last 10 years, while imports have increased from around 15% to 20% during the same period. The structure of imports has changed somewhat since the revolution in 1974, with considerably more food now being imported in absolute terms and also relative to other commodities. Petroleum products, machinery and equipment and manufactured goods account for most of the remainder. The percent of imports and exports by commodity sector in both 1974 and 1985 is shown in Figures 4 to 7.

2.2.2 Trading partners and foreign exchange

Ethiopia's major trading partners are currently the Federal Republic of Germany, Italy, Japan, the Netherlands, the United States, the United Kingdom, and the USSR. The rate of exchange has



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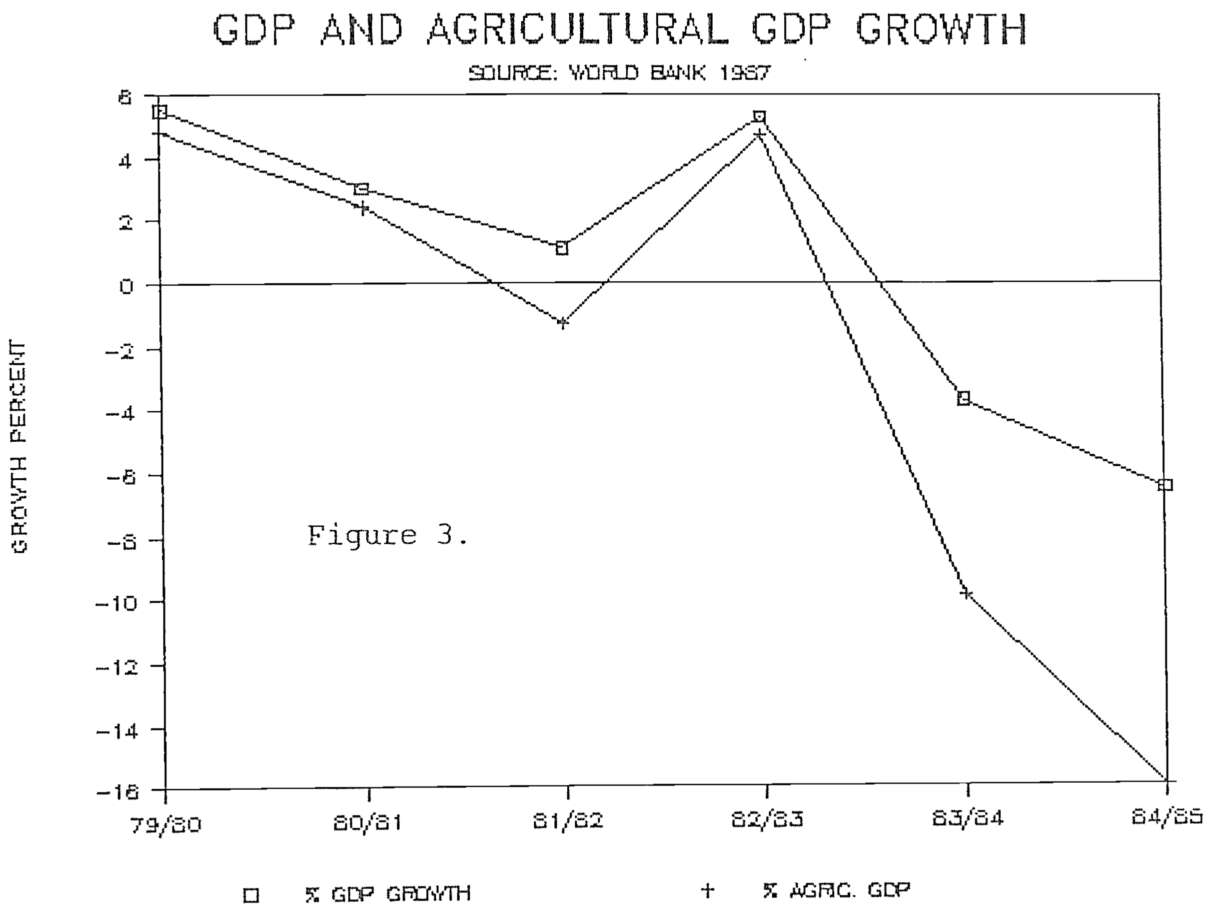

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Figure 4.

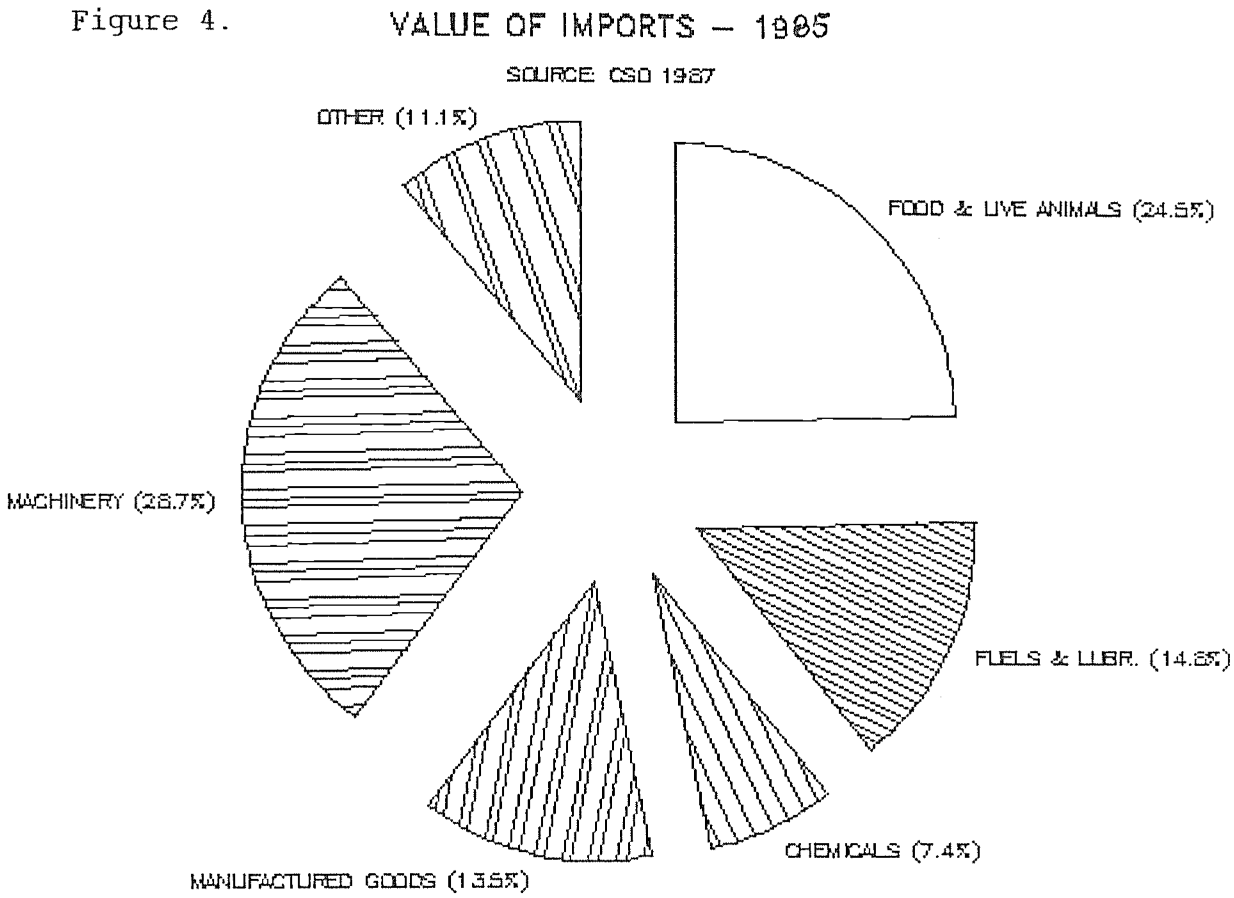


Figure 5.

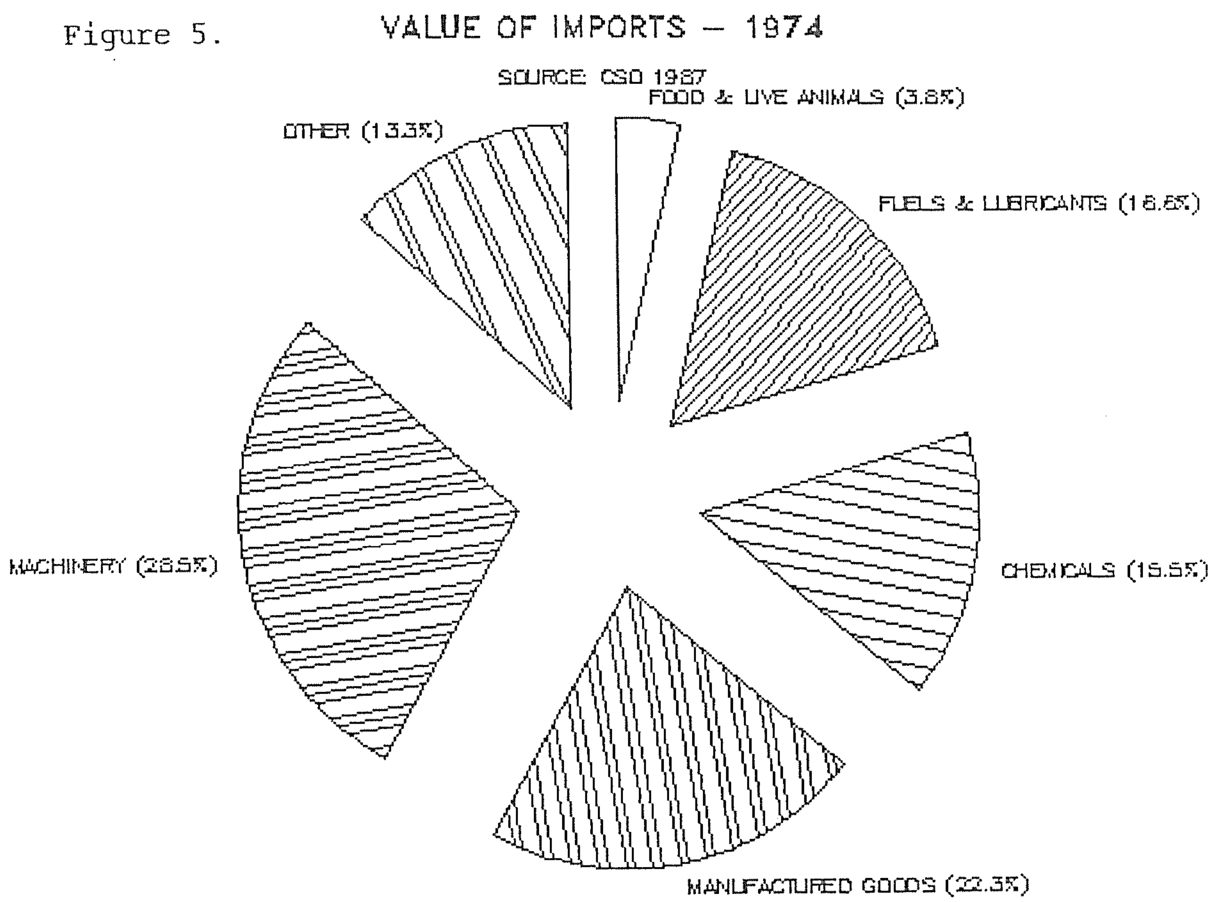


Figure 6. VALUE OF EXPORTS – 1985

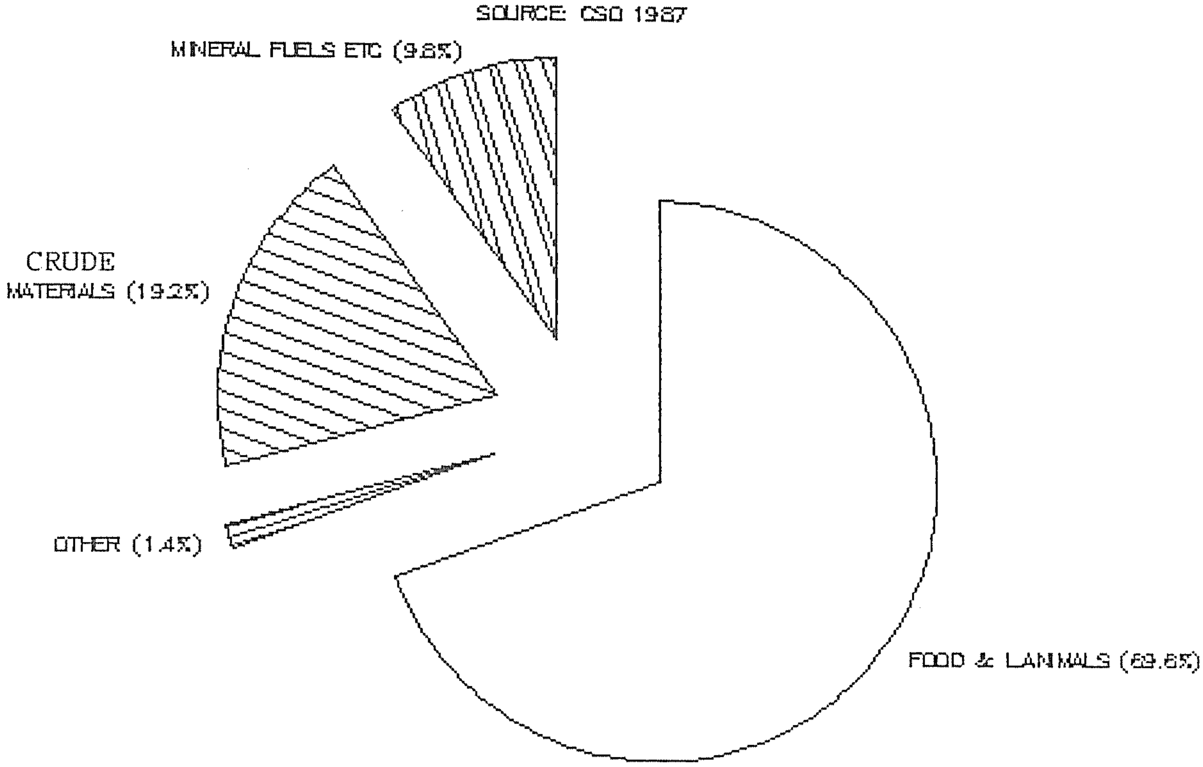
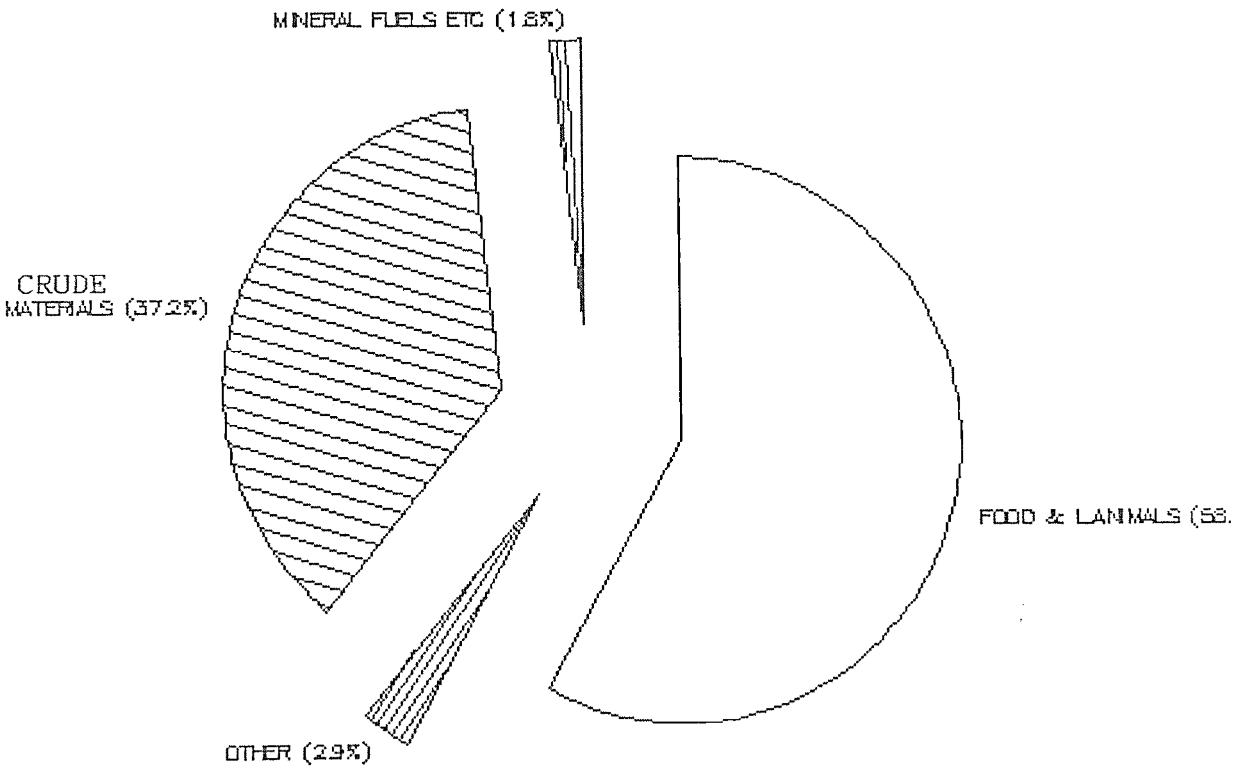


Figure 7. VALUE OF EXPORTS – 1974



remained essentially unchanged since 1975, at 1US$ = 2.07 Eth. Birr, and it is estimated that up until 1983, the import weighted real effective exchange rate appreciated by nearly 40% (IMF 1983). Recent international currency fluctuations should have reduced this imbalance somewhat, but nonetheless it has tended to act as a disincentive to export (EHRS 1986).

2.3 INDUSTRY

Food and textile industries account for most manufacturing in Ethiopia, with the vast majority taking place in or around Addis Ababa and Asmera. Most large-scale industry is run by the state, consistent with the GoE's desire to develop a socialist economy. It is mostly based on the processing of agricultural raw materials such as cotton or livestock products, is highly import-dependent, capital intensive and caters mainly for the urban sector (EHRS 1986). Small-scale and cottage industries are very diverse and widespread, mostly privately owned, labour-intensive and based on locally available resources. Availability of credit, lack of technical support and confidence about future government policy are cited by EHRS (1986) as the main constraints to expansion of this sector of the economy.

2.4 OTHER SECTORS OF THE ECONOMY

2.4.1 Transport and communications

Modern transportation in Ethiopia comprises national and international air, road, sea and rail links. One of the two railways links Addis Ababa and Djibouti. The second, linking Asmera and Massawa, has been inoperative since 1974. Air traffic is intensive, especially on international routes, as Addis Ababa provides a transit point to and from Europe and Asia for traffic exiting Eastern, Southern and Western Africa. The national airline, Ethiopian Airlines, thus contributes significantly to foreign exchange earnings. Domestic air routes are also well established, with daily flights to most regional capitals from Addis Ababa. Road transport, despite one of the lowest road densities in Africa, is the backbone of the modern transportation system within the country. The mountainous topography in Ethiopia has placed natural limits on the expansion of the road network and this remains today one of the most severe constraints to accelerated development of the country. Sea links are also limited, with facilities at the port cities of Aseb and Massawa barely able to cope with the demand placed upon them, despite recent upgrading of freight handling facilities.

Traditional transportation is either by foot or by donkey, horse or mule. Equines have been estimated to carry more than 10% of that carried by all the modern means of transport in the country (EHRS, 1986).

The utility of the donkey as a freight carrier has led to it being labelled 'the Ethiopian LandRover' by many Government workers. Its future role, however, may be threatened by diminishing feed resources.

Communications in Ethiopia have been steadily upgraded over the years following the revolution and include a modern telephone network in Addis Ababa, with radio and telephone connections to and within Regions. International telex and facsimile connections exist in the national capital but, beyond this, postal services in towns provide the main source of long distance communication in rural areas.

2.4.2 Fuels and Energy

According to recent surveys (Anderson and Fishwick, 1984), Ethiopia's fuel consumption is divided almost entirely between fuelwood (including charcoal) and animal dung supplemented by crop residues. Kerosene, LPG and electricity are minor contributors overall, but are important in major cities and towns. Energy consumption is primarily centered around fuel for cooking. Recent population trends indicate that fuel availability will soon reach critical levels in Ethiopia. Details are discussed later in the report.

2.5 EDUCATION AND HEALTH

2.5.1 Education

Education has grown at a considerable rate in Ethiopia in recent years, with literacy improving from 7% in 1974 to around 50% in 1985. This was mostly the result of a non-formal, nationwide literacy campaign instigated by the Government in 1979. Formal schooling has also considerably expanded, with total enrolments in all levels rising from 1.15 million in 1974/75 to 3.12 million in 1985/86 (CSO, 1987). The most substantial increase has been at the primary level. The number of schools at all levels increased over the same period from 3827 to 9109, but despite increased numbers of teachers, the teacher to student ratio continues to decline.

2.5.2 Health

Ethiopia's location in tropical Africa, the relatively low nutrition of many sectors of the community, coupled with the fact that only 4% of the population has access to protected water supplies (World Bank, 1985), means that disease problems are considerable. According to the World Bank (1985): "Disease patterns are exacerbated by low standards of living, producing in turn poor hygiene and inadequate nutrition, and by limited use of health facilities."

The leading causes of morbidity at hospitals and health centres are quoted as follows: Malaria; Helminthiasis; Skin irritations; Venereal disease; Rheumatic pain; Malnutrition; Fevers; Upper respiratory tract infections; and Tuberculosis.

Source: World Bank 1985, MOH statistics, 1981

In addition to these frequently occuring diseases, diarrheas play an important role in infant morbidity. Some 60% of childhood diseases appear preventable (World Bank 1985). Other diseases of importance are schistosomiasis, yellow fever, leprosy, leishmaniasis and onchocerhiasis (river blindness). Epidemics of viral hepatitis, cholera, tick fever, typhus and typhoid occur, but can be managed by improved sanitation, provision of potable water, and improved medical facilities and education. Overall, the high incidence of parasitic diseases and malnutrition lowers the resistance of individuals to a wide variety of other serious infections.

Mortality data are not widely available or reliable, but those which are indicate the crude death rate to be in the region of 18/1,000. Life expectancy is about 47 years, average for sub-Saharan Africa, but around 23% of children die under 5 years. The main causes of death recorded in hospitals are dysentry and gastroenteritis, tuberculosis, pneumonias, malnutrition and anemia, liver diseases including hepatitis, tetanus and malaria (World Bank 1985). In or following drought years, death from malnutrition becomes acute. Such famines have regularly visited Ethiopia over history, but recent population trends have hightened the probability of further problems.

An ambitious ten-year health sector plan developed by the government for the period 1984/85 to 1993/94 sets out a detailed strategy of health services development, among other things to reduce infant and child mortality and increase overall life expectancy. Financial and manpower constraints may limit the anticipated gains of the plan according to the World Bank, but overall its objectives are sound.

2.6 POPULATION AND FOOD DEMAND

2.6.1 Population projections

In May 1984 the first complete census in Ethiopia revealed that 42 Million people were living in the country (CSO, 1985), about 7 million more than previously believed to be the case. At the national level population is presently increasing by 2.9% per annum. The World Bank (1985) offers three scenarios for population growth up to 2010 using the 1984 census. They are:

- no fertility decline;
- gradual fertility decline;
- accelerated fertility decline.

The first assumption implies that fertility will not change and provides a benchmark for comparison. The second scenario assumes a gradual decline in fertility after 1990. Such a decline is expected during the course of normal socio-economic development without major government intervention. The final model assumes a rapid fall after 1990 and represents the maximum that could be achieved with considerable government involvement. This latter situation is based on the experiences of countries which have achieved considerable reductions in population in the recent past. This is not considered likely in Ethiopia in the forecast period in view of the current stage of economic development. For the purposes of the MLUP, therefore, the population was only projected for the two remaining growth scenarios, adjusting the 1984 census data to 1985 and taking into account the increased deaths during the 1984/85 famine. The projected population data for the years 1985, 1995 and 2010, which are used in the MLUP, are shown in Figure 8. Further details of the methods used to project population are given in MLUP Technical Report 2, Agricultural Economics Consultancy. Detailed graphic presentation of the projected rural population is also provided in Annex 1 of this main report.

The emerging pattern is clear from Figure 8, Ethiopia's population is entering a phase whereby it is likely to double to more than 90 million before 2010, placing enormous strains on the economy through the increased demand for food, energy and services. A comparison of the index of population and food production between 1979/80 and 1984/85 is given in Figure 9. Low levels of urbanization have so far reduced the burden on employment and urban development. But, even with the relatively low levels of projected urban population growth, the numbers will probably treble by 2010 and thus throw the burden back on these factors with all the implied consequences.

2.8 FOOD DEMAND

2.8.1 General

The demand for food depends on the size and composition of the population and on its purchasing power. Food demand estimates presented below are based on combinations of the population growth projections and different economic growth scenarios. The percentage growth in the demand for food was calculated taking into account population growth, value added growth, demand and value added elasticity. The exact methods of calculation are detailed in MLUP Technical Annex 2.

2.8.2 Apparent consumption of grain equivalents

Before estimating the demand for food, it was first necessary to quantify the average apparent consumption, taken over a number of years, to obtain a reasonable estimate for the base year, 1985. Production and availability of cereals, pulses, enset, roots and

PROJECTED POPULATION OF ETHIOPIA

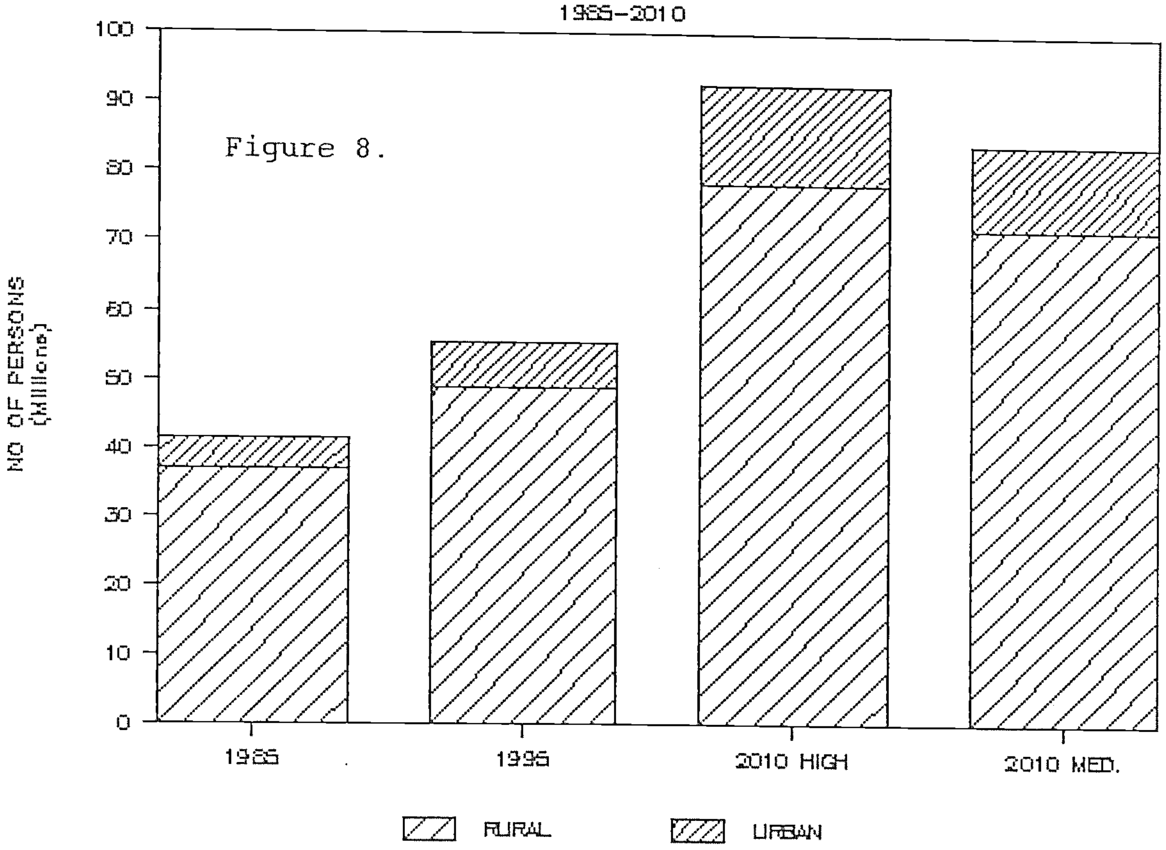


Figure 8.

INDEX OF POPULATION AND FOOD PRODUCTION

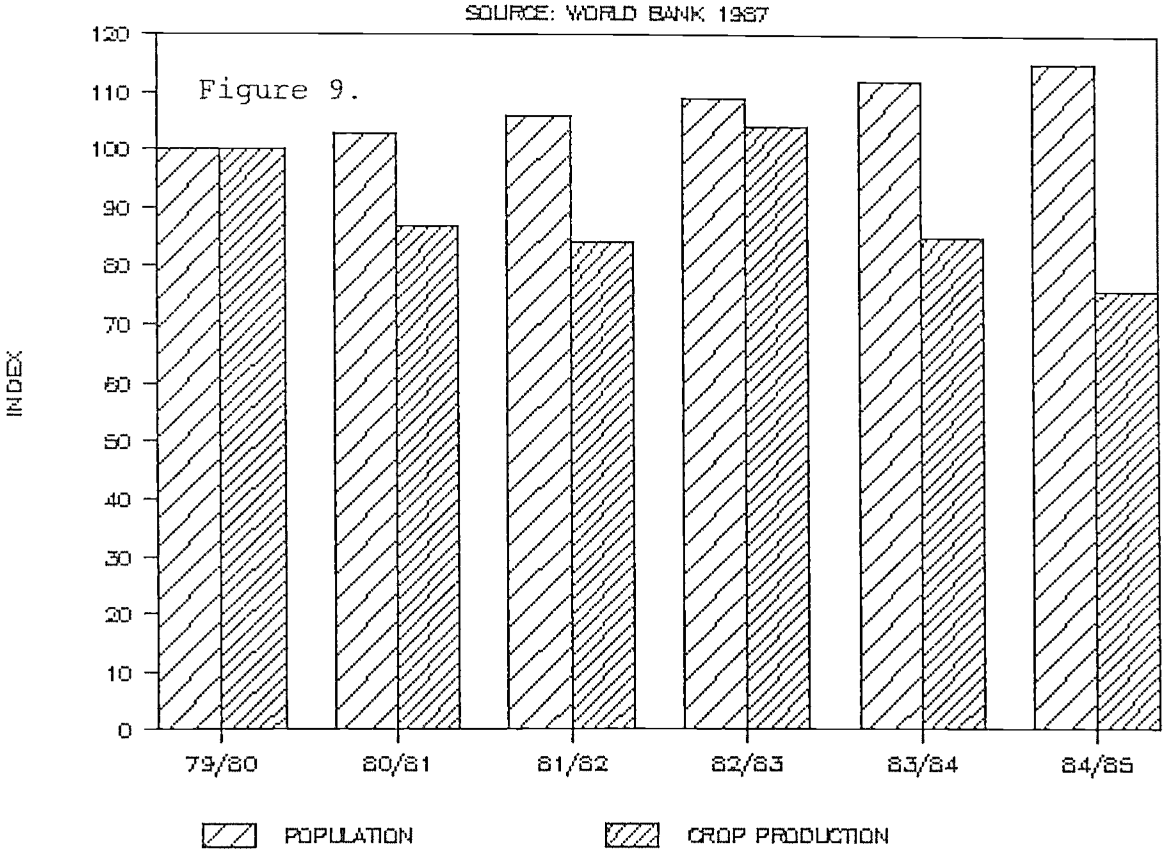


Figure 9.

tubers, and milk and milk products were taken into account in this process. The calculation is based on area and yield data of crops, and FAO (1987c) nutrition data, the details of which are presented in MLUP Technical Report 2. Table 1 below summarizes the results of this analysis.

TABLE 1

TOTAL APPARENT CONSUMPTION PER CAPITA IN THE BASE YEAR

	Grain equivalents kg/year			Calories/day		Total
	Domestic Production (1)	Imports (2)	Subtotal	Subtotal (3)	Cons. of oils vegetables & meat	
National average	155	10	165	1306	260	1566
Rural areas	146	9	155	1227	245(4)	1472
Urban areas	207	21	228	1805	347(4)	2152

(1) Domestic production of cereals and pulses, enset, roots and tubers, and milk and milk products.

(2) Imports of cereals, commercial as well as food aid.

(3) Conversion from kg grain equivalents/year to calories/day: 0.85*(3400/365) = 7.918

(4) National average of 260 calories/capita/day, divided between rural and urban sectors as follows:
Rural (0.80/0.85)*260 = 245; Urban (0.20/0.15)*260 = 347

2.8.3 Economic growth projections

The World Bank (1987a) offers two growth scenarios for the development of the Ethiopian economy between 1983/84 and 1991/92. In the first, referred to here as low growth, GDP is estimated to grow at 2.6% per annum, the value added growth of the agricultural sector at 2.4% per annum and the value added growth of the non-agricultural sector at

2.8%. In the second scenario, referred to here as medium growth, GDP is expected to grow at 3.6% per annum, the value added growth of the agricultural sector at 3% per annum and that of the non-agricultural sector at 4.2% per annum.

A third scenario is introduced for the MLUP which postulates that the average national consumption of food will reach adequate nutrition standards by 2010. This implies 2330 calories per capita per day in Ethiopia. Assuming the same percentage is met from oils, vegetables and meat as at present, 1943 calories are required from cereals, pulses, enset, roots and tubers and milk and milk products. Assuming also that imports of food are no longer required, this increased demand for food will have to be met by domestic production. At the national level this means that production must increase from 155 kg grain equivalent per capita to 245 kg. Details are summarized in Table 2.

TABLE 2

REQUIRED INCREASE IN FOOD PRODUCTION BETWEEN 1985 AND 2010 TO RAISE NUTRITION TO RECOMMENDED STANDARDS

Total production required from cereals, pulses, enset, roots and tubers, and milk and milk products.

	1985	2010 High Population Growth	2010 Medium Population Growth
Total prod. MT*1000	155*42.41 = 6,574	245*95.0 = 23,282	245*84.89 = 20,651
Increase in production required by 2010 relative to 1985		3.5 times	3.1 times
Percent growth per annum required		5.2 %	4.7 %

Information concerning food demand income elasticities and the population growth rates in rural and urban areas, detailed in MLUP Technical Report 2, indicate that the value added growth in the agricultural sector under the high population growth alternative will have to increase at some 5.1% per annum, while in the non-agricultural sector it will have to grow at 8.6% per annum. Under the medium population growth alternative it will still have to grow at 4.6% in the agricultural sector and 8.1% in the non-agricultural sector to meet demand at the desired minimum nutrition levels.

Growth rates of the order postulated above appear impossibly high to maintain over 25 years. No other country in the world has sustained such levels, most particularly under rainfed agricultural conditions (World Bank, 1987). This points to the need to lower targets for the agricultural sector. To achieve this, lower nutrition and/or continued import of cereals financed by exports of other commodities, such as coffee, will be necessary. The high growth scenario, despite appearing impossible to achieve in 25 years, provides useful insight into the enormity of the task ahead for Ethiopia and a measure of the upper limit for the necessary growth in the agricultural sector. More importantly, is the fact that policies toward certain aspects of agriculture will have to change before high growth rates can be approached. Foremost are the price and marketing policies. Farmers will be required to sell a greater proportion of their production in order to adequately feed the growing non-agricultural population, in addition to providing enough food for their own increased consumption levels. They must have incentives to do so, especially since the risk/reward situation changes with the higher level of inputs required. Cash for these can only come from sales of surpluses at prices which reflect the risks involved to the farmer. Credit, input supply, research, extension and infrastructure are also important in the context of improved production.

Productivity of land (increased yields and increased gross margin per ha) would have to increase to achieve the growth in agriculture suggested, since the availability of arable land for expansion of cultivation is limited and insufficient to feed the expanding population at current levels of production (the availability of land resources for food production is discussed later in the report).

The low growth scenario discussed by the World Bank (1987a) implies a continuation of current government policies regarding food production in the peasant sector. The overall growth of GDP projected under these circumstances - 2.6% per annum - is less than projected population growth, which implies that per capita income and consumption will decline. In the medium growth scenario, GDP is projected to grow at 3.6% per annum, higher than population up to 1995, implying increased per capita incomes and consumption up to that time. After 1995 a growth rate of 3.6% of GDP is marginal for increased per capita incomes under high (3.5% per annum) population growth rate conditions. If the medium population growth rate of 2.7% per annum can be achieved, per capita incomes will continue to improve.

To realize medium growth conditions, the World Bank (1987a) considers that major policy changes are necessary including: adjustment of the exchange rate, improvements in producer incentives, and measures to raise domestic and external resource mobilization.

It has been suggested that post drought (1984/85) recovery should occur before 1990 and enable Ethiopia to return to a growth of around 3%. However, variability of weather conditions from year to year, especially in marginal production areas, makes such predictions tenuous. A target of 3% growth is only considered feasible by the World Bank (1987b) under the following assumptions: remunerative input-output price relations, a favourable marketing situation, sufficient and timely supply of inputs, adequate agricultural research and extension, and widespread adoption of conservation based farming to arrest degradation. This latter point is elaborated on later in MLUP Technical Report 1.

2.8.4 Food demand projections

The projections of food demand in this section of the report are based on the population growth projections and economic development scenarios presented earlier. Detailed analyses for a total of 11 population and economic growth scenarios are contained in MLUP Technical Report 2, Table C9, but these are summarized here for convenience. Figure 10 compares several of the possible combinations of population growth and economic development for 1995 and 2010.

In 1995, the range of possible food demand indicated in Technical Report 2 is for a 31% to 36% increase over that in 1985, indicating production increases of between 2.7% and 3.2% per annum are required. Only under a medium growth projection would there be a slight increase in per capita food availability. Under the high population projection, in 2010 a medium level of economic growth would merely maintain the present food demand levels, while food availability would deteriorate to the extent that only 139 kg grain equivalent per capita per annum (1100 calories per capita per day) would be available. Under a high economic growth projection, which raises nutrition to the levels discussed in section 2.8.3, total food production - not allowing for imports - has to increase by a factor of between 3.1 and 3.4 times, depending on population growth.

An increase of this magnitude without significant yield increases is dubious, since the amount of land available for expansion of cultivation is limited in extent and, in many parts of the country, further limited by the competing requirements of land for forage and fuelwood - fundamental to the rural farmers' existence with currently available energy technology and cultivation techniques. It has been estimated for example, that one ha of annual cropland requires 1.7 ha additional grazing land for the draught oxen used to bring land under cultivation to feed a farm family at current yield levels (FAO 1986b, 1987b).

Much of the land currently used for forage production is potentially arable, although certainly not all. But the use of

PROJECTED FOOD DEMAND IN ETHIOPIA

1985–2010

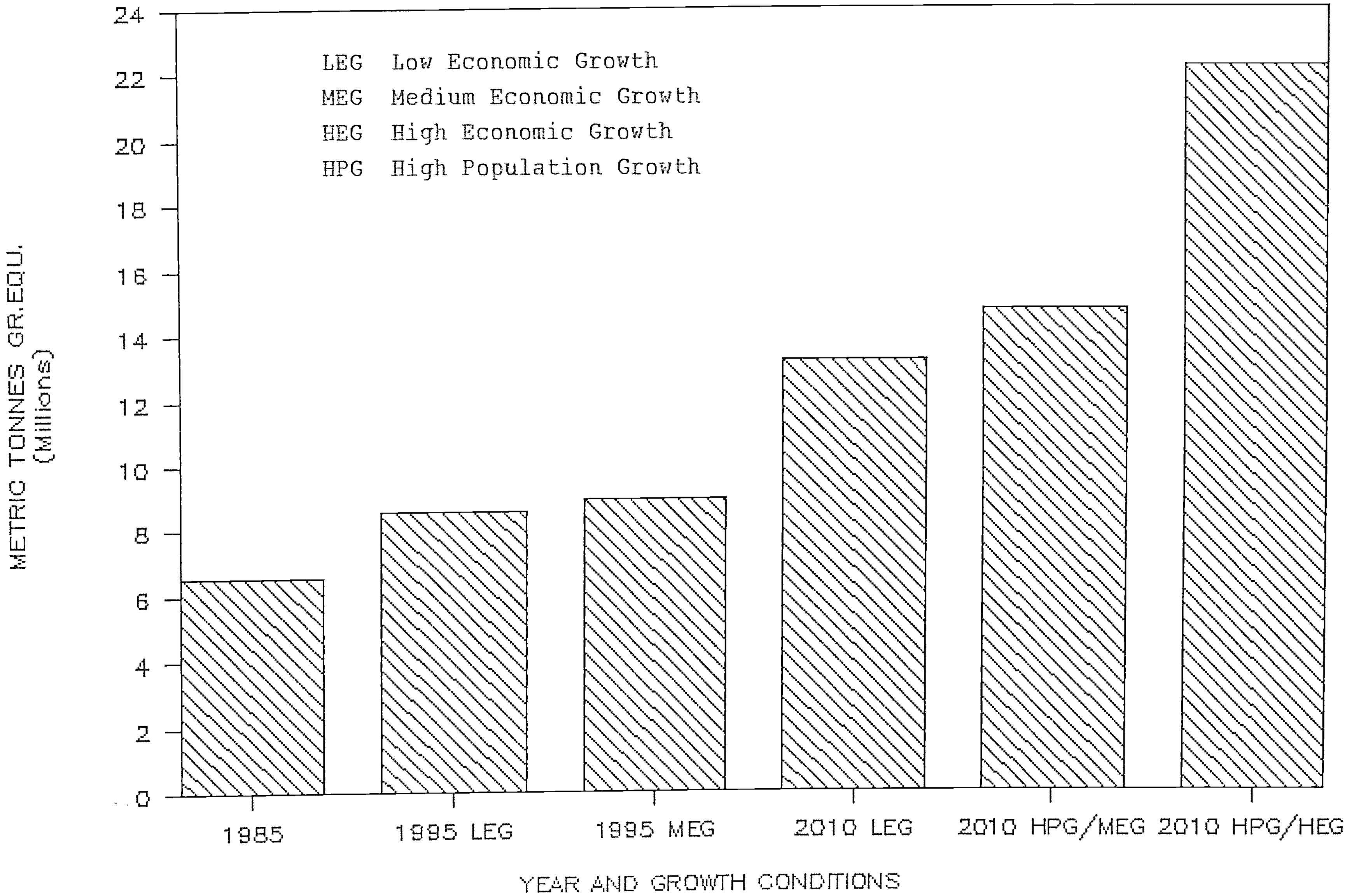


Figure 10.

potentially arable land for forage production may be in competition with crop production requirements in the future. Thus, even if 3.4 times as much arable land were available than presently used for cropping, it is unlikely, given the livestock and fuelwood demands of the future population, that enough land would be available annually to meet 3.4 times the food demand at current yield levels. Thus, under a high economic growth and population scenario, the outlook is bleak unless significant increases in yield can be achieved. Under the medium population projection the situation is somewhat improved. The situation would be negative, however, if the current low economic growth combined with high population growth rates continues.

A detailed analysis of the competing requirements of livestock and crops in the future can be found in MLUP Technical Report 2. These aspects are further expanded in this report under discussions related to the population supporting capacity model.

2.8.5 The need for a population policy

Population, together with improved agricultural productivity, appears, therefore, to hold the key to adequate food availability in Ethiopia over the next 25 years. Considerable effort has been spent in the past devising means to increase agricultural production, but the other half of the equation, population, has not been considered in depth up to this time. However, a policy to encourage family planning is paramount to Ethiopia's future prosperity. Considerable resistance to family planning can be expected in rural areas, as the traditional concept of an extended family offers security in old age and labour for farm operations. Appropriate education of the rural population is going to be essential in this regard. A more appropriate start may be the urban areas, until employment possibilities can be expanded in the non-agricultural sector.

3. PHYSICAL RESOURCES

3.1 GENERAL

This section of the report contains a brief outline of the various physical resources of Ethiopia. More detailed information can be found in technical publications in the LUPRD and other government offices.

3.1.1 Geology

Ethiopia is underlain by Precambrian metamorphic and sedimentary rocks, the greatest extent of which are exposed in the west of the country. These are among the oldest rocks on earth, laid down more than 600 million years before the present (b.p.). Mesozoic (135-240 million years b.p.) sedimentary sequences overly the Precambrian basement in the central, northern and eastern parts of the country. These are in turn overlain in central Ethiopia by much younger Tertiary (less than 65 million years b.p.) basalts and other lavas on which fertile soils have developed. Localized areas of sediments deposited by wind and water and lake deposits of Quaternary age (less than 1.8 million years b.p.) occur, the latter mainly in the Rift Valley. Quaternary lava flows and other volcanic deposits are also common in the Rift Valley and evidence of Quaternary glaciation is apparent on the highest peaks (Mohr, 1971).

Mineral wealth in Ethiopia is limited mainly to gold deposits in the basement complex and alluvial placers in the west. Platinum also occurs in the south. Persistent searches for petroleum in the Ogaden lowlands in the east have failed to locate significant deposits, but the geological setting is favourable for oil.

3.1.2 Physiography

The physiography of Ethiopia is strongly linked to the underlying geology, more perhaps than any other country in Africa (Mohr, 1971). It is dominated by the deeply eroded volcanic mountains and high altitude plateaux of the central, northern and eastern highlands, much of which lie above 2000 m elevation, and by the Great African Rift Valley which terminates off the coast of Ethiopia. Dramatic tectonic events in the Upper Eocene (36-45 million years b.p) resulted in widespread uplift of the central land-mass and the subsequent rifting associated with the formation of the Rift Valley has effectively bisected the country from SW to NE.

Perhaps the best known physiographic feature of Ethiopia, is the Blue Nile, which rises in the mountains surrounding Lake Tana (considered the source of the Blue Nile) and flows southeast into a picturesque canyon of immense proportions. This physically separates the administrative regions of Gojam and Welo. From here it makes an about face and flows westward through an ever-widening canyon, whereupon it flows out into the Sudan plains to meet the White Nile on its way to Egypt. Hot, dry lowlands lie east and southeast of the highland massive, while hot and humid lowlands exist in the west of the country.

3.1.3 Soils

The FAO/UNDP Assistance to Land Use Planning Project has provided an extensive data base on soils, as a result of surveys conducted since 1979. Details can be found in the Geomorphology and Soils map of Ethiopia, the Soil Association map of Ethiopia (FAO, 1984a) and a number of supporting field documents and reports produced over the years since this project began operations.

Soils in the highlands commonly have high clay contents (eg Nitosols and Vertisols) and are relatively high in nutrient status, despite the common opinion that they are severely degraded through poor agricultural practices. Exchangable cations, organic matter and potassium are relatively high by African and even world standards, although nitrogen levels are declining due to the widespread use of dung for fuel and reduced fallow periods because of increased pressure on land. Phosphorous is low in most soils and fixation by clay minerals may be the cause of the poor field responses to this element noted by researchers, despite the low phosphorous levels indicated in laboratory analysis of Ethiopian soils.

Much of Ethiopia is covered by shallow (< 25 cm depth), stony soils (lithosols), the end product in many cases of centuries of careless land management. These soils occur commonly in the northern provinces of the country. Soils of intermediate depth (25 - 50 cm depth) also occupy significant areas in this zone. Despite the depth restrictions, population pressure has resulted in their intensive cultivation for the production of cereals. Not surprisingly, the shallower soils are more drought sensitive because of limited moisture holding capacity. Deep red, brown and black clays are the main soils used for agriculture in the more productive central, southern and eastern highlands of Ethiopia, and are remarkable in that they maintain much of their fertility at depth. Exchangable bases and other nutrients appear in adequate quantities even at 100 cm in the deeper soils. This point will be elaborated upon in later discussions concerning the effect of degradation on the yield of crops.

3.1.4 Climate

Ethiopia is blessed by substantial areas of the country having high rainfall. In the central, southern and eastern highlands of the country mean annual rainfalls are commonly over 1000 mm per year.

In the southwest highlands they approach, or exceed, 2000 mm per year. However, the northern highlands of Ethiopia, encompassing the provinces of Welo, Tigray, Eritrea and parts of Gonder, have a much lower and more variable rainfall regime. Rainfall is generally correlated with altitude, the middle and higher altitudes (above 1500 m elevation) receiving substantially greater falls than low-lying areas (FAO, 1984b). The exception to this rule are the lowland areas in the west of the country where rainfalls are high. While the average annual rainfall above 1500 m altitude may exceed 900 mm per year, variations from year to year can be extreme. This makes agricultural planning difficult, with high risk of failure in below average rainfall years unless crops and cultivars are carefully chosen to cope with this variation. Even traditional crops, with inherent resistance to drought, do not always fair well in extreme years such as 1984. Rainfall in the eastern, northern and southern lowlands of Ethiopia is even more variable, with overall totals ranging from 200 to 750 mm, depending on locality. These areas are mainly populated by pastoralists.

The distribution of rainfall throughout the year also varies widely. In the northeastern zone rainfall is mainly bimodal, the smaller of the two seasons, occurring around March/April, is referred to locally as the Belg. The second season is referred to as the Kremt or Meher and occurs mainly in the second half of the calendar year. It is usually the main cropping season, beginning around June/July. In some areas the two rainy seasons combine into a unimodal pattern of rainfall distribution. This is more common in the west and northwest of the country where rainfalls are generally higher. Between the two extremes, in the central highlands for example, there is a tendancy for the two seasons to merge, with the Belg season being indistinguishable in many years from the Meher season. In other years the Belg may be absent altogether. The lowlands of the east and southeast contrast with the remainder of the country by having a distinctly bimodal rainfall distribution. Here the main component of the rainfall comes in the first half of the year, beginning around March and ending in May. The second, smaller season begins between September and November, depending on the locality. Generally speaking, the more distinctly bimodal areas are those with marginal rainfall conditions for annual crops. The influence of rainfall amounts and distribution on moisture availability for crops is discussed further later in this section of the report.

The other equally important aspect of the overall climate in Ethiopia is temperature. Temperature is very strongly correlated with altitude, as indicated previously. Variations are extreme, from the searing heat of the Dallol Depression, the hottest place on average on earth, to the sub-zero temperatures which occur at high altitudes. Snowfalls, for example, have been recorded on Mt Ras Dashen, the highest peak in Ethiopia (4620 m). Much of the high altitude plateau above 2000 m also suffers from overnight frost between October and February. Because of the strong influence of altitude on temperature regimes, a traditional zonation related to the crops and farming systems which are favoured in particular areas, has evolved among Ethiopian farmers. This provides a very useful first approximation to crop suitability and is widely understood by local planners and farmers alike. It is therefore treated in this report as fundamental information for higher level decision makers and planners. Details are provided later in the report and in Annex 2 and Annex 4.

3.2 TRADITIONAL ALTITUDE ZONES

3.2.1 General

Altitude dominates all aspects of agriculture in Ethiopia, because of its influence over temperature. Strong statistical correlations (r^2>0.9) have been demonstrated between the two (FAO 1984b) and these relationships provide a good approximation of the temperature regimes existing at different elevations and, thus, to the suitability of crops and other vegetation to these elevations. The Weina Dega and Dega zones are preferred for cropping and are mostly free from malaria and trypanosomiasis. The Kolla zone is favoured where moisture is not limiting for crops, but the diseases mentioned above are commonly present, particularly in the west of the country. The Wurch zone is frost prone and generally unfavourable for cropping, except for hardy strains of barley and a few other frost tolerant crops. The High Wurch is largely under natural vegetation and used for livestock grazing where land pressure is high.

The definition of traditional altitude zones is somewhat imprecise as microclimes may influence their classification on a local scale. The different zones and their approximate altitudinal limits are listed below and the extent of each in Ethiopia is shown in Figure 11.

Zone	Code	Temperature Range (°C)	Altitude limits (m)
High Wurch	UW	< 7.5	> 3500 / 3700
Wurch	W	7.5 - 12.0	2900 - 3500
Dega	D	11.0 - 16.0	2300 - 2900
Weina Dega	WD	16.0 - 21.0	1800 - 2300
Kolla*	K	> 21.0	< 1500 / 1800

*Below 500/800 m altitude, where dry, the Kolla zone is referred to as Bereha. This has not been treated as a separate altitude zone in Figure 11.

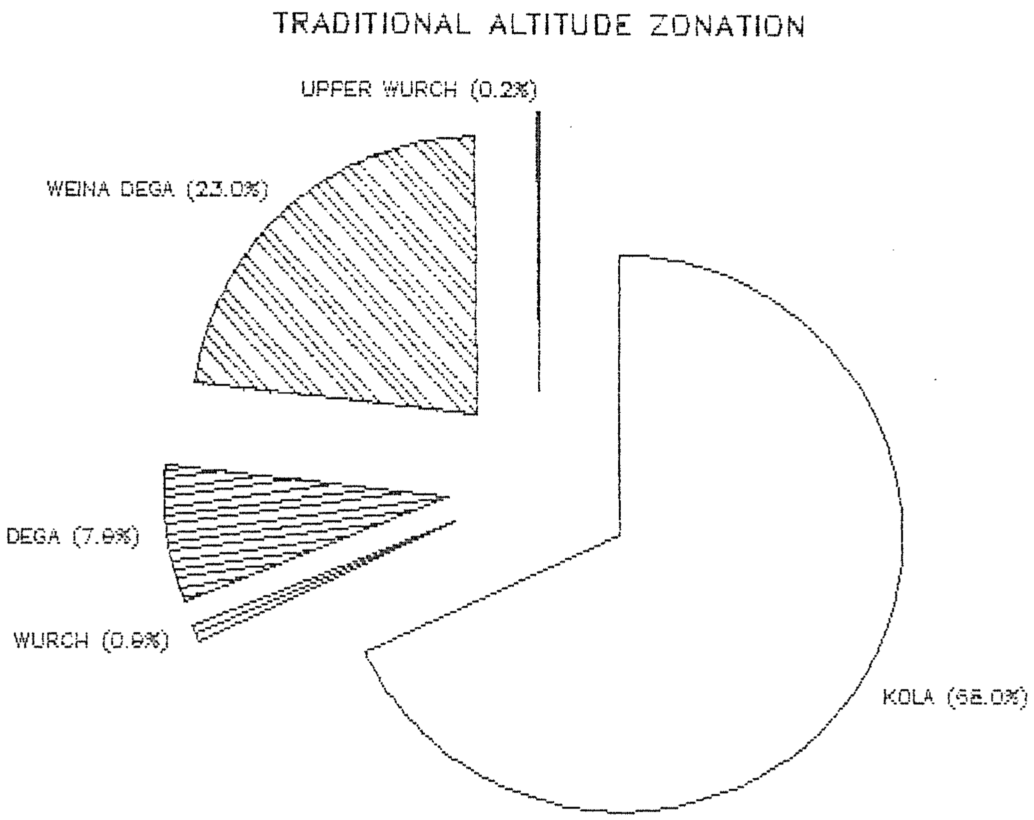


Figure 11.

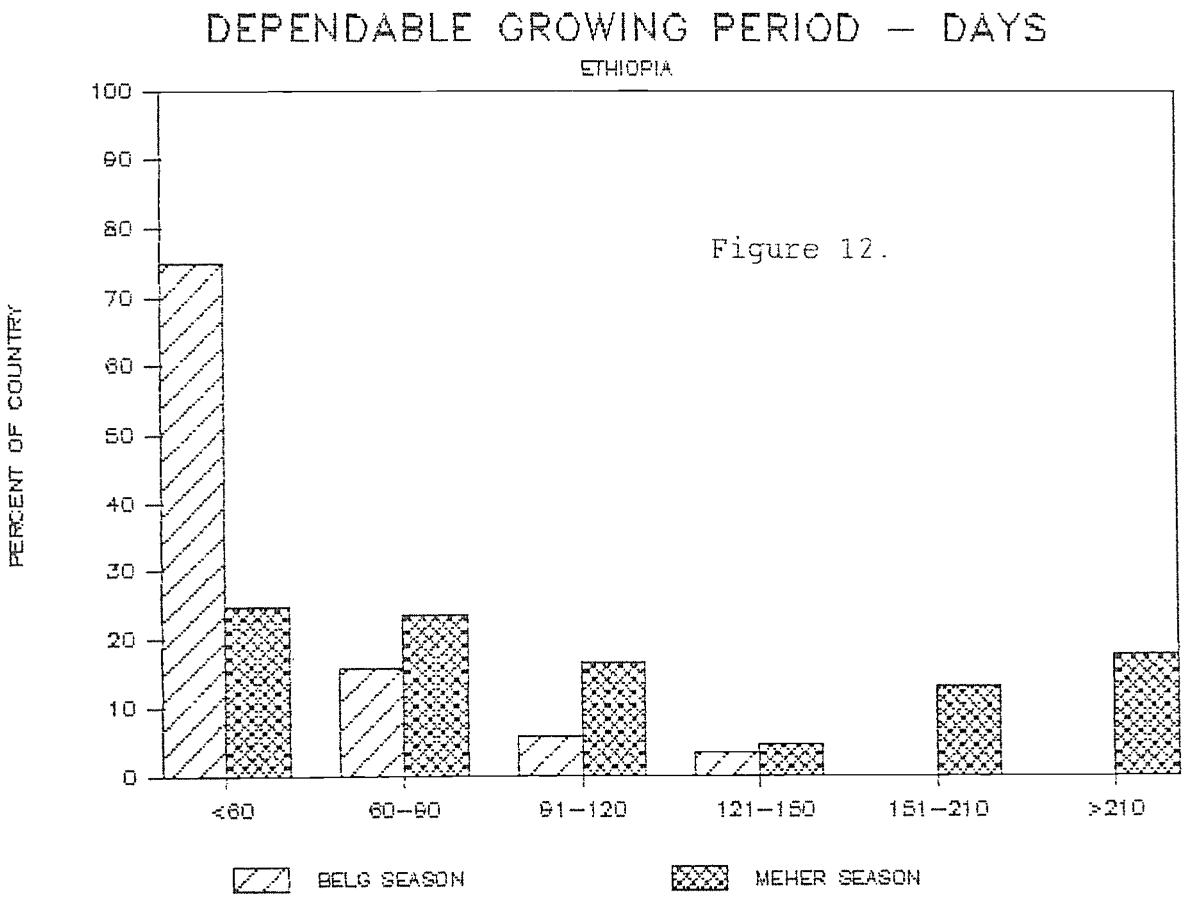


Figure 12.

Because these zones are widely used by local planners to estimate agricultural potential at regional and sub-regional levels, charts detailing the percent area of the different zones in each Awraja are presented in Annex 2. The area assessment was made using the GILES geographic information system in the LUPRD.

3.3 MOISTURE AVAILABILITY FOR RAINFED CROP PRODUCTION

3.3.1 General

Moisture availability is an important control on the development of crops and vegetation in general, and so knowledge of the amount and distribution of moisture for plant growth is critical to effective agricultural planning. Unfortunately, a high degree of variability over time in moisture conditions makes planning difficult. Strategies aimed at reducing the risk of failure over a 10 or 20 year period involve statistical predictions from meteorological data collected over long periods of time, commonly 25 years or more. Data recorded for periods of less than 25 years are still useful, but less reliable results can be expected.

The likelihood of drought periods occurring during critical stages in the development of different crops can be determined with considerable reliability, provided the frequency of meteorological data recording is sufficiently high. Daily records are desirable, but 10-day periods are acceptable for most agricultural applications. Apart from a few selected stations, however, data of this type are unavailable to land use planners in Ethiopia and this represents a serious constraint to more effective planning. The monthly rainfall data currently available through the NMSA provide only general guidance on moisture availability.

3.3.2 Dependable growing period

A number of methods are available for estimating expected moisture conditions for crops, including the statistical examination of rainfall data and the use of water balance models. Water balance models examine the effectiveness of rainfall for crop growth and provide a more reliable means for determining seasonal growing conditions than is possible from rainfall data alone. A model of this type, the LGP model, developed by FAO (1978), was used in the Phase I Assistance to Land Use Planning project to estimate the average length of growing periods (LGPs) in the different ecological zones of Ethiopia.

Growing period (GP) is a technical term used to describe the period in days throughout the year when moisture conditions in the soil are suitable for the crop growth uninhibited by moisture stress. Moisture available for crop growth at any point in time is influenced by the moisture stored in the soil. This is the sum of moisture stored from previous rainfall and the amount of rain falling in the period considered, less losses due to evaporation and the transpiration of plants carrying out their life processes, losses from surface run-off,and the amount water percolating through the soil without being stored. The manner in which GPs are calculated is detailed in MLUP Technical Report 5.

GPs can be estimated for individual seasons of the year, one year, averaged over many years, or treated statistically to give some measure of their likely reoccurrence over time. Dependable growing period (DGP) is a term used to describe the likelihood of a GP of a particular length occuring 8 years in 10. If the expected length of the GP is known with this degree of certainty, selection of crops and cultivars for improved production can proceed with greater confidence. Some crops require very long GPs, 200 or more days uninterupted by drought periods of just a few days. Other crops can succeed on as little as 60 days GP.

Figure 12 indicates the proportion of Ethiopia which experiences different lengths of DPGs. The lengths of DGPs which occur during the Belg and Meher seasons are shown separately according to the legend. DGPs of less than 90 days are considered unreliable for the production of most crops and varieties currently grown in Ethiopia. Growing periods in excess of 150 days are indicative of secure production zones, while those experiencing greater than 210 days of favourable moisture conditions are suitable for intensified agriculture and for perennial crops. The proportion of the country with DGP's sufficient for reliable crop production is limited to about 50%, as indicated in Figure 12.

The concept of DGP and its application in planning is developed further in the next section of the report. Details of the distribution and length of DGPs in each Awraja of the country are provided in Annex 2. The details are presented in graphic form for ease of comprehension and are intended for regional planners who may require information on the prevailing moisture conditions in a particular Awraja.

3.4 LAND MANAGEMENT CLASSES

3.4.1 General

Knowledge of the extent of land in a planning zone which has certain limitations or potentials with respect to intended uses, is essential for meaningful land use planning. In Ethiopia, most land is required for subsistence agriculture. The amount of land suitable for food production is, therefore, the most obvious limitation on the population supporting capacity in Ethiopia. Other limitations inherent in the land which prevent forage or fuelwood production, also reduce its capacity to support a larger number of people.

For the MLUP, characteristics which could reduce the land's capacity to support a subsistence population were identified using the land resources inventory generated during the Phase-I, FAO/UNDP Assistance to Land Use Planning Project. This information was computerized for MLUP use and fed into a population supporting capacity model described later in this report.

3.4.2 Land management classes

To simplify the population supporting capacity estimation, a minimum number of land management classes were identified using the land resources data base described above. Detailed information on the distribution of these classes by Awraja is presented in Annex 2 and Annex 4 of this document. The charts and maps in the report annexes also provide and easy to use, and suitably generalized, picture of the distribution of land resources in Ethiopia suitable for the use of higher level decision makers and planners.

A simplified definition of the 5 land management classes used in the population supporting capacity analysis is shown below. A more comprehensive definition can be found in Annex 2.

Arable land

- DGP more than 90 days
- soils more than 25 cm deep
- surface stoniness less than 50 to 90% stone cover
- Vertisols not included
- slopes over 30% not included

Vertisols

- all areas predominantly covered by heavy black clay soils

Steep land

- all land over 30% slope
- all other factors as for arable land

Marginal land

- land with significant moisture limitations in many years (less than 90 days of DGP, but more than 60 days on average

All other factors similar to arable land

Non-arable land

- land with severe moisture limitations (less than 60 days of GP on average)
- soils less than 25 cm
- surface stoniness > 50 to 90%

As implied above, the definition of arable land is somewhat generous, bearing in mind that soils down to 25 cm depth and land up to 30% slope have been classed as arable for the MLUP. However, in the context of Ethiopian subsistence agriculture this land is often as productive as that with much deeper soils and gentler slopes. In marginal rainfall years shallow soils are more vulnerable to moisture stress, but otherwise production on the complete gambit of land and soils classed as arable is uniformly low, as the production figures in Annex 3 indicate. The reasons for this are complex, but relate mainly to the nature of the traditional crops and cropping systems used throughout the country and the very low level of inputs, such as fertilizer and herbicides, which are used.

Vertisols were separated in the land classification because, although potentially arable, they do have special management requirements for crop production. Their poor drainage once saturated and their high draught requirements are both important constraints to successful cultivation. On the positive side, they do have a very high water holding capacity and are relatively fertile. In most cases, they provide dry season grazing reserves for livestock in the highlands of the country, where most of the human population is concentrated. Where population pressure is particularly high, Vertisols are increasingly being brought under cultivation by farmers. Vertisols have considerable potential, however, for more intensive crop production using techniques developed by ICRISAT and ILCA which are described later in the report.

Steep lands were separated in the classification of land management types to take account of the need for intensive conservation measures to ensure their sustained productivity. Some 20% of the land area on slopes over 30% is required for conservation structures, biological conservation such as tree lines, and to allow for pockets of shallow stony soils. Steep lands are quite widely cultivated in Ethiopia where land pressure is significant, and this will continue at an increasing rate in the future in the absence of regulation by government. There is potential for fuelwood and perennial crop production on these lands, provided land pressure is sufficiently reduced to enable their assignment for this purpose.

Marginal land was separated in the classification of land types used in the MLUP because of its limited moisture availability for rainfed cropping and its significant extent (13% of the country). This zone is presently used for livestock production and for limited and uncertain cropping. However, with appropriate early maturing crops and varieties there is considerable potential for increased and more secure food production in this zone.

Non-arable land was identified because it has little or no potential for rainfed crop production. At present it provides subsistence for a considerable number of nomadic pastoralists, habitat for wildlife and is utilized for the production of incense. There is potential for more intensively managed ranching, improved wildlife management and tourism, and incense production in this zone.

Figure 13 provides a countrywide picture of the distribution of the land management classes. The spatial distribution of the various land management classes is shown in map form in Annex 4. An important constraint in Ethiopia is apparent from Figure 13, the limited amount of arable land available for the expansion of rainfed agriculture, even according to the somewhat generous definition of arable used. This is in contrast to the popular belief in Ethiopia that the land resource potentials in the country are more or less unlimited for expansion of rainfed agriculture.

3.5 LAND COVER AND VEGETATION RESOURCES

3.5.1 General

Land cover is largely dictated by climate, the characteristics of land resources and population pressure. Due to centuries of expanding cultivation in northern Ethiopia, natural vegetation in the highlands has diminished to a minimum. Natural vegetation in central, eastern and southern Ethiopia has also come under increasingly heavy pressure in the last century. The steadily rising human population, with its energy demands and need to clear land for cultivation, has been taking an ever-increasing toll on natural vegetation resources during the later half of this century. Forests and woodlands for example, once considerably more widespread than at present, are shrinking rapidly in area. The existing distribution of land cover types, including both cultivated land and natural vegetation, is summarized in Figure 14 to provide an appreciation of the structure of the remaining vegetative resources of the country. This is based on data contained in the Land Use and Land Cover map of Ethiopia, produced by the LUPRD (FAO, 1984c). Further information on the distribution of the major land cover and natural vegetation types is provided in Annex 3, in the form of bar charts for easy comprehension. A general description of the land use and land cover types which appear on the Land Use and Land Cover map of Ethiopia is provided below.

3.5.2 Intensively cultivated land (CI)

In the summary of land cover given in Figure 14, this category includes both state farms and land cultivated by small farmers. More than half of the land is assumed under cultivation in any one year, the remainder being fallow and mostly used for livestock grazing. This category includes the most productive cereal producing areas of the country.

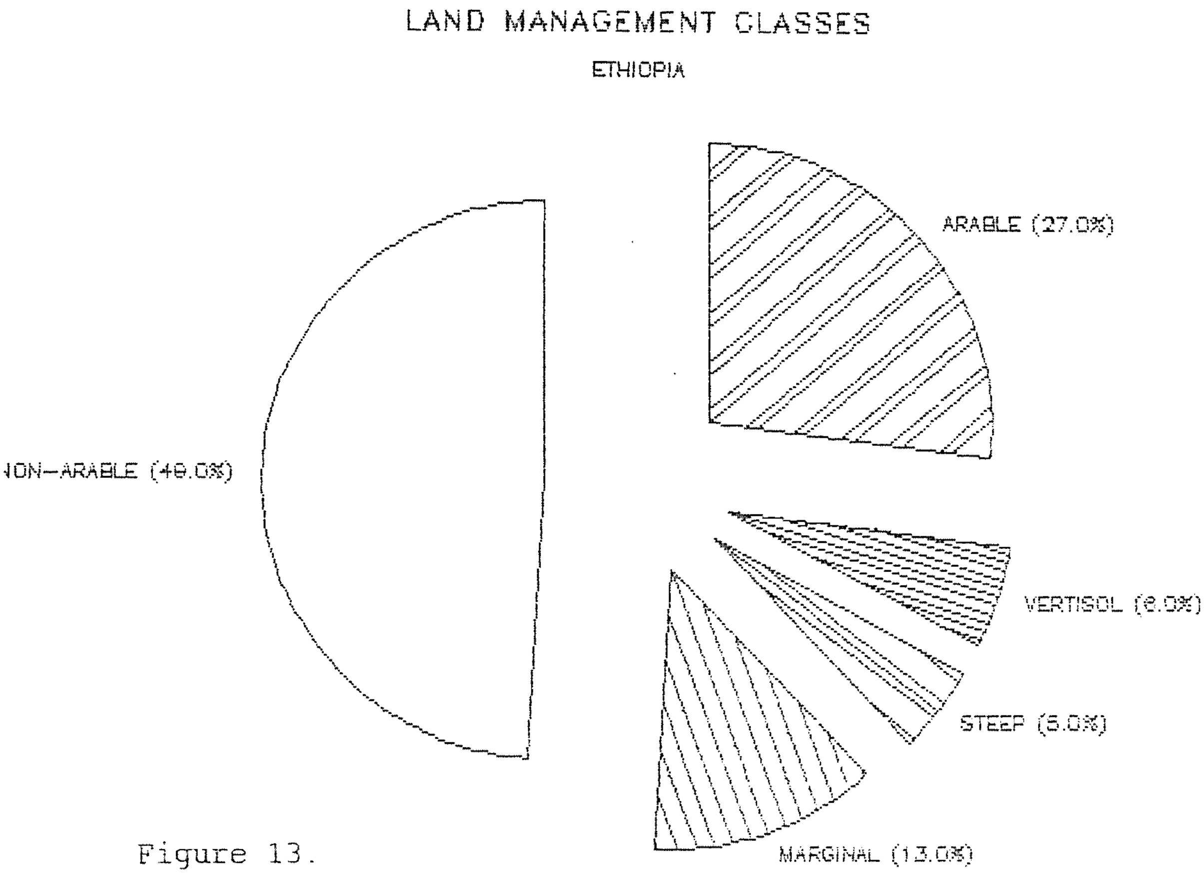


Figure 13.

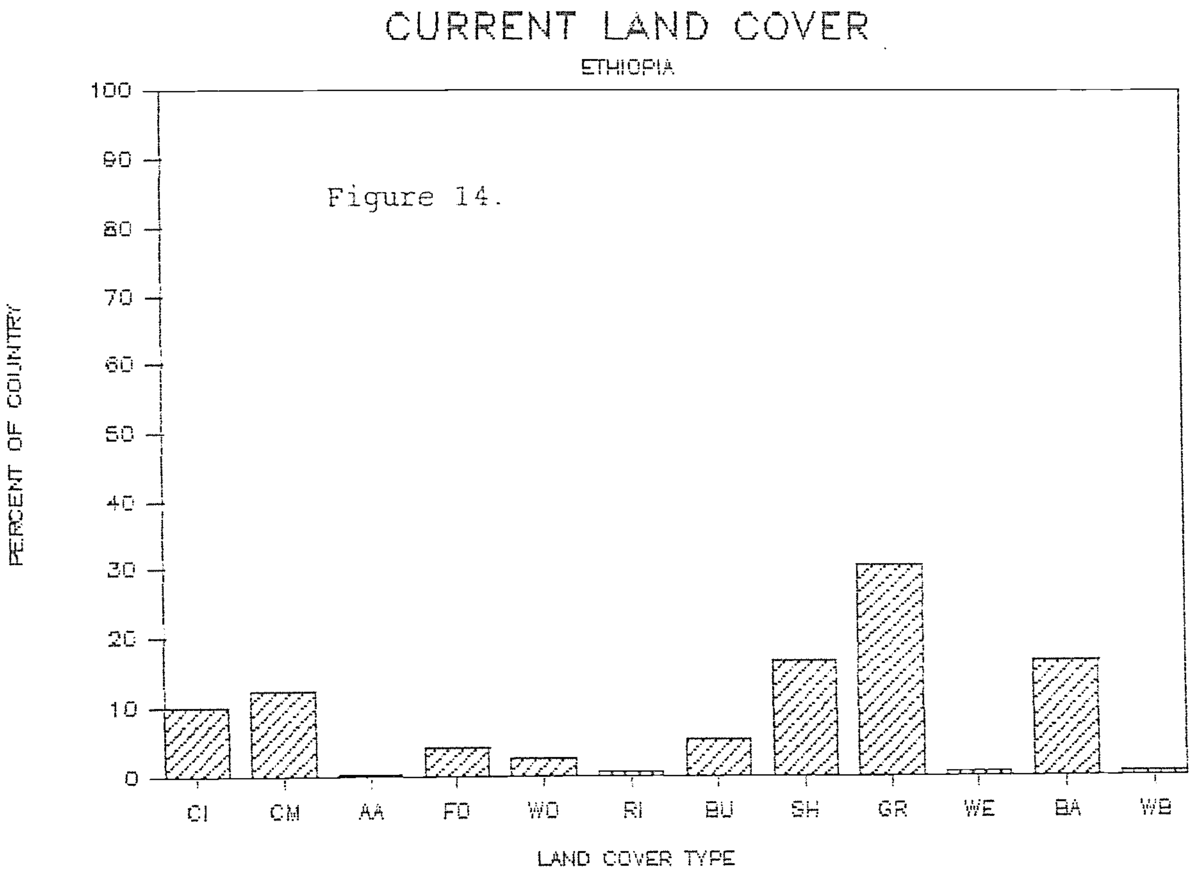


Figure 14.

3.5.3 Moderately cultivated land (CM)

Land of this type is described as having a significant proportion of natural shrub or bush which is grazed or browsed. This latter component is not cultivated. More than 50% of land in this class is said to be fallow. Included in this category are lands with significant areas of perennial crop. The proportion of fallow land is approximately that of the moderately cultivated land.

3.5.4 Afro-alpine and sub Afro-alpine vegetation (AA)

This occurs at high altitudes, generally above 3200 m elevation. It includes *Erica* woodland, shrubland and scrub and is often browsed by livestock.

3.5.5 Forest land (FO)

Three categories of forest land are included here: dense coniferous high forest, dense mixed high forest and disturbed high forest. In the last case, forest harvesting and expansion of cultivation are taking place in the forest.

3.5.6 Woodland (WO)

Woodlands include *Acacia* species interspersed with grasslands and scrub, and Eucalyptus woodlands for local fuelwood production.

3.5.7 Riparian woodland or bushland (RI)

Includes riverine vegetation.

3.5.8 Bushland (BU)

Includes woody vegetation of medium height. May include incense producing species, smaller Acacias and bamboo interspersed with shrub or grasslands.

3.5.9 Shrubland (SH).

Small shrubs and scrub interspersed with grass vegetation.

3.5.10 Grassland (GR)

Some woody species may occur, but generally open grasslands used for pastoral production (where water is available).

3.5.11 Wetland

Swamp and marsh vegetation. May be either perennial or seasonal, but inundated for considerable periods of the year.

3.5.12 Bare land

This category is rarely bare in a total sense. Patches of hardy scrub and bush colonize most exposed rock surfaces and sand and salt flats to some degree.

3.5.13 Water bodies

Lakes and permanently inundated lands of significant area.

3.6 NATIONAL PARKS AND WILDLIFE

Ethiopia is extremely fortunate in possessing valuable wildlife resources which have hitherto been little developed compared to those of some of its African neighbours. More than 100 species of animals and over 800 species of birds have been identified and a number of these are specific to the country. Major national Parks include:

- Awash
- Simien mountains
- Rift Valley Lakes
- Bale Mountains
- Nechisar

In addition there are 14 wildlife sanctuaries/reserves and 14 controlled hunting areas. Taken together they represent some 4% of the land area of the country.

Some emphasis has been placed on the cultural heritage of the wildlife by the GoE, but education of the rural population is required to emphasize this point. Encroachment of national parks through livestock grazing emphasizes the lack of appreciation for the worth of wildlife by pastoral populations living adjacent to parks. Reducing local interference to park habitats and more intensive management programs for wildlife offers great potential for increased foreign exchange earnings through tourism.

4. LAND USE AND PRODUCTION SYSTEMS

4.1 GENERAL

Rainfed crop production is the basis of almost all subsistence farming in Ethiopia and accounts for 95% of the land area cultivated annually. Export crops, livestock and livestock products are also essential components of the production systems. Since the revolution in 1974, the small farmers, who till the 6 to 10* million hectares of land cultivated each year, have user rights to land and are organized in Peasant Associations (PAs) which comprise 200 to 400 families. There are some 120,000 PAs organized in groups of 3 to 6 to form Service Cooperatives (SCs) which act as management centres for grain purchases, retail outlets for the provision of comodities such as salt and coffee, and outlets for agricultural inputs such as fertilizers. The PAs and SCs are organized along democratic lines, with officials at each level elected by their constituents.

Other important production systems in Ethiopia include state farms and producer cooperatives. The formation of producer cooperatives is actively encouraged by government through incentives and subsidies, but to date their contribution to the economy has been minimal as yields and total production appear less than or equal to those from PAs (World Bank, 1987b). State farms receive considerable financial assistance from the GoE to develop export production, promote import substitution, increase the area of cultivation and promote better farming technology and organization through provision of improved seeds to the agricultural sector. State farms account for 3% of the area sown to major crops and 5 to 6% of national production. The efficiency of the state farm sector has been criticized by a number of agencies, especially in relation to its past credit performance (World Bank, 1987b).

A wide variety of farming systems are practised by small farmers in Ethiopia, but there are many common threads such as the predominant use of draught oxen for the tilling of land. Inputs tend to be minimal and yields low. Management practices, such as weeding, also tend to be much less intensive than required for higher yields. Livestock, mainly through the requirement for draught, are principal components of most farming systems and Ethiopia possesses the largest livestock population in Africa, approximately 40 million TLU. Most are concentrated in the highlands.

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*Comparison of CSO and LUPRD estimates for the cultivated area of land in Ethiopia are discussed later in this report

4.2 FARMING SYSTEMS

4.2.1 General

The great variety of agroecological conditions in Ethiopia has encouraged the development of diverse crop and livestock systems. The major limitation to intensification and expansion of rainfed crop production is availability of moisture (FAO, 1984b). However, given adequate moisture availability, altitude, and thus temperature, determines crop suitability.

Three agroecological zones can be distinguished at a general level in Ethiopia sufficient to broadly classify systems of agriculture: highlands, moist lowlands and dry lands (AACM, 1987). Westphal (1974), FAO (1984c) and AACM (1987) all recognize four main farming systems in Ethiopia which can be further subdivided according to classifications for tropical farming systems (FAO, 1984c). The four major systems are as follows:

- the seed farming complex
- the enset-planting complex
- shifting cultivation and
- the pastoral complex.

4.2.2 Seed-farming complex

This system is predominantly a cereal farming system with the production of almost all crops from seed. Pulses and oil seeds are also important, with roots and tubers subsidiary. Livestock are primarily for draught, but provide a store of wealth, fuel (through dried dung), food and transport. Systems with these characteristics can be found in the central, eastern and northern highlands of Ethiopia, and in the Konso region of the south. Details regarding the further subdivision of this system can be found in Technical Report 3, AG:DP/ETH/78/003 (FAO, 1984c)

4.2.3 The enset (*Ensete ventricosum*) planting system

Enset is restricted in extent as a major production system in Ethiopia to the southwest of the country. It is found in the highlands from 1600 to 3000 m elevation. The plant is related to banana and both the pseudostem and corms are cut and pulped for food. The pulp may be cooked when fresh or, as is more common, fermented in silos usually in the ground. Fermentation may take a few weeks or years (FAO, 1984c). The main production zone of enset is above 2000 metres where it yields exceedingly well, generally providing more than 30 quintals/ha of product. It is often interplanted with coffee or chat (*Catha edulis*) and is rarely the sole source of human food in the farming system. Cereals, pulses, tubers and cash crops are usually important components of the overall farming system, supplemented extensively by livestock raising. Land preparation may involve a long digging stick or the plough may be used. Planting, harvesting and preparation for food vary widely throughout the enset zone. Because of its high productivity, both in terms of food production and livestock forage, it has potential for expansion in heavily populated areas with suitable environmental conditions for its culture. Social acceptance on a wider scale has so far limited its expansion. Further details can be obtained from AG:DP/ETH/78/003 Technical Report 3.

4.2.4 Shifting cultivation systems

Shifting cultivation is not well documented in Ethiopia and is mainly confined to the lowland tribes in the west and southwest of the country. It is reportedly practised by the Gumuz, Berta, Kaffa, and Gimira-Maji groups and among the Mekan-Surma and some peoples in Sidamo. The typical pattern of shifting cultivation, is use of the same area for one or two years and then abandonment of these fields and movement to more productive land. Crops grown are mainly sorghum, supplemented by maize, finger millet, sesame, groundnut and pumpkin. Cotton is used as a cash crop. Again, details can be found in AG:DP/ETH/78/003.

4.2.5 The pastoral complex

The role of livestock in almost all farming systems in Ethiopia is very important, beyond the simple provision of draught power. For the current purposes, however, pastoral systems are defined as those which depend almost completely on livestock production for the subsistence of those who practise them. Pastoralism as defined is practised in the hotter and drier zones of Ethiopia, usually because no other sustainable system is possible in these areas. Most pastoralists can therefore be found in the north, east and south of the country, but limited pastoralism is also practised along the Sudan border in the west of Ethiopia. Pastoralism is discussed in more detail in MLUP Technical Report 3.

4.3 MAIN CROPS AND CROPPING PRACTICES

4.3.1 General

The crops and cropping practices in Ethiopia are almost as diverse as the environments in which they are found. The following section of the report presents a statistical summary of the area cultivated to the major crops and the average yields of these crops. An Awraja based presentation of area cultivated and crop yields is presented in Annex 3.

4.3.2 Area cultivated to major crops.

Over recent years, a considerable degree of discussion has developed in Ethiopia regarding differences between two alternative estimates of the area cropped each year. The CSO produces a yearly summary of the area, production and yields of common crops, based on statistical samples drawn on a regional basis for all accessible Regions of the country. The LUPRD, in 1984, produced an estimate of the area of <u>cultivated</u> <u>land</u> in Ethiopia as part of its nationwide land use assessment. The LUPRD data are derived in the main from satellite image interpretation and field traverses.

The first and most important fact to note is that the two sources of information (ie CSO and LUPRD estimates) quote data concerning two quite different aspects of land use. On the one hand, the CSO estimates are aimed entirely at estimating the <u>cropped area</u> in any one year. The LUPRD data provide details of the area of land which has been subject to cultivation in the recent past; <u>the cultivated area</u>. The two are quite distinct. The spatial extent of the cultivated area estimated by the LUPRD was determined in the main from the patterns of cultivation evident on satellite imagery. These patterns indicate where land has been cultivated in the recent past, not just where land is cultivated in the current year. The patterns formed by cultivation scars and former field boundaries may, however, last for several years in fallowed land, as casual observation will demonstrate. The fallow area in any one year can thus be considerably understated in the LUPRD estimates. Taken on face value, the estimated crop producing area will be overstated by an equal margin when extrapolated to estimate total production.

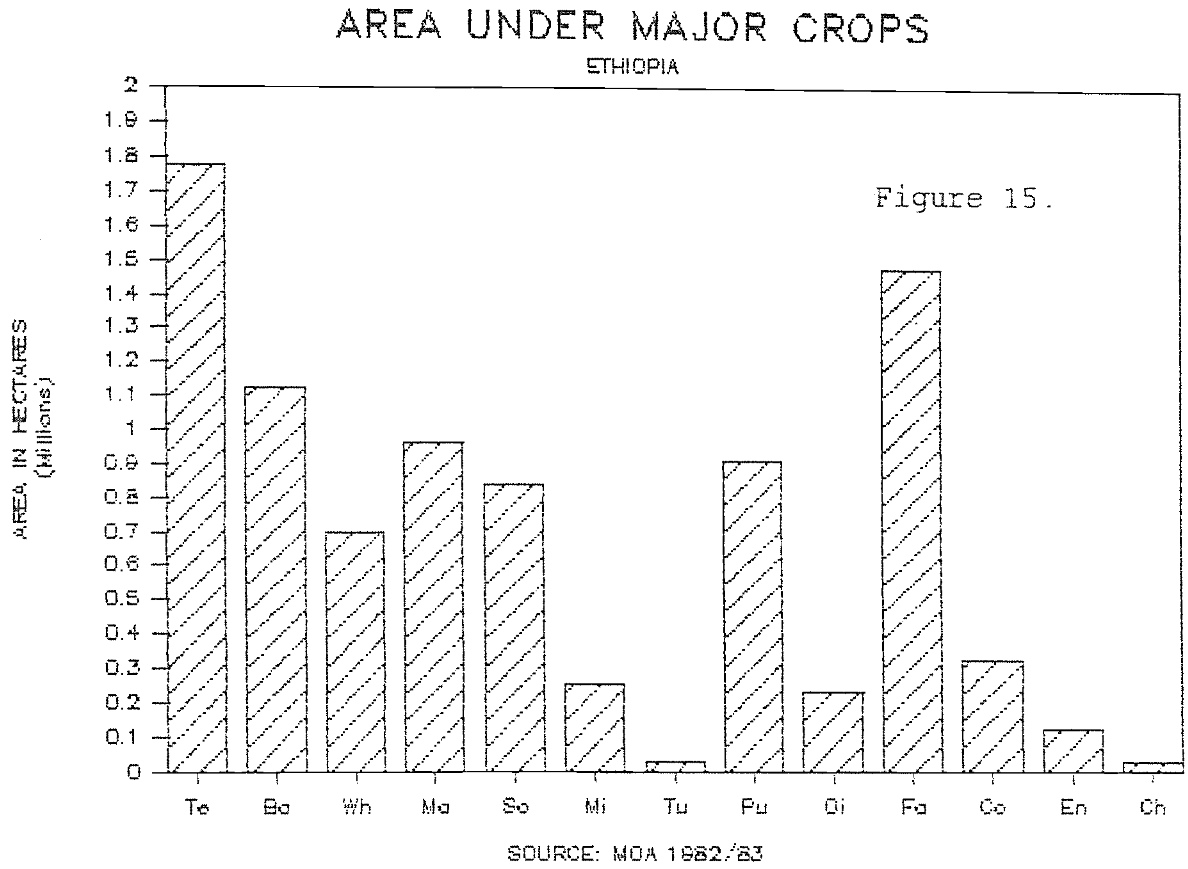
By the same token, the inability of the CSO to be able to conduct more extensive surveys and to reach insecure Regions also serves to underestimate the total area of production. The truth no doubt lies somewhere between the two estimates, but the belief of the MLUP mission is that the CSO estimates are much closer to the actual cropped area than those derived from the LUPRD data in their present form.

The production area of the main crops grown in Ethiopia for the 1982/83 cropping season is presented in Figure 15. These figures are indicative only, as year to year variations in the area cropped can be considerable depending on environmental conditions such as rainfall. The figures are drawn from the 1982/83 MoA agricultural surveys, which represent the only available crop production data on an Awraja basis for the entire country. They are presented here in preference to the CSO average figures (overall they are concordant), for consistency, as these are the data used to estimate production figures on an Awraja basis in Annex 3. The symbols used in Figure 15 for the main crops are as follows:

> Te-Tef, Ba-Barley, Wh-Wheat, Ma-Maize, So-Sorghum,
> Mi-Millet,Tu-Tubers, Pu-Pulses, Oi-Oilseeds, Fa-Fallow,
> Co-Coffee, En-Enset, Ch-Chat.

4.3.3 Crop yields

The estimated yields of major crops grown in Ethiopia are shown in Figure 16. The symbols used are the same as those in Figure 15. Yield estimates are derived from the data contained in the MoA, General Agricultural Survey (1982/83), which forms the basis of all


AREA UNDER MAJOR CROPS
ETHIOPIA
Figure 15.
AREA IN HECTARES (Millions)
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Te
Ba
Wh
Ma
So
Mi
Tu
Pu
Oi
Fa
Co
En
Ch
SOURCE: MOA 1982/83

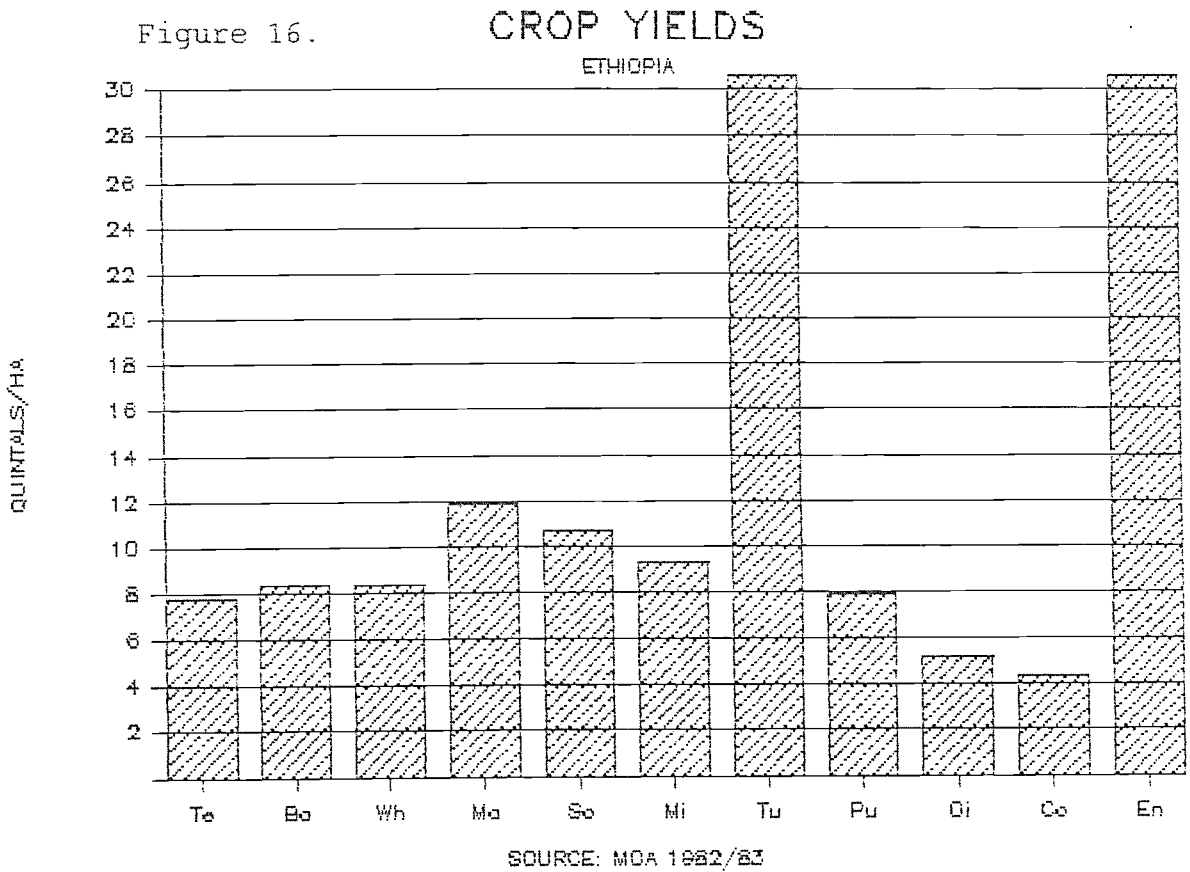


Figure 16.
CROP YIELDS
ETHIOPIA
QUINTALS/HA
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
Te
Ba
Wh
Ma
So
Mi
Tu
Pu
Oi
Co
En
SOURCE: MOA 1982/83

currently available Awraja yield estimates. These data were used in a farm model, described later in the report, to estimate the minimum land area required to support the various subsistence farming systems present. This was an essential input into the population supporting capacity estimation carried out for each Awraja, presented later in the report.

4.3.4 Cropping practices

A great deal of information already exists on cropping practices in Ethiopia and it would be counterproductive to present other than a brief summary here from a selection of references, including Westphal (1975), EHRS (1986) and AACM (1987).

Land preparation. Most cultivation in Ethiopia depends on the plough. Westphal (1975) estimates this has been the case for some 2000 years. The traditional plough is still basically unchanged. The 'Maresha', as it is known locally, has a chisel action and does not invert the soil as it passes. Weed control is less effective than for a mouldboard. However, it has lower draught requirements than a mouldboard and provides minimal tillage, which tends to leave the soil less susceptible to erosion.

Preparation times are prolonged, especially for the favoured cereal tef (*Eragrostis abyssinica*). The average number of passes of the plough for tef is 6, and for most other crops 2 to 3. This places considerable stress on livestock resources at peak land preparation times. Although the distribution of total livestock numbers roughly equals the draught requirement on a PA or Awraja basis, inequitable distribution of livestock constrains farmers with few or no oxen during the peak land preparation period. It results in less land cultivated or late planting which, in shorter than average growing seasons, may cause severe yield reductions. Wealthier farmers with adequate livestock tend to do well under these circumstances while the poor get poorer, a point elaborated upon by Gryseels et al (1986).

Another serious disadvantage of repeated ploughings is that it lays open the soil to more severe erosion, especially since the peak land preparation period is usually early in the wet season when rainfall is most intense.

The main reason for prolonged land preparation requirements, especially for tef, appears to be weed control. There is clearly a constraint with respect to weed infestation and control and, if alternative control measures were available, such as the application of pre-emergence herbicides, there is potential for reducing draught requirements during the peak land preparation period.

Other systems of cultivation include the hoe and digging stick. In enset/root crop systems the hoe and digging stick are the main tools for land preparation. Hoe cultivation is also widely practised in the eastern highlands, especially where farmers apply more inputs and obtain greater yields. The limitation on the hoe system is primarily one of not being able to bring sufficient land under cultivation to support a farm family at current, low yield levels.

Seeds and planting. Suitable varieties are available for maize and wheat (EHRS, 1986). Some 5000 tonnes of improved seed are used in the peasant sector, mostly by producer cooperatives. Improved seeds are generally not available for other crops. ADD (1988) estimates that improved varieties generally provide only 20% more in terms of yield than local varieties and that more improvement comes from scrupulous weeding and fertilizer inputs.

Most seed is broadcast in cereal systems and covered by a final pass of the plough. In the case of tef, seed is puddled into the surface and left uncovered. AACM (1987) estimates 5 days for ox-assisted seeding and 4 days for hoe seeding.

Crop husbandry. Fertilizer use is estimated to be 2.5% of land cultivated by peasants (EHRS, 1986). This is negligible on a countrywide scale. Where applied it is usually in less than recommended amounts. The reasons for such low levels of fertilizer use are limited availability, timeliness of delivery, inadequate credit and cost. Yield responses in traditional crops are also attenuated by the lack of complimentary inputs, such as adequate weeding and protection from pests. Weeding is most commonly done by hand, but for large grain crops the plough may be used. AACM (1987) estimates tef receives 3 weedings, maize and sorghum 2 and other crops one. First weedings are estimated to take about 20 man-days per hectare, reducing for later weedings. ADD (1988) suggest this is totally inadequate and that ineffective weeding is a major constraint to achieving potential yields.

Harvesting is generally carried out using the sickle and crops left to dry in the fields. Threshing is most commonly accomlished using oxen to trample the harvested crop. Winnowing is done using wooden pitch forks or other similar instruments.

Pests and diseases. Local varieties of crops are generally resistent to most pests and diseases, but fungal problems and smut have been reported in some grains. Rodents are a major problem in many areas, both pre and post harvest. Baboons create a great deal of damage in areas where there is sufficient natural vegetation cover nearby for their protection. In the western zone, elephants and pigs can be problematic, but as cultivation expands in the western zone this may increase. Locusts, grasshoppers, and armyworm have also caused serious problems in the past in Ethiopia and national and international programs are in place to monitor these serious pests. Termites and weevils are serious post harvest pests in some regions of the country.

4.4 LIVESTOCK

4.4.1 General

Livestock are fundamental to almost all farming systems in Ethiopia. Recent surveys (AACM, 1984) confirm that the reasons for keeping livestock include:

- as a store of wealth,
- insurance against crop failure and famine,
- draught power for crop cultivation systems,
- manure for fuel,
- manure for fertilizer,
- transport,
- products for sale
- products (eg dairy) for home consumption

The ubiquitous role of livestock in subsistence systems in Ethiopia no doubt accounts for the estimated 40 million TLU (see MLUP Technical Report 3) which are present.

4.4.2 Types and distribution

Livestock comprise cattle of the Zebu type, small ruminants, equines and camels. Cattle and sheep are dominant in the highlands and cattle and goats in the lowlands, except for the large camel herds of the Afar and Issas peoples in the northern Rift Valley and in eastern Ethiopia. Equines are evenly distributed throughout the highlands with the exception of southeastern Ethiopia. Here they are more abundant. The estimated proportion of species on a national scale is shown in Figure 17.

4.4.3 Feed resources

Detailed estimates of available feed resources are contained in MLUP Technical Report 3. These results are summarized on an Awraja basis and in graphic form in Annex 3 of the Main Report. In Technical Report 3, it is estimated that the 36 to 40 million TLU present in Ethiopia have available some 86 million tonnes of dry matter annually. This represents an average daily consumable dry matter of 2.32% of liveweight. While the overall figure appears satisfactory, substantial differences occur on a Region and Awraja level. Large quantities of dry matter, for example, are available in the sparsely populated western lowlands, but here tsetse and trypanosomiasis are widespread.

Similarly, in eastern Ethiopia, there is substantial dry matter available from natural savanna vegetation, but water availability for livestock limits access to these resources.

LIVESTOCK BY TYPE (% TOTAL TLU)

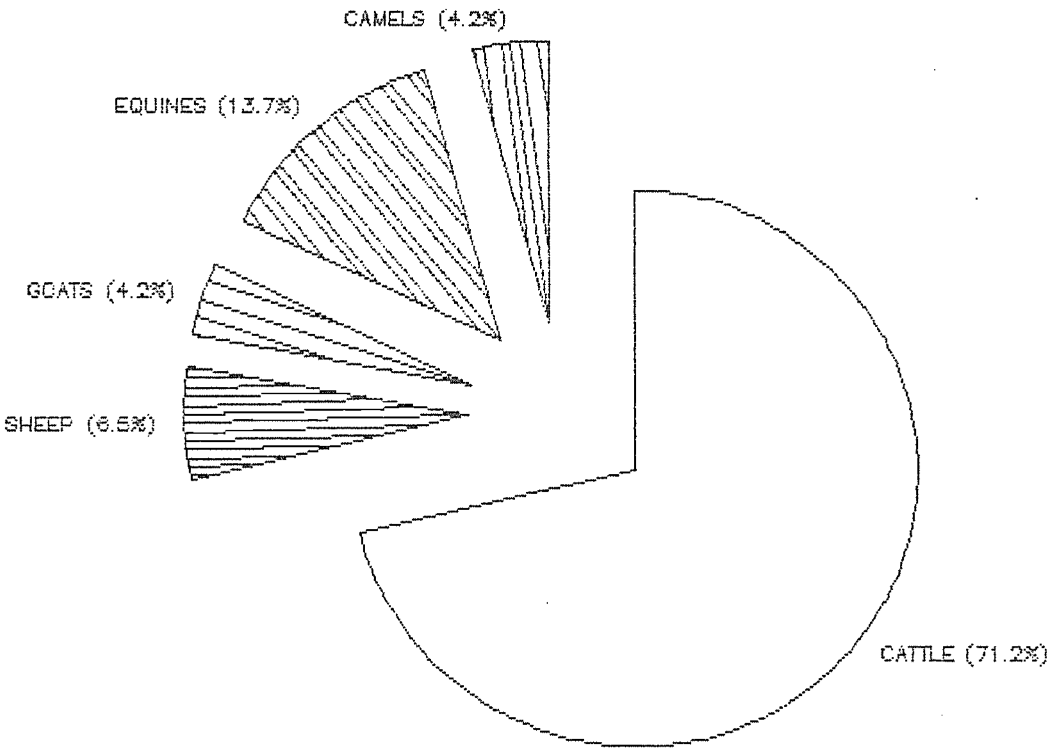


Figure 17.

Dry matter production comes from three main sources in Ethiopia: natural vegetation, crop residues and aftermath grazing. For the purposes of the MLUP, total annual dry matter production for each Awraja was determined using crop production data, crop residue conversion factors and conversion factors for production from natural herbage. The production from the latter was obtained using the Land Use and Land Cover map attached to the Assistance to Land Use Planning, Technical Report 3. Substantial differences in available dry matter are indicated by the Awraja level data. Areas intensively cropped are, in general, in a deficit situation with regard to feed resources. The high requirement for draught during the peak land preparation period places pressure on farmers to keep more animals than can be adequately fed from available resources, creating a spiral of vegetation degradation. Since grazing lands are largely a communal responsibility little is done to improve production. There has thus been an increase in the need to use steep and degraded terrain and to depend more on waterlogged areas with attendant risks to animal health. The most productive pastures in the highlands are inundated for much of the growing season and animals have to be moved to more marginal areas on higher ground or to fallow land to avoid these risks. These lands are predominantly on Vertisols, which poses a future problem when these soils may need to be brought under crop cultivation to feed the growing human population.

Seasonal shortages in both the quantity and quality of forage can be acute. At the onset of the rains there is usually a shortage of bulk. Seasonal waterlogging at an advanced stage of the rainy season can also cause shortages and by the time inundation recedes, the quality of the feed has already passed its best. In densely populated areas with less animal-dependent cultivation, more intensive feeding systems have developed for livestock. Here feed is cut and carried, as in parts of Harerge and the enset zone of the southwest. Potential exists for increased dependence on hillside exclusion zones and cut and carry systems. In general, intensive management of crop and forage production, through systems such as alley cropping, will become mandatory in the future if livestock forage requirements are to be met.

Environmental factors, such as bush encroachment and recent decreases in rainfall in pastoral areas, are concerning, as they indicate an accelerating spiral of declining forage resources when coupled with the trend toward overgrazing. Availability of water during recent droughts has further intensified the problems for nomadic pastoralists. For some years now, the traditional lands of the Afar and Kereyu people of northern Rift Valley have been reduced in extent through irrigation development, although some compensation has been attempted by limited irrigation of pasture adjacent to the Awash river.

4.5.3 Animal health, nutrition and productivity

Health. Livestock in Ethiopia are subject to numerous parasitic and infectious diseases which, together with poor nutrition, restrain animal productivity. Major diseases such as Rinderpest, Contagious Bovine Pleuro Pnueumonia (CBPP) and Trypansomiasis have caused high levels of morbidity and mortality in the past. Trypanosomiasis is a major constraint to the expansion of traditional farming systems, which depend on animal draught, in the western zones of Ethiopia. Tick-borne livestock diseases are also important in this regard.

Nutrition. Nutrition is a fundamental problem affecting the productivity of livestock in Ethiopia. High stocking rates, as discussed above, tend to produce unfavourable rates of forage available for livestock in many areas of the country. Together with poor feed availability and the generally low levels of nutritive value of many of the forage species, shortages in both energy and protein are common. In addition, results of forage and blood analyses (Faye et al, 1983) suggest the extent of trace element deficiencies is considerable throughout the country.

Productivity. Most livestock are estimated to be kept at intakes near the maintenance level. Overall efficiency of feed use is therefore low, as 85-90% of feed is estimated necessary to cover maintenance, while the remainder is available for productive purposes. Exposure to disease and poor nutrition has also tended to direct livestock selection toward survival rather than performance. According to EHRS (1984), Ethiopian productivity indicators are up to 1/3 lower than the average for tropical Africa. The tendency to communal grazing further increases the trend toward greater numbers of less productive animals, in order for individuals to gain the most from shared resources.

4.5 SOIL DEGRADATION

4.5.1 General

A considerable volume of information has been produced in recent years regarding soil degradation in Ethiopia, but certain basic facts remain obscure. Why, for example, do farmers require incentives such as Food For Work to encourage them to conserve land if the benefits from the increased production are so great? Why, if the anticipated fertility decline is so dramatic throughout Ethiopia, have yields not declined in an equally dramatic manner over the last 10 years (see MLUP Technical Report 2). Total productivity may have fallen for lack of rainfall, poor farm management or socio-economic reasons, but yields have remained more or less uniform across the country, albeit low. Answers to these questions are basic to a proper perspective of soil degradation in Ethiopia and its eventual solution.

4.5.2 The nutritive character of Ethiopian soils

While the fertility of soils in many parts of Africa is confined to the topsoils, where nutrients are concentrated and once lost cannot be replaced without fertilizers or other soil improvements, the majority of Ethiopia's highland soils remain relatively fertile at depth. For example, exchangeable bases at 100 cm depth are available in equal amounts to those found in topsoils (FAO 1984a). The same is true for a number of other important nutrients. Under these circumstances erosion reduces depth and the water holding capacity of the soils, and not inherent fertility. Depth becomes limiting when insufficient to provide the moisture reserve needed to protect crops against the droughty periods which may occur during their growth cycles.

Virgin soils retain even higher levels of inherent fertility in the organic layer of the topsoil. Substantial quantities of nutrients and organic matter can be lost after just a few years of careless farming when these soils are first opened up for cultivation. On the intensively farmed land in Ethiopia the clock has already been set to zero and the high nutrient levels in the top few centimeters of these once virgin soils has long since disappeared.

4.5.3 Minimum soil depth for productive yields

Yield reductions due to erosion have traditionally been assumed to stem mainly from nutrient losses (EHRS, 1986). Loss of water holding capacity and decrease in rooting depth are cited by Thomas and Cassell (1979) and Stocking and Pain (1983) as equally, if not more important. Stocking and Pain (1983) point out, however, that provided 50 to 75% of target yields can be achieved in small holder systems, the minimum soil depth tolerated by grain crops is remarkably low. Depths down to 25 cm were modelled as being sufficient to meet 50 to 75% target yields in sorghum. The extent of these reductions is very much a function of individual crop tolerances, soil character and depth, and management techniques. Most crops grown in Ethiopia have evolved with a bias for survival and modest yields in most years, rather than for high levels of production in some years. This makes yield reduction under moisture stress less severe than for higher yielding varieties under similar circumstances. The rooting depth of most local crops is also of the order of 25 to 50 cm. Beyond this depth moisture remains largely inaccessible to them, indicating that moisture problems are unlikely to appear above this threshold unless due to rainfall deficits.In those zones of Ethiopia where cultivation has been practised for centuries, soils have become excessively shallow as a result of poor management practices and steadily worsening erosion. Here the problem of soil depth and associated poor moisture retention is a major concern. But emphasis should be made of the fact that soils in northern Ethiopia are generally more erodable than other parts of the highlands and they have also taken centuries to reach their current levels of decline. Despite the shallow soils, in years of adequate rainfall, yields equate to those in areas with much deeper soils.

4.5.4 Farmer motivation for conservation

One of the main reasons that farmers in Ethiopia are not motivated to apply conservation measures, is that yields rarely show any improvement without simultaneously increasing levels of other inputs such as fertilizers. Physical conservation measures also occupy up to 20% of the land in steep areas and this further discourages their adoption. Once it is understood that shallow soils are capable of sustaining the present low yields of subsistence farmers in all but the poorest rainfall years, it becomes clearer why farmers do not invest effort in soil conservation without inducements such as Food for Work. This is, of course, an oversimplification, because many other factors enter into their motivation. Prevailing market prices for their produce and the need to feel security of tenure, so that they invest effort in improving their land, are equally important.

4.5.5 Soil depth modelled over 25 years

The emphasis in recent years placed on the urgency for soil conservation in Ethiopia, prompted the MLUP mission to examine the influence of soil loss rate on the extent of potentially arable land over the next 25 years. Using available data on estimated soil loss rates and present soil depth, produced during the Phase-I project, the probable soil depth in 25 years was modelled for each Awraja. The most vulnerable soils were assumed to be those presently 25 to 50 cm in depth. With high soil loss rates of 0.5 cm or more these soils could be reduced to critical levels in 25 years.

Despite estimated loss rates in excess of 1 cm/annum in some locations, critical soil depths of 25 cm or even 50 cm, appear unlikely to be reached before 2010, except for those already critical areas in northern Ethiopia. For the remainder of the country, it may take 50 years or more for the problem to become critical at a national level.

4.5.6 The future role of soil conservation

The EHRS estimates that the loss of productivity caused by soil degradation in Ethiopia will amount to EB 15,000 million over the next 25 years, or some EB 600 million per annum. These figures are based primarily on the estimated losses from lower crop yields, loss of crop land, and lower forage production. Losses of productivity are linked by the EHRS to reduced soil depth and loss of nutrients. While the loss of soil is undeniably extreme in Ethiopia, the opinion of the current mission is that productivity losses are somewhat overestimated in the above study, in view of the low input levels and uniformly low yields of current farming systems. This is not to say that soil degradation is not a serious problem in Ethiopia, but that the present loss of productivity is concentrated in areas where soil depths reached critical levels more than a century ago, in the northern provinces of Eritrea, Tigray, Welo and parts of Gonder. Given sufficient time, productivity losses will also become extreme in other, rapidly eroding areas of the country, such as southern Shewa, Gamo Gofa and Harerge.

The question is really one of time. The MLUP mission believes that Ethiopia faces a food crisis driven by its rapidly expanding population and low agricultural productivity, long before a modern degradation crisis has time to significantly alter the current food production potential of the land. Of course production in many areas of the country will eventually be reduced to the current levels of northern Ethiopia if soils are not properly conserved. However, simply conserving soils will do little in increase total food production, but merely maintain the status quo. Yields must be increased if food sufficient to meet the population's needs is to be produced over the next 25 years. Intensified farming in which conservation forms an integral part of generally better land management is one answer. Under these circumstances inputs, such as fertilizer, are more effective on land susceptible to erosion, as losses caused by surface water movement are minimized. Details are discussed later in the report.

4.6 DEGRADATION OF VEGETATION RESOURCES

4.6.1 General

The extent of natural woody vegetation has been diminishing for some time in Ethiopia, at rates vastly greater than it can regenerate. The two main reasons for this are land clearance for agriculture and the growing need for fuelwood and wood for building materials. Closed canopy forest has been reduced to below 4% of the land area of Ethiopia, according to LUPRD figures produced in 1983. Unless appropriate state intervention in the control of these resources is forthcoming, they will degenerate much more rapidly in the future because of the demands of the rising population.

4.6.2 Fuelwood availability

The energy needs of the population are already placing undue strain on the natural vegetation resources in most of the highlands of Ethiopia. Demand will continue to expand exponentially over the next 25 years without an energy substitute for cooking. At the present time, dried cattle dung and crop residues provide up to 50% of the annual per capita requirements for fuel. This has negative feedback on attempts to improve food production, because of the loss of nutrients to the soil. An alternative energy source is obviously desirable, but has yet to be defined and established as economical and reliable.

The estimated availability of fuelwood for each Awraja in the country is shown in Annex 3, in chart form. Estimates indicate a positive or negative availability, according to the demand of the projected population and the annual production rate from natural vegetation. Estimates of the projected national requirement, availability, and the plantation area required to supplement the demand are included in Table 3. The figures in the table were derived from estimates of the annual regeneration rate of the various natural vegetation types in the country and the fuelwood demand of the projected population in 1985, 1995 and 2010. Consumption of fuelwood per capita is assumed to be 0.8 m^3/caput/annum, the remaining portion of the 1.3 m^3 required is assumed to come from dried dung and crop residues.

Rates of regeneration were determined using the Land Use and Land Cover map produced by the LUPRD (FAO, 1984c), and annual production rates for analagous agro-ecological zones in Africa (Anderson and Fishwick, 1984). It is important to note that production from closed high forest was excluded in the current estimation, because the MLUP mission feels that these ecologically unique resources should only be harvested under strict Government management and not indiscriminantly by farmers. Otherwise, irreversible damage may be done to these dwindling resources. Estimates of production from closed high forest are included in Table 3, and Annex 3.

The volume of fuelwood required and the plantation area necessary to meet the demand of the population is staggering. Ethiopia has clearly entered a crisis with respect to fuelwood availability. A crisis which must be addressed at the earliest possible time to reduce the prospect of further degradation of the regenerative capacities of natural vegetation resources.

TABLE 3

ESTIMATED ANNUAL FUELWOOD DEMAND

Year	Requirement m^3/ann (millions)	Net Demand* m^3/ann (millions)	Plantation Area** Requirement in ha (millions)
1985	33.9	14.8	0.98
1995	45.4	26.2	1.75
2010	76.1	56.9	3.79

Total annual production assumed constant at 19.15 million m^3/annum without including production from closed high forest. This would add an additional 6.29 million m^3/annum.

*Requirement less production from natural vegetation

**Plantation area based on an average production of 15 m^3/annum.

4.6.3 Industrial wood

Existing high forests constitute the only significant source for production of industrial wood in Ethiopia. As the high forests diminish through unmanaged exploitation and clearance for agriculture, the need for establishment of industrial plantations will grow. Existing forest, however, represent the source at hand and state management is essential for their long term productivity. The extent of industrial plantation required to supplement existing forests can best be determined after bringing all the high forests under management. The area suggested in 1984 was 110,000 ha (FAO, 1984a), but this represented only an initial target around which more detailed planning would take place after an assessment of existing resources.

5. QUANTIFICATION OF LAND USE

THE POPULATION SUPPORTING CAPACITY MODEL

5.1 BACKGROUND

For 95% of Ethiopia's population, maintenance of a basic subsistence standard of living requires the production of a minimum area of crops, maintenance of a livestock population adequate to produce sufficient draught oxen, and access to adequate fuelwood for cooking. Livestock compliment the subsistence system by providing some meat and milk for household consumption, and dung for fuelwood substitution. This section of the report examines the potential of each Awraja in Ethiopia to provide these subsistence needs under varying population, production and consumption projections.

5.2 THE POPULATION SUPPORTING CAPACITY MODEL

5.2.1 General

The population supporting capacity (PSC) of each Awraja depends on the resources available to meet the combined food, livestock and fuelwood requirements of the subsistence population. To quantify the capacity of available resources to support these needs, a PSC model was developed during the course of the MLUP. The model (through a farm sub-model) first estimates the available food grain equivalent produced by the composite farming system in an Awraja, oxen requirements, income from sales of grain and costs of production. The minimum area required for subsistence by a typical farm family is estimated in the model from these parameters, for each Awraja. This takes into account the basic nutrition and fuel needs of a farm family, and the area required to maintain their draught oxen. Additional land must also be set aside by subsistence farmers in many areas to meet their share of government grain quotas. Subsequent steps in the PSC model calculate the number of farm families which can be supported by the available resources at current levels of productivity. The supportable number of families is compared in the model with present and future estimates of family numbers, based on population projections detailed in MLUP Technical Report 2. Disposable incomes based on AMC, open market and CMC (if applicable) incomes are also estimated.

5.2.2 Data sources

The minimum area required for subsistence depends to a large extent on the productivity of the land and farming system in the Awraja concerned. To estimate the productivity of different systems, area and production estimates from the General Agricultural Survey of the Ministry of Agriculture (1984) were examined, together with a data set from Anderson and Fishwick (1984). Coffee data were compiled from a combined data set obtained from MCTD, FAO (1983) and the mapped distribution of coffee areas.

5.2.3 The farm sub-model

A single standardized model of a composite farming system was developed for each Awraja from the data above. This was necessary as the detail required to take account of the spatial distribution of farming systems within Awrajas could not be justified in terms of available time or the quality of the available data. Since the model was developed from Awraja totals, the results of the farm model component cannot be taken as a reflection of any component system within the Awraja, but an indication of the average situation.

The farm model takes into account global parameters, regional parameters and individual composite farming system models. Global parameters include:

- number of ploughings;
- crop residue coefficients;
- percent loss and seed requirement;
- AMC and CMC prices; and,
- a parameter for modifying yields.

Parameters for each of the major grain crops, tubers/root crops, pulses, oilseeds, fallow, coffee, enset and chat, are also included. The various global parameters were estimated from LUPRD reports (FAO, 1985, 1986b, 1987e). The values of the global parameters, such as the number of ploughings, influence the demand for draught oxen pairs per hectare of the farming system. This subsequently affects the area of pasture land required and, ultimately, the PSC. Sensitivity of the analysis to different values of global parameters could readily be tested by altering these values in the model. AMC and CMC prices for crops were obtained from official sources where applicable.

One set of regional parameters were specified, indicating the average open market price for grains, pulses and oilseeds. These were obtained from a variety of sources specified in MLUP Technical Report 2.

Individual composite farming system models provide estimates of the aggregate production, less percentage losses and seed requirement, for each Awraja. Consumable or marketable surpluses of each crop component of the system are also estimated. Dry matter production from crop residues and fallow are provided, based on the residue coefficients and yields per hectare of fallow land specified in MLUP Technical Report 3. For an improved technology scenario described in MLUP Technical Report 2, cash costs per hectare are also estimated. Finally, income is estimated from sales to AMC, CMC and the open market.

The output from the farm sub-model for input into the PSC model includes:

- available food grain equivalent from grain and pulses (kg)
- available food grain equivalent from tubers and enset (kg)
- income from AMC sales (EB/annum)
- income from CMC sales (EB/annum)
- total residue production (kg)
- total ox-pair plough requirement (days)
- cash costs of the farming system (EB/ha)

The details of the methods of computing these values for each Awraja are contained in MLUP Technical Report 2.

5.2.4 Population supporting capacity estimation

The PSC model integrates the crop, livestock and fuelwood requirements of farm families in each Awraja. The solution of the model, a linear programming problem, identifies the maximum number of rural households, plus the associated urban population, which can be supported from the available resources in each Awraja.

Inputs to the model include:

- estimated area of potentially arable land;
- estimated rural and urban population (1985, 1995, 2010 medium, 2010 high);
- average rural household size, and hence estimated number of rural households in 1985, 1995, and 2010;
- an oxen to cattle conversion factor which uses the herd structure of different areas to compute the minimum number of cattle required by the farming system;
- the proportion of total AMC procurement which has to be obtained from each Region, based on current practice;
- potential fuelwood production per hectare from non-arable and arable land in each Awraja;

- potential forage production per hectare from non-arable and potentially arable land in each Awraja

- global parameters for the entire model defining human nutrition levels, cattle nutrition levels, current AMC purchases, projected AMC purchases (1995, 2010), per caput fuelwood consumption, and farm fixed costs.

Arable and non-arable land. The supporting capacity of each Awraja depends to a large extent on the characteristics of the land available to produce the subsistence requirements of the population. The relative extent, therefore, of arable and non-arable land from which the crop, fuelwood and livestock production requirements can be met in each Awraja is a necessary input to the model. The extent of arable and non-arable land was determined from the land resources data base produced by the Phase-I, Assistance to Land Use Planning project, according to the definitions set out in Chapter 3 of this report. The relative extent of arable and non-arable land in each Awraja is shown in Annex 2, and the spatial distribution in Annex 4.

Fuelwood requirements. Annual fuelwood requirement of rural households, plus a proportion of the urban demand, is estimated in the PSC model for 1985, 1995 and 2010. Fuelwood consumption is estimated on the basis of Anderson and Fishwick's (1984) figures, but can be varied in the model to simulate different situations, including the influence of substituting dried cattle dung for fuel. These aspects are discussed later in detail.

Forage requirement. Requirements are estimated from the results of the farm sub-model. This is achieved by comparing the feed requirement of the cattle needed to sustain one hectare of the farming system, with the feed available from residues. If in deficit, the forage requirement is computed from the size of the deficit and the recommended crop area, otherwise the feed balance is set to zero.

Optimizing land use. Since crops can only be grown on potentially arable land, two possible situations exist in the model for determining the maximum PSC in an Awraja:

- Where crop requirements exhaust all potentially arable land and limit the possible number of households;

- Where available arable land exceeds the requirements of a population constrained by insufficient non-arable land to provide the necessary livestock forage and fuelwood.

In the first case, the maximum number of households which can be supported is determined in the model by comparing the area of arable land with the minimum farm size required to support a subsistence farm family in the Awraja under consideration. The minimum farm size is the number of hectares required to provide the food grain equivalent needs of a rural family, taking into account the the needs of the local urban population and the AMC quota.

Where non-arable land is insufficient to meet the fuelwood and forage production needs of the population which could otherwise be supported from the available arable land, the model reclaims arable land for production of fuelwood and forage and adjusts the land use until all of the land is used and a balance is struck between the competing needs of the system. This maximizes the number of households which can be supported under these conditions.

Presentation of PSC results.

For each of the projected situations in the model, the number of households under each series of population growth assumptions and consumption levels is compared with the supportable number of households according to the model. This is expressed as a positive or negative percentage, depending on whether the particular Awraja is projected to be over or under supporting capacity. A detailed graphic presentation of the results of several simulations is given in Annex 1.

Farm economics. Incomes are expressed as Disposable Income Less Fixed Costs. In view of the number of assumptions involved in the model and general nature of the data base, disposable income is a more appropriate indicator of cash available for consumer goods for rural families. Income from crop sales is assumed to come from:

- sales to AMC
- open market sales
- sales from coffee

All sales of coffee are assumed to be conducted through CMC. Fixed costs are deducted from disposable income to a total of EB 34.00, comprising household poll tax, fees and depreciation of tools. Details of the methods of calculation and interpretation of results are contained in MLUP Technical Report 2.

5.3 ANALYSES UNDERTAKEN

5.3.1 General

The population supporting capacity model was used to simulate a number of future land use scenarios to determine the robustness of the model, particularly in view of the many assumptions made. A number of analyses are presented in MLUP Technical Report 2. Subsequent analyses were conducted using more precise data on the extent of arable and non-arable land, which became available from the GILES geographic information system in the LUPRD after the initial runs of the model had been completed. The trends of the results are generally concordant, and differ only in detail.

5.3.2 The Base Model

The base model represents a reasonable approximation to the existing PSC situation in many parts of the country, with the possible exception of the assumptions concerning fuelwood consumption and Vertisol use. Dried cattle dung and crop residues, such as sorghum roots, are used as substitutes in areas desparately short of fuelwood, accounting for up to 50% of the per capita fuelwood requirement per annum (World Bank 1984). Cultivation of Vertisols is also expanding in areas where arable land is in short supply, but not without severe land management constraints for farmers. Despite the pessimistic picture this model presents, it does provide a means for determining the relative worth of interventions into the land use systems aimed at improving the PSC, by establishing a zero level against which to measure potential gains.

Assumptions. The following assumptions are contained in the base model:

- Arable land defined as in Chapter 3;
- Vertisols not available for cultivation;
- Nutritional requirements of the human population 162.6 kg of grain equivalent per annum;
- Nutritional requirements of livestock, a total of 2280 kg of consumable dry matter per annum;
- Fuelwood requirements/caput/annum set at 1.3 m^3/caput/annum;
- Tseste affected areas are excluded from arable land.

5.3.3 Reduction of fuelwood demand to 50% current of levels

The influence of fuelwood demand on the PSC in each Awraja was tested independently by holding all other factors constant in the base model and reducing the demand for fuelwood to 0.7 m^3/caput/annum. The standard fuelwood comsumption adopted in the base model is 1.3 m^3/caput/annum. This scenario most closely resembles the actual situation in Awrajas with a serious shortage of fuelwood. The burning of dried cattle dung and selected crop residues have been estimated to supplement the fuelwood requirements of families in such circumstances by up to 50% (AACM 1987). All assumptions regarding arable and non-arable land remain as defined in the base model.

5.3.4 An increase in forage production of 50%

The base model was again altered with respect to one parameter, the amount of forage available for livestock. The objective was to determine if an increase in forage production, without prejudice to other levels of productivity in the base model, could make a significant difference to the population supporting capacity. All assumptions regarding arable and non-arable land remain as defined in the base model.

5.3.5 Vertisols fully untilized for crop cultivation

Vertisols are the heavy black clay soils widespread in the bottomlands of the Ethiopian highlands and along the Sudan/Ethiopia border. They are quite extensive, occupying as much as 8% of the land area of the country. Vertisols are mainly used for forage production at present, because they are difficult manage. Poor drainage and high draught requirements are the main problems. However, the high proportion of Vertisols in growing period zones suitable for cropping increases their relative worth as potentially arable land.

5.3.6 Tsetse control

The presence of Tsetse (Glossina sp) in many areas of western Ethiopia has provided a natural barrier for the westward expansion of cultivation for centuries. Tseste flies are vectors for trypanosomiasis, a disease which is fatal or debilitating to cattle, the essence of draught power for cultivation in the highlands of the country. The species of flies known to carry human sleeping sickness have also been identified in Ethiopia, as has the disease itself (Schaller & Kuls 1972). However, livestock trypanosomiasis is far more widespread and is serious in Gomo Gofa, Gojam, Ilubabor, Kefa, Sidamo and Welega Regions. It is generally confined to altitudes below 1800 metres. These Regions all have substantial land area below 1800 metres with the associated high humidity necessary for survival of the Tsetse flies.

In the base model, the areas affected by Tsetse have been eliminated from consideration as arable land, because sustained production of food crops under the current animal-draught systems cannot be guaranteed. In this run of the PSC model Tsetse is assumed to have been controlled.

5.3.7 Yields increased by 50% over current levels

This run of the PSC model demonstrates the influence of the current low yields and the high food demand of the increasing population on the PSC of each Awraja. Yields are assumed to increase by 50% without prejudice to other factors, all other variables in the model assuming the values used in the base model.

5.3.8 Achievable optimum

This run of the PSC model reflects the combined effect of simultaneously introducing all of the improvements treated independently in previous runs of the model and, at the same time, improving human nutrition to recommended levels (FAO 1987c). It reflects what might be realistically achievable over the next 25 years if appropriate development policies can be implemented in the near future. The most difficult of the desired improvements to make, is that of providing an alternative fuel to wood while at the same time achieving biological improvement in the nutrient status of soils.

5.3.9 Other simulations

Several other runs of the PSC model were carried out, including an investigation of the amount of land available for production after first satisfying future food needs. Runs simulating reduced yields due to drought and the impact of improved farming systems are also included. These results are not presented graphically in Annex 1 for reasons of conciseness. However, they are discussed at length in MLUP Technical Report 2.

5.3.10 Disposable incomes

Details of the methods and interpretation of the disposable income analysis are contained in Technical Report 2. The results are summarized further in this report.

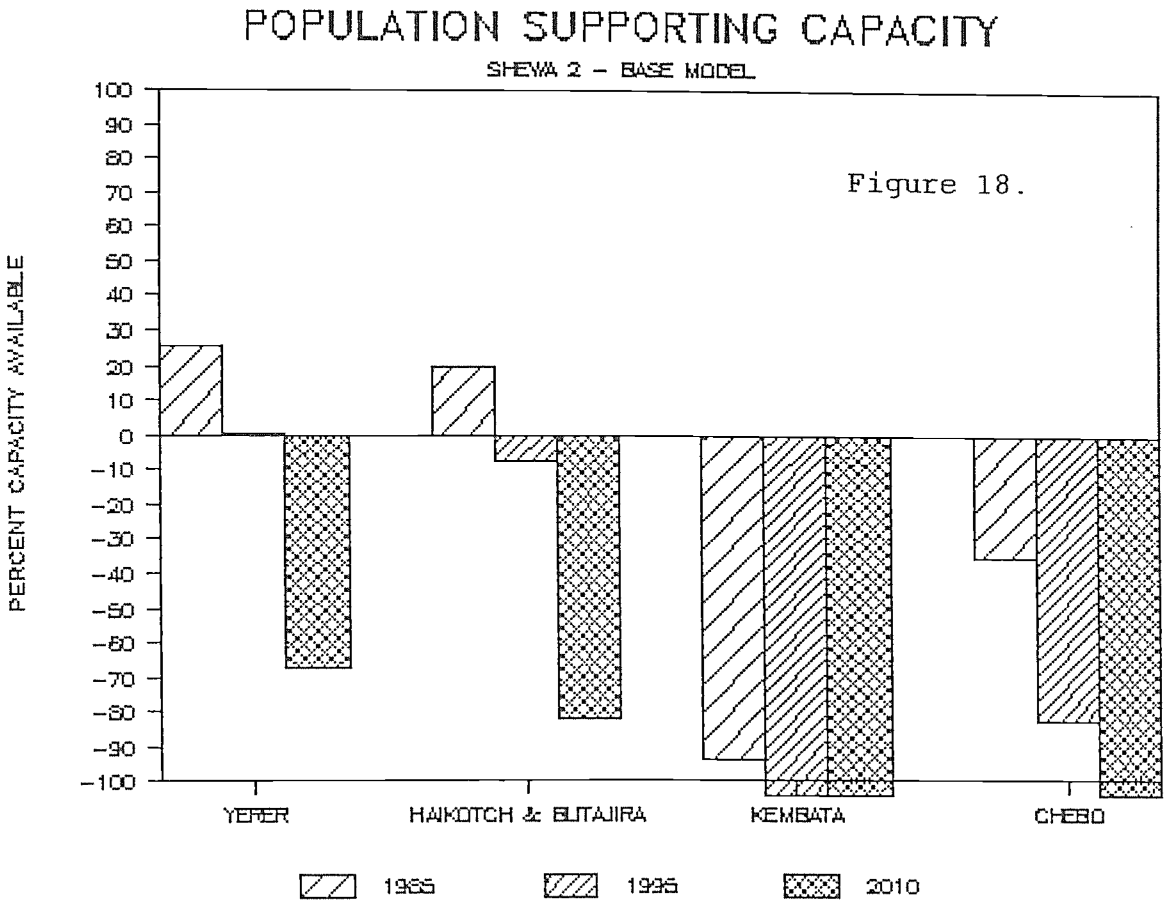
5.4 RESULTS OF THE ANALYSIS

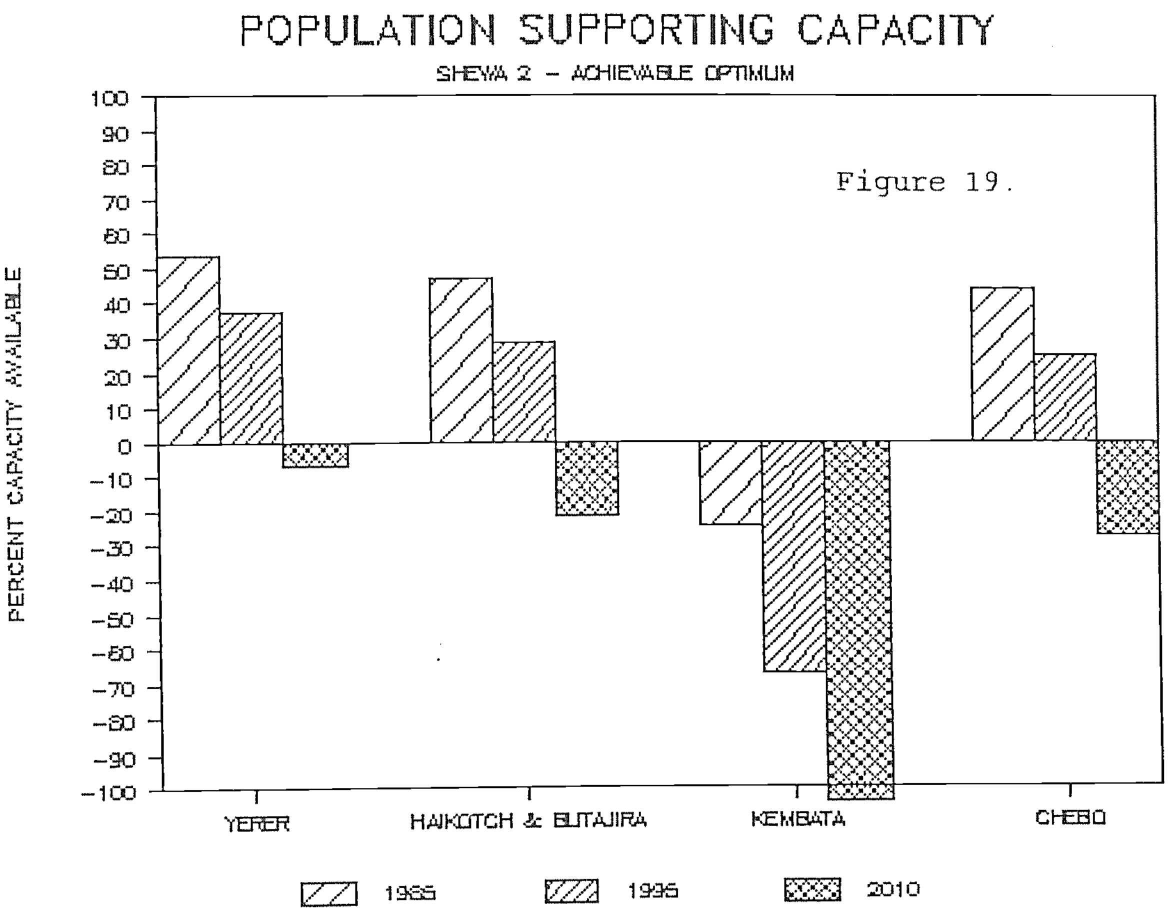
5.4.1 General

In view of the brief time available for development and testing of the models and the reconnaissance nature of the data base on which the various analyses depended, a degree of caution should be maintained when interpreting the results. Considerable scope remains for improvement of the models, but this lies beyond the present terms of reference of the MLUP. Despite these limitations, the wide range of sensitivity tested in the various runs of the model is believed to reasonably reflect the limits of the actual PSC situation in Ethiopia.

Charts indicating the PSC by Awraja are presented in Annex 1 to this report, to provide higher level planners and decision makers with a means for rapidly appraising the sitation. Two examples of the charts are given in Figures 18 and 19. Figure 18 reflects the result of including all limitations on the extent of arable land, ie the base model. Figure 19 reflects the most optimistic run of the model attempted, the achievable optimum. All major constraints were removed and a 50% increase in food and forage production included in this case.

By examining the consecutive charts in Annex 1, each of which reflects the influence of removing or easing one constraint on potential PSC relative to the base model, an indication of the possible benefit of each intervention can be gained. Typical differences are apparent in Figures 18 an 19.


POPULATION SUPPORTING CAPACITY
SHEWA 2 - BASE MODEL
Figure 18.
PERCENT CAPACITY AVAILABLE
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
YERER
HAIKOTCH & BUTAJIRA
KEMBATA
CHEBO
1985
1995
2010


POPULATION SUPPORTING CAPACITY
SHEWA 2 - ACHIEVABLE OPTIMUM
Figure 19.
PERCENT CAPACITY AVAILABLE
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
YERER
HAIKOTCH & BUTAJIRA
KEMBATA
CHEBO
1985
1995
2010

5.4.2. Minimum farm size

The results of the base model analysis suggest a variation of around four times between the most and least productive Awrajas, in terms of grain equivalent produced per hectare of farming system. That is, a minimum area requirement of between 0.8 and 3.2 hectares. Most values lie between 1.0 and 2.2 hectares. Surprisingly, the Awrajas in which enset is important do not appear to be as intensive, in terms of grain equivalent production, as anticipated. The main reason, supported by more detailed LUPRD studies currently underway, is that despite the high productivity of enset relative to common cereals, a considerable proportion of the farming systems in these areas is devoted to grain crops. Another complicating factor may be the reported enset yields in the General Agricultural Survey (MoA 1984), which are only two thirds of values reported by the LUPRD (FAO, 1987b).

Data detailed in MLUP Technical Report 2 indicate that minimum farm sizes need to increase over the next 25 years, as a result of the assumptions that family size of rural households will remain constant at 2.9% and that growth of urban households will increase at 4%. Each rural household therefore, has to provide food to an increasing urban population if self sufficiency in food production is intended by 2010. This can only be done by increasing the cropped area and/or increasing yields.

5.4.3 Population supporting capacity analysis

This indicates a disturbing trend throughout the heavily populated highlands of Ethiopia. Even if population growth can be curtailed to some extent in the future, a number of Regions in the country are clearly approaching, or have already entered, a crisis with respect to PSC. Welo, Tigray and Eritrea, for example, have more Awrajas presently over capacity, according to the model, than under capacity. This appears to be the case regardless of the influence of possible interventions proposed in the various runs of the PSC model.

The next 10 to 25 years appear to be the most critical, with many previously considered surplus producing areas predicted to exceed their population supporting capacity between 1985 and 2010. Figure 20 shows the trend in the number of Awrajas, according to the base model estimates, in each of five PSC classes . The five classes shown in Figure 20 are explained in Table 4. Figure 21 shows the distribution of the same classes by 2010, according to each of several strategies to improve the PSC. This diagram suggests that unless a concerted effort is made to bring about improvements in the yields of crop and forage, tsetse control, and reduction of fuelwood requirements, the PSC will continue to decrease to critical levels. By comparing the relative numbers of Awrajas predicted to be in particular classes by 2010, it becomes clear that isolated improvements through intervention in any one sector has little effect. The improvements gained on a national scale from combining the possible interventions is substantially greater

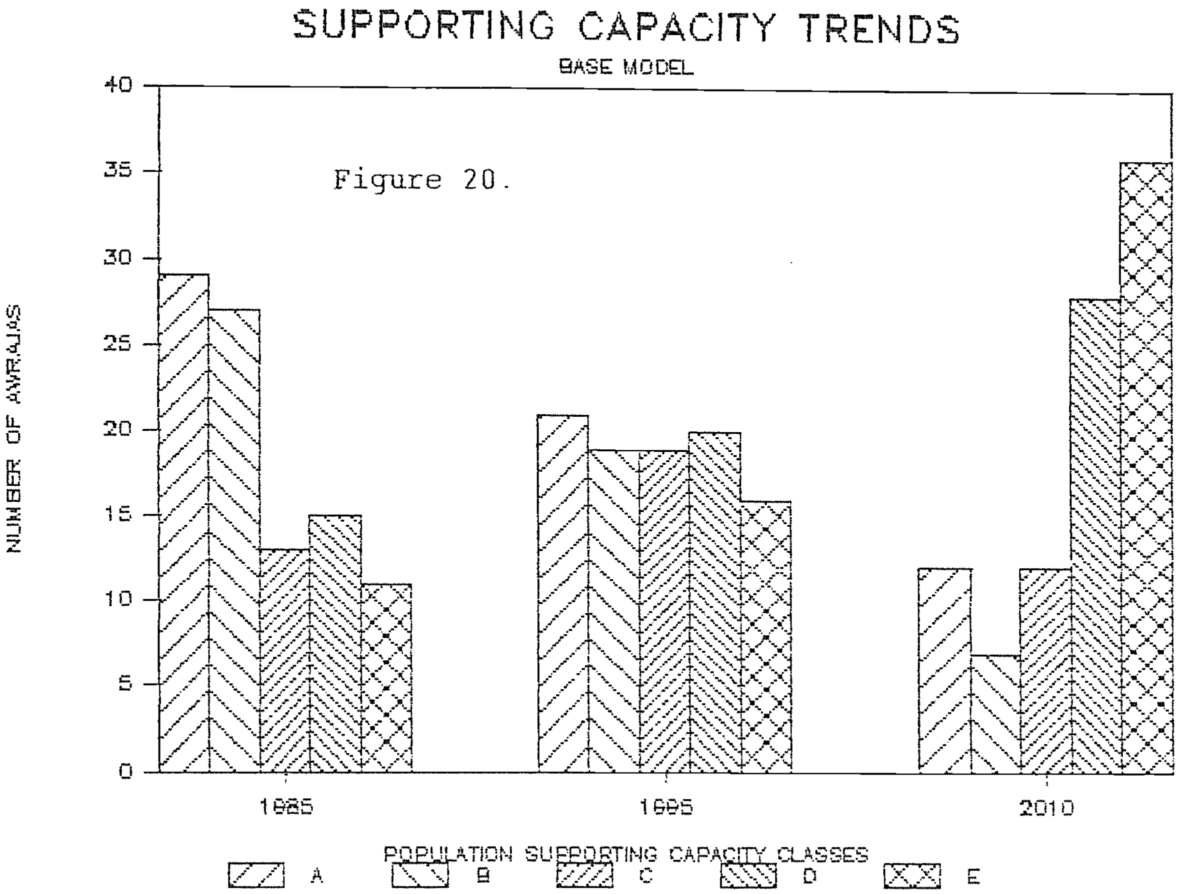


Figure 20.

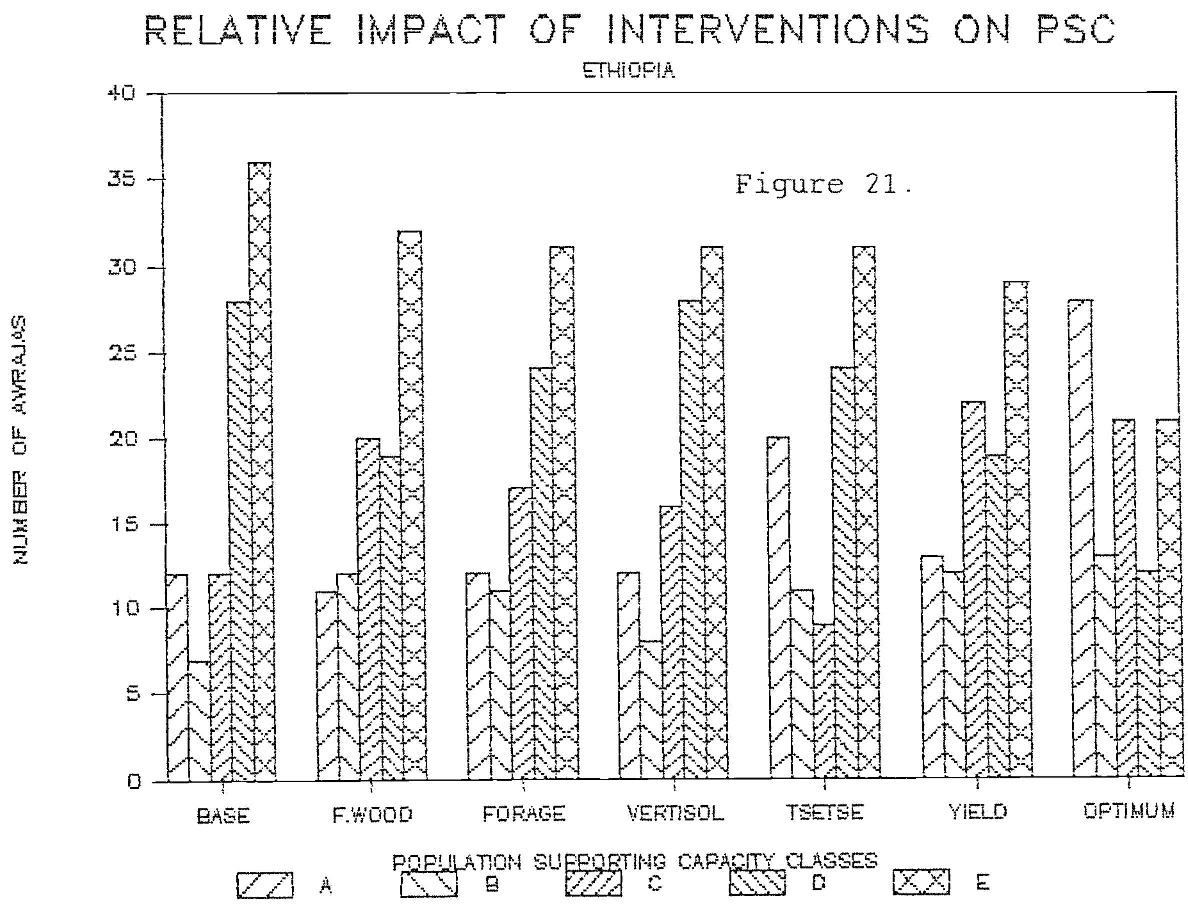


Figure 21.

TABLE 4.

POPULATION SUPPORTING CAPACITY CLASSES

PSC Class	Percent of supporting capacity remaining	Remarks
A	+50 to +100%	Under capacity
B	+20 to +50%	Acceptable
C	+20 to -20%	Marginal
D	-20 to -100%	Over capacity
E	< -100%	Critical

than for the individual factors. Of the individual factors, the control of tsetse appears to have the most influence on improving the PSC.

The influence of the various interventions can, of course, be interpreted in an entirely different manner. Increasing production is akin to reducing demand, and it is this side of the equation which has so often been neglected by planners in the past. Population is the <u>key</u> to demand. A policy aimed at reducing the population levels assumed in the PSC predictions would have the same effect as simultaneously reducing demand for fuelwood, food production and livestock for tillage, thereby substantially increasing PSC.

5.4.4 Limitations on the interpretation of the PSC results

Additional caution should be exercised in interpreting the results of the PSC analysis, because of the variable environmental characteristics of some Awrajas. Where substantial areas of non-arable lowlands are included in an Awraja, this may influence the apparent supporting capacity estimation as pastoralists may have been included in the estimates of total population. This tends to inflate the projected food demand beyond the requirement from grains, as pastoralists live to a large extent on livestock products. Without a more detailed sampling frame, ie Woreda level analysis, it is not possible to remove this limitation. This level of detail lies beyond the mandate of the MLUP.

Additionally, in Awrajas such as Dire Dawa, many families have been recorded in the census as rural households, when in fact they have trading activities outside the agricultural sector. Incomes are therefore likely to be substantially greater than reflected in the simple analysis of grain and coffee sales. This fact applies to a number of Awrajas in Harerge, where trade in chat keeps disposable incomes at much higher levels than reflected in the output from the base model. Income from trading and from livestock were not possible to estimate from the available statistics on an Awraja level, which leaves the possibility that disposable incomes may be substantially greater than estimated in areas where dependence on grain and coffee sales are less than average. Income from labour, for example for coffee harvesting, may also alter rural incomes significantly. Again this was not possible to estimate at the Awraja level from the data base available for the MLUP. This may help to explain why highly populated areas in Shewa, such as Kembata and Hadiya, are able to survive when they appear to have already passed their supporting capacity from subsistence farming. Areas in southern Shewa also produce enset, roots and tubers. The per hectare production figures of these crops used in the model may underestimate PSC. It is possible yields are up to 30% more than estimated, but this would still not offset the food demand projected for these Awrajas by 2010.

Although rural incomes from sources other than grains and coffee may be considerably higher in some Awrajas than could be estimated during the current planning activity, the present and projected dependence of these Awrajas on food purchases can be seen from the PSC results. Unless these sources of income can be guaranteed, vulnerability to food shortages will be considerable.

5.4.5 Critical areas

By examining the results of the PSC analysis for each of the scenarios presented (including those in MLUP Technical Report 2), it is possible to judge which Awrajas (or Regions) appear to be facing difficulties which render them vulnerable to food shortages in the next 25 years, or limited purchasing power to obtain food.

For Gojam, Shewa and Arsi Regions, which together currently provide 85% of AMC purchases, the population growth by 2010 will increase food demand to such an extent that food now available as surplus will be required for home consumption. If per hectare production does not increase markedly, either the PSC will fall, nutrition levels decrease to unacceptable levels, or AMC will have to tap additional sources of supply to meet urban demand.

Southern Shewa and northern Sidamo may be particularly critical if incomes and production are not increased. In particular, the Awrajas of Kembata and Hadiya, Chebo and Guragie and Welayita appear critical. As indicated previously, incomes from sources other than those assessed may enable these Awrajas to survive as they are, but this is doubtful. Expansion of the area under enset, roots and tubers may further improve the PSC in this zone.

The Regions of Eritrea, Tigray and Welo all appear to have poor prospects for the future, even assuming the optimistic situation presented in the achievable optimum run of the PSC model. There seems little alternative but to redistribute the population if alternative sources of income outside agriculture cannot be generated in the short to medium term.

5.4.6 Prospects for coffee

The results obtained from the FSC model (see MLUP Technical Report 2) indicate that the Awrajas of current importance for coffee are: Gardula, and Geleb and Hamer Bako in Gamo Gofa; Gursum and Gara Muleta in Hareroe; Buno, Gore and Mocha in Ilubabor; Limu, Kulo Konta, Kefa, Maji and Goldiya, and Gimira in Kefa, Arero in Sidamo; Nekemte, Arjo, Gimbi, Kelem, and Asosa in Welega. There is potential for conflicts in land use in these areas, because they are designated as suitable for expansion of cultivation. The comparative advantage of coffee and food crops should be carefully weighed in these areas before more intensive development of either is commenced.

Dolo, Metekel, Wegera and Jem Jema Awrajas are currently minor producers of coffee, but their favourable FSC position suggests that possibilities for increased coffee production should be investigated.

6. POTENTIAL FARMING SYSTEMS

6.1 GENERAL

The population supporting capacity analysis indicates that per capita food production will decline at increasing levels over the next 25 years unless food production and export earnings from agriculture can be significantly increased in the same period. There are two main possibilities for achieving this: to increase productivity of crops and livestock per hectare, and to expand the area used for cultivation and livestock production. Increasing the area under cultivation at current levels of productivity will alone not meet these needs. There is thus a clear need for increased yields of most major crops and forage production in Ethiopia. This raises the obvious question of where this increase is to come from.

Since 95% of the food production in the country originates from individual peasant farms, this would seem the obvious place, where modest but effective improvements would bring the greatest overall benefit in terms of total production. A number of alternative strategies designed to achieve such improvements are discussed below.

6.2 FERTILIZERS VERSUS ROTATIONS

6.2.1 The present situation

Yields have stagnated under the low input levels of peasant agriculture and must be improved if Ethiopia is to come near to self-sufficiency in food production over the next 25 years. This implies the use of improved technologies such as fertilizers and generally more intensive agriculture. Fertilizers do increase yields, but to obtain the full benefit farmers must use recommended amounts and improve crop husbandry, including more intensive weeding and improved seeds. The fertilizer price relative to grain prices has an important influence on the willingness of farmers to apply fertilizers, even when available. The timeliness of supply and the efficiency of the distribution network also influence attitudes to fertilizer use.

The fertilizers farmers use are imported, which implies considerable cost in foreign exchange to the economy. The lack so far of significant quantities of raw materials suitable for the manufacture of fertilizers makes dependence on imports effectively total. Handling and transportation costs in Ethiopia, with its limited infrastructure, are also considerable. Prices to the farmers reflect the costs at the official exchange rate of EB 2.07 = US$ 1.00, plus the average marketing prices which include transport and handling charges. There are some 100 marketing centres where fertilizers are delivered to Service Cooperatives (SCs) upon request, but requests must be approved by the MoA and ONCCP. All fertilizers are imported and marketed through AISCO.

Fertilizer prices in 1987 are shown in Table B4 of MLUP Technical Report 2. The fertilizer/price ratio for tef and maize, together with statistics on the total fertilizer used, are shown in Figure 22, based on World Bank (1987b) figures. It is apparent from the graph, that when the cost of fertilizer is high relative to the grain Price Ratio, the amount of fertilizer used declines sharply.

6.2.2 Improved technologies for peasant farmers

In view of the current difficulties related to widespread fertilizer use in the peasant sector, a series of alternative technology levels is set out below which could both improve production and nutrition at the same time. The improvements are based on modest applications of fertilizer coupled with cereal, legume, pulse rotations which provide 50% yield increases and a ratio of calories to protein of 3:1. The present national ratio is 6:1.

Present technology (Type I), practised by the vast majority of peasants, is defined for comparison to include:

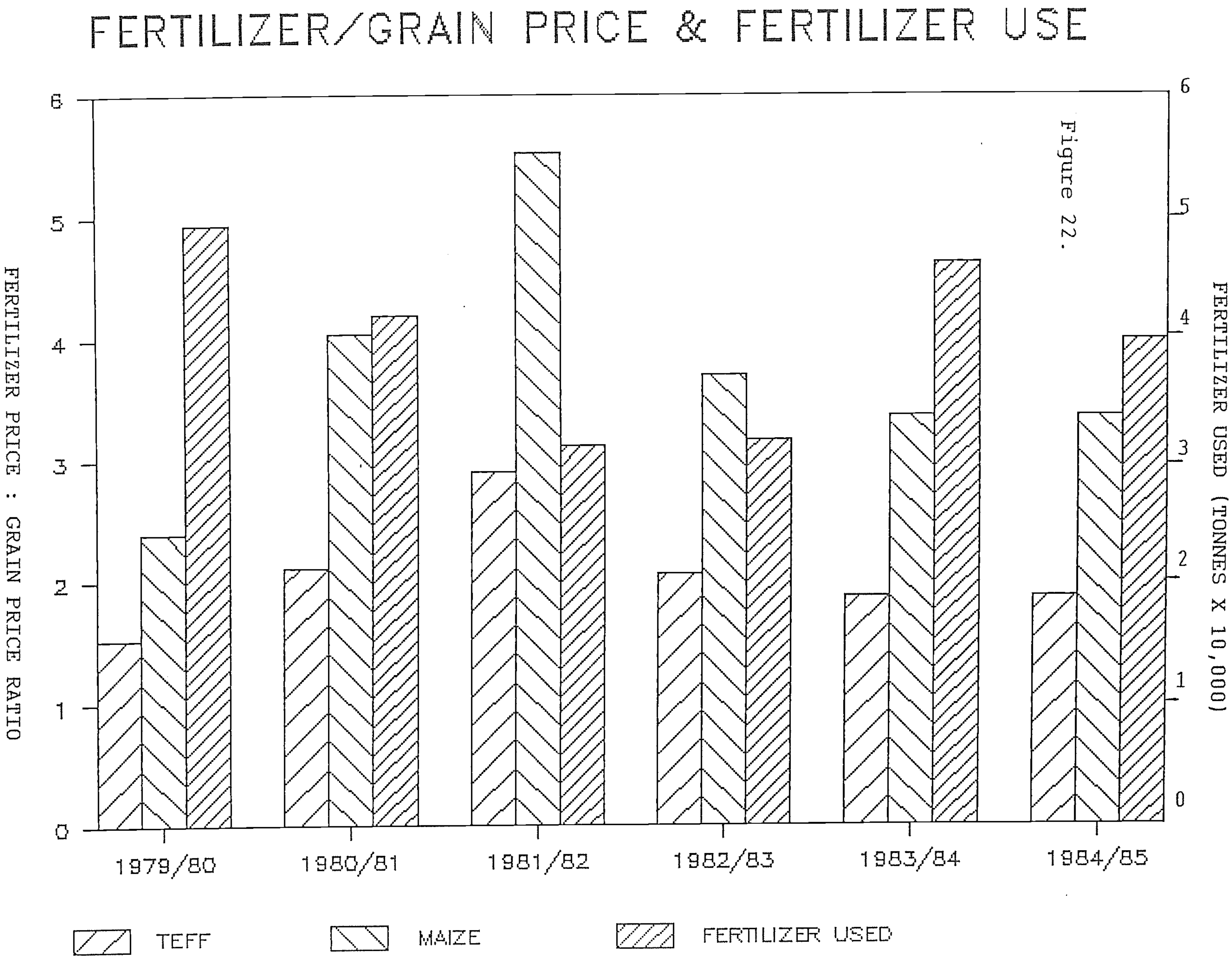
- local unimproved varieties of crops;
- no fertilizer use;
- no pesticides or weedicides;
- current agronomic practices;
- draught animals and/or hoeing;
- stagnating yields caused by shortening fallows, lack of green manure, decreasing amounts of dung for fertilizer, loss of organic matter and land degradation through erosion.

Improved technology (Type II) suggested for adoption by the majority of individual peasants by 2010 is characterized by the following:

- local or improved varieties, whichever is demonstrated to be the most effective;
- limited amounts of fertilizer (25-100 kg DAP and 50Kg Urea to increase yields up to 50%)

  <u>or</u>

  a rotation of cereals and pulses in a ratio of 3:1, in combination with undersowing cereals with a leguminous green manure, increasing cereal yields up to 100% over a 10 year period;
- no pesticides
- improved agronomic practices, with emphasis on row planting and better weeding;
- draught animals and/or hoeing;
- improved conservation, but must be practical and not too costly;
- current cropping patterns, except in the case of the cereal/pulse/legume rotations.


FERTILIZER/GRAIN PRICE & FERTILIZER USE
Figure 22.
FERTILIZER PRICE : GRAIN PRICE RATIO
FERTILIZER USED (TONNES X 10,000)
0
1
2
3
4
5
6
1979/80
1980/81
1981/82
1982/83
1983/84
1984/85
TEFF
MAIZE
FERTILIZER USED

The third technology type recommended (Type III) is for possible adoption by producer cooperatives. It is characterized by:

- inputs similar to those of Type II, but if economic, mechanized land preparation. The main benefits of mechanization are not in higher yields, except where soil preparation needs to be achieved in a short time to achieve sowing/planting at the correct time in an intensified system of production. Mechanization could reduce pressure on livestock numbers and release land for other purposes (eg for fuelwood or crops) and reduce land degradation due to livestock pressure;

- crops and cropping patterns as defined under Type II;
- pesticides if required;
- adequate conservation.

A fourth alternative is suggested for state farms in Technical Report 2 but, since this simply places more emphasis on mechanization, fertilizers and pesticides, it is not discussed further here.

6.2.3 Input-output analysis for improved technologies using fertilizer as recommended

The question of whether fertilizers provide a satisfactory incremental benefit for farmers hinges on the relationship between fertilizer cost, yield improvement and market prices. The results of the input-output analysis for a number of economically important crops indicate that this is not the case at present.

Since fertilizers must be bought, farmers are required to sell a higher proportion of their harvest to meet the increased costs of production. Input-output calculations in MLUP Technical Report 2 reveal that the percentage of production sold should rise from the current 20% to between 30% and 40% at current fertilizer and AMC grain prices to meet costs and achieve a small improvement in domestic grain availability. The benefits of fertilizer use are thus scarce and the risks considerable, considering the variability of factors such as rainfall or pest attack.

The incremental benefits and costs of the suggested technologies were tested against the current situation by setting imaginary prices for grains which are above AMC prices, but below open market prices. Farmgate prices are well above AMC prices in most cases in most years because of the artificially small markets caused by a forced quota, relatively low price and restriction on private trade between Regions. The imaginary prices are more or less in line with proposals for AMC price increases made by the Food Strategy Taskforce (July 1987). The detailed results of these input-output calculations for the main cereals in Ethiopia are contained in Tables B9 to B21 in MLUP Technical Report 2. A summary of the results is contained in Table B8.

It should be noted that price increases alone will not necessarily result in increased inputs and, therefore, increased production. Much more is necessary, including adequate and timely delivery of seeds and fertilizers to accessible market places, adequate extension services, adequate research, improved marketing, transport and infrastructure, and, where required, credit schemes.

6.2.4 Results of Type II technology using fertilizers

Results indicate that barley, wheat, tef, maize, and horsebean would be economic under the Type II technology proposed using fertilizer. This is not the case for oats and millet, while sorghum is marginal. Except for oats and millet, the gross margin per hectare increases with increased fertilizer use, as well as the gross margin per labour day. The amount of grain available for home consumption also increases, but a higher proportion of yield, as suggested earlier, has to be sold.

There are a number of consequences of increased grain sales, including the need for an effective demand for these grains. The creation of an effective demand can only be accomplished if sufficient remunerative employment can be created outside agriculture. Increased net disposable incomes in the hands of farmers may also cause a significant increase in livestock numbers, as this is a traditional 'banking system' that rural peasants use. Other consumer goods need to be available therefore to stimulate the economy if disposable incomes should rise significantly. This dictates the need for development of the marketing system and rural infrastructure.

Foreign exchange implications

Estimates contained in MLUP Technical Report 2 indicate that to meet the food demand in 2010, the harvested area under the present low yielding technology (Type I) would need to increase by some 2 to 3.5 times. Assuming that such an extent of arable land is available, and that yields in 2010 are 50% higher under Type II technology, there would still be a need for an area expansion of some 1.3 to 2.3 times the present area under cultivation. This presupposes about 50kg of DAP and 50 kg of Urea per ha of all land. This would require between 700,000 MT and 1,300,000 MT of fertilizers, a 7 to 13 fold increase in fertilizer imports. This implies between US$ 128 million and 226 million at present prices. And all of this to provide food for domestic consumption. Added to these costs are the demands on transportation and infrastructure, which are tremendous. This makes the whole question of fertilizers at such levels of input questionable.

6.2.5 Cereal/legume/pulse rotations as an alternative to higher levels of fertilizer use

A considerable amount of detail on the agronomic benefits of such rotations is contained in MLUP Technical Reports 3 and 4. Taken over 25 years, it appears that a two-year wheat/one-year horsebean rotation, with the wheat undersown with the legume Trifolium, would be at an economic advantage over the use of fertilizers alone. Through an assumed build up of organic matter in the soil, wheat yields could be expected to increase from 1.0 to 1.5 MT in the first years, to 3.0 MT over 13 years, after which they would remain stationary. Nutrient supply for the cereal would come from horsebean N-fixation of 18 kg per year and from the Trifolium N-fixation of 20 kg per year, and the application of 50 kg DAP per year to wheat and 30 kg per year to horsebeans.

The internal rate of return for the system would be of the order of 25 to 30%. The fertilizer use of such a system is about 40% of that for continuous planting of wheat. Additional benefits come from the increased feed supply for the livestock necessary to meet the draught requirements of the farming system. In later years, some 3.7 MT of dry matter per year (2 years wheat, Trifolium, one year horsebeans) could be anticipated, compared with 2.3 MT dry matter from continuous wheat planting. The needs for improved technology of this kind are discussed further, later in the report.

6.3 GENERAL AGRONOMIC CONSIDERATIONS AND POTENTIAL CROPPING SYSTEMS

6.3.1 General

The low overall levels of crop husbandry in Ethiopia, even discounting production limitations of local crops and varieties, tends to hold production down to a minimum. Broadcast seeding, insufficient weeding and minimal levels of other inputs such as fertilizer, pesticides and herbicides are all partly responsible. While many of these limitations are controlled by economic considerations, as indicated in the previous section of the report, there is still room for considerable improvement in crop yields with economically viable alternatives, such as locally manufactured weedicides. Perhaps an even more pressing requirement is for the intensification of agriculture. In the more secure production zones of the country, for example, substantial increases in the productivity could be achieved by making more effective use of the available moisture. These agronomic considerations are discussed below, together with details of potential farming systems.

6.3.2 The case for herbicides

Weeds cause production losses because small farmers do not have cultivating implements capable of creating a sufficiently clean seed bed. Crops such as tef face severe weed competition without sufficient land preparation, requiring an average of 6 cultivations to prepare an adequate seed bed with traditional implements. Fallow fields in a low intensity agricultural system are also sources of weed reinfection.

Weeding is a labour intensive activity for small farmers with considerably more weeding necessary than is usually available or the farmers are willing to apply. Small grains are more severely effected than the large grains such as maize, because effective weeding is near impossible. Broadcast methods of seeding exacerbate the situation, but farmers currently have neither the implements or the experience for sowing in rows.

The only way in which to prepare an adequate seed bed in the absence of appropriate cultivating and sowing implements is to use herbicides. ADD (1988) have suggested that knock down herbicides applied 1 to 3 weeks before first ploughing, would significantly reduce the number of ploughings necessary for most crops. Pre-emergence herbicides applied just after sowing would further reduce weed competition. However, soils must be left undisturbed after the application of pre-emergence herbicides to maintain the herbicide film.

Yield improvements

ADD (1988) reports that yields of local and improved maize cultivars at various sites in Ethiopia are between 20 and 45 quintals per hectare, applying a package inputs which included intensive weeding. Improved varieties offered only a 20% advantage over local cultivars and most of the reported yield difference (3 to 4 times) is attributed to the improved husbandry, especially weed control.

Cost of herbicides

Costs per hectare of some suitable herbicides are:

Roundup (1l+1l 24D) (Two applications of 1/2 l)	EB 68.00
Pre-emergence types for wheat and barley	EB 30.00
Triazines for maize and Sorghum	EB 16-22.00
24D/MCPA (follow up)	EB 8.00

The cost of knapsack sprays must be added to the cost of herbicides.

Potential for local production of herbicides

There is a case for local production of many herbicides as they are not particularly complex to manufacture and the patents have expired some time ago. This would greatly alleviate the cost and encourage more widespread use of the technology.

The potential advantage

There are a number of implications to the use of herbicides beyond simply increased yields. For example, if the number of ploughings can be reduced for many crops, especially tef, the soil degradation problem associated with leaving the soil without vegetative cover during the most intensive rainfall period prior to planting, could be reduced considerably. Secondly, the requirement for draught power is always critical during the few weeks prior to planting. Reducing the need for ploughing could greatly ease the burden on farmers with limited livestock resources, who normally have to wait until neighbours have completed their ploughing before oxen can be borrowed or hired. This results in late planting with attendant risks of crop failure in drier than normal years.

The main drawbacks of increased herbicide use include: cost and maintenance of knapsack sprays, cost of herbicides and increased extension and training of farmers.

6.3.3 More effective use of available moisture

There is considerable scope in Ethiopia for more intensive use of the land where moisture availability permits. In zones with two reliable growing periods, examination of relay cropping and double cropping options should be made. In many parts of Ethiopia Belg and Meher seasons are distinctly separate and could support two short season crops on a regular basis. Also, in long growing seasons such as occur in western and southwestern Ethiopia, there is ample time for two crops in a year. The problem is one of having to harvest the first crop during the wet season. A further alternative where harvesting in the wet season may be problematic, or where the Belg season is too short for a cereal or pulse crop, is the incorporation of a leguminous forage crop into the farming system or a crop to be ploughed-in for green manure.

Details of these improvements are contained in MLUP Technical Annex 4, Potential Farming Systems.

6.3.4 Intercropping

Intercropping is successfully practised in many countries and is applied to a limited extent in eastern Ethiopia, in the Hareræge highlands. Intercropping involves the combination of two or more crop types grown at the one time, in the same field. The crops usually have different maturation cycles and are planted and harvested at different times. In some systems of intercropping, one crop may provide shade or nutrient stimulus for the other. The different crops in the system are normally grown in alternating rows, or on ridges and in furrows.

The crop combinations grown in Ethiopia depend to a large extent on the prevailing environmental conditions in the locality, but the more common include: maize/pepper, sorghum/pepper, papaya/maize/sweet potato, maize/sweet potato. The technique need not be confined to food crops. Forage crops are also useful components of an intercropping system in many parts of the world. Forage legumes have the advantage that they fix nitrogen and stimulate the production of other crops grown in combination with them. There is enormous <u>potential</u> in Ethiopia for intensifying crop production through intercropping, especially in view of the limited use which is made of available moisture in many parts of the country.

6.3.5 Relay cropping

Relay cropping is a refinement of intercropping. Crops are planted in relays as the term suggests, in the same field. One is planted early in the growing season and the other much later, when the first is near maturity. The technique makes very effective use of available moisture, but these conditions should be predictable, as relay cropping requires careful timing of operations and a good appreciation of environmental conditions for total success. Timing is particularly important with respect to excess moisture during the harvest of the first crop or drought periods prior to the harvest of the second. Typical crop combinations could include a forage legume planted early, followed by tef or barley, or barley followed by chickpea.

6.3.6 Undersowing

Undersowing most commonly involves the use of permanent pasture species in the last cropping cycle before land is fallowed. It involves the sowing of pasture and crop, or two crop species, simultaneously or shortly after one another, with the intention that one of the two will follow on to maturity after the first has been harvested. Typical examples of species grown in relay systems include Trifoliums sown with cereals, and Stylosanthes species with maize and sorghum.

6.3.7 Minimum tillage

Where erosion losses are acute, minimum tillage has been successful in a number of countries in reducing this problem. Another important advantage of minimum tillage is conservation of soil moisture. The technique is based on the use of herbicides to control weeds, but locally produced scrapers have been suggested as an alternative. The technique was suggested as an alternative system by the EHRS, but no research has been attempted to date to see if it could be successfully applied in Ethiopia.

6.3.8 Alley cropping

Alley cropping is both a form of intensification of agriculture and a conservation technique. Leguminous trees, such as Leuceana sp. and Sesbania sp, are grown on conservation bunds and terraces to help reinforce these structures, while at the same time providing nitrogen fixation, limited fuelwood, and forage for livestock. The trees are extremely vigorous and can be cut regularly for livestock feed. The leaves are high in protein and an excellent form of nutrition for livestock.

Crops are grown in the alleys between the trees. Stabilizing the bunds can also be achieved using grasses or other types of vegetation. Grasses carelessly managed can invade croplands, so greater care is required in their management. The FLDP has had considerable success in recent field trials using forage grasses to stabilize bunds. ILCA has also demonstrated the advantages of Alley cropping over a number of years at its research sites in Ethiopia.

6.4 CROP SUITABILITY ASSESSMENT

6.4.1 General

The Phase-I Assistance to Land Use Planning project produced a land suitability assessment of a number of crops in Ethiopia, based on resource data available at the time the first project phase was completed. Subsequent studies on moisture availability, including the Agroecological Zones study of Ethiopia (see MLUP Technical Report 5), take account of probability factors, which were unavailable in Phase-I.

A computer assessment of land suitability which used this later, more reliable information, was carried out as part of the Agronomy Consultant's inputs to the MLUP. Details can be found in MLUP Technical Report 4, Potential Farming Systems. A summary of the methods is set out below.

6.4.2 Crops and crop groups considered for evaluation

Following in the theme of an improved population supporting capacity throughout the country, crops considered for the evaluation were grouped according to both their environmental requirements and their nutritive value. For example, each group defined contains crops which provide carbohydrates (cereals, roots and tubers), protein (pulses), or fats (oilseeds). In this manner, farming systems can be built up from the groups which provide the basic nutritional requirements of rural families. Cash crops and perennials, such as coffee and enset, were considered as single crops for matching with available land resources. Table 5 contains a list of the crops which go to make up the 9 main groups.

Perennial and cash crops treated separately include: grape, citrus, sisal, coffee, sugarcane, cassava, banana, pineapple, enset, pyrethrum, tobacco, kenaf and rice. Altogether, 46 crops were examined for suitability.

6.4.3 Methods of suitability assessment

Methodology follows closely along the lines used in the Phase-I project with two important differences. First, the environmental parameters include DGP and traditional altitude zones, both

TABLE 5

MAIN CROP GROUPS USED IN THE LAND SUITABILITY ASSESSMENT

Group	Crop members
1	Barley, oats, wheat, horsebean, fieldpea, linseed, rapeseed and white potato
2	Barley, wheat, oats, haricot bean, soybean, sunflower, safflower and white potato
3	Tef, chickpea, lentil, vetch, safflower, linseed, noug, sunflower and white potato
4	Barley, wheat, oats, chickpea, lentil, vetch, safflower, linseed and noug
5	Sorghum, maize, haricot bean, soybean, lima bean, sunflower, sweet potato, and taro
6	Maize, sorghum, tef, soybean, haricot bean, sweet potato and sunflower
7	Pearl millet, haricot bean, lima bean, soybean, sweet potato and sesame
8	Finger millet, sweet potato, sesame, groundnut and cowpea
9	Tomato, shallot, cabbage and pepper

described earlier in the report. This enabled estimation of the suitability of a crop group or individual crop to a particular locatity on the basis of sustainable cropping 8 years in 10. The suitability of crops in relation to traditional agroecolcgical zones, which broadly equate to temperature regimes, is set out in Table 6.

The second important difference is that the crop groups matched against the characteristics of the land contained in the land inventory were selected for their potential as components of farming systems, designed to improve nutrition. The land inventory used to assess crop suitability is that used for the Phase-I study, but input into a computer for more rapid reapraisal of land suitability.

Different traditional zones may support similar crop groups, but the lower temperatures at higher altitudes require increased lengths of growing period for crops to reach maturity. This requirement was built into the suitability assessment, together with details of how intensification of different available growing periods might be achieved. An example of crop group suitability in the Kola zone, for different lengths of GP, is shown in Figure 23. All possible combinations of GP, altitude/temperature zone and crop suitability are provided in MLUP Technical Report 4.

The results of the matching of land characteristics with crop groups and crops is presented in MLUP Technical Report 4. Maps which show the locations in the country suitable for each group or crop are attached to this report.

6.5 IMPROVEMENT OF FORAGE SUPPLIES

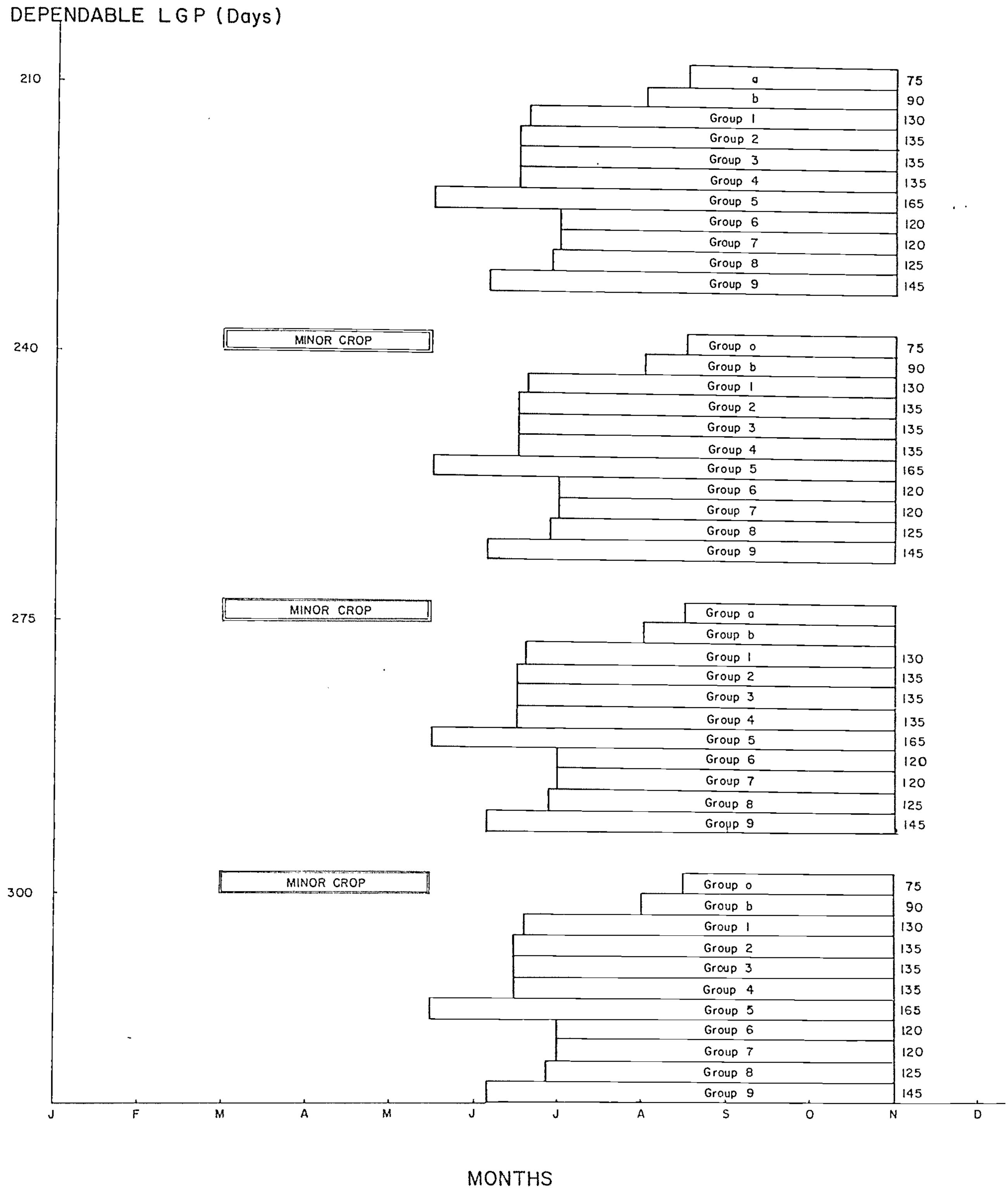
6.5.1 General

In the mixed farming systems common to Ethiopia it is imperative that considerable interaction between livestock and crop production should exist for the benefit of overall farm productivity. Livestock, by providing draught power, transport, manure and cash play a vital role in the development of crop production. Improvements to livestock should therefore spinoff to the system as a whole. Animal nutrition and animal health are two significant areas where potential exists to improve overall farming systems significantly.

The present overgrazed and mismanaged range and pasture resources in much of the country would benefit from a move toward more intensive systems which integrate aspects of crop and livestock production. Any attempt to improve communal grazing lands will be difficult because of utilization and management constraints, and forage development is therefore most likely to be successful if concentrated on individual holdings. Multi-purpose systems, such as alley cropping, meet these objectives. Alley cropping offers opportunities for simultaneous erosion control, soil fertility improvement, fuel supplementation, and livestock feed production. Interaction between highlands and lowlands, where the latter has surplus capacity to produce a stock of draught animals, should also be encouraged to reduce pressure on highland pastures.

Improvements in animal nutrition should not be viewed in isolation, but should be accompanied by animal health measures to improve productivity.

Figure 23.



PROPOSED CROPPING CALENDARS FOR DIFFERENT LENGTHS OF GROWING PERIOD (LGP) IN THE KOLA ZONE.

TABLE 6.

SUITABILITY OF CROPS IN RELATION TO TRADITIONAL AGROECOLOGICAL ZONES

AEZ	Crop group	Single crop	Perennial crop
Kola	1,2,3, 4,5,6 7,8,9	Pearl millet, finger millet, haricot bean, sorghum, maize tef, soybean, sesame, rice, kenaf, cotton, tobacco and	Grape, citrus, sisal, coffee, sugarcane, cassava, banana and pineapple
Weina Dega	1,2,3, 4,5,6 7,9	Tef, soybean, haricot bean, lentil, vetch, fieldpea, chickpea, kenaf, rice and tobacco	Grape, coffee, sisal sugarcane, tea, pineapple and enset
Dega	1,2,3, 4,5,6, 8,9	Tef, soybean, haricot bean, lentil, vetch, fieldpea, chickpea and kenaf	Coffee, tea, pyrethrum and enset
Upper Dega	1	None	Enset and pyrethrum
Wurch	None	Horsebean and barley	None

6.5.2 Strategies for forage development

Several low cost alternatives for forage production which are aimed at integrating good land husbandry with increased forage production are listed below. Most of the strategies suggested are currently being field tested by the Fourth Livestock Development Project in the MoA. They are generally applicable to altitudes below 2400 m.

The alternatives include:

- Forage strips (bunds, alleys etc);
- Exclusion area improvement
- Backyard forage;
- Undersown legumes;
- Oversown legumes;
- Conventional pastures;

- Fodder crops;
- Grazing management;
- Reduced livestock numbers.

The alternatives, with the exception of the last, are more or less ranked in order of economic potential, technical feasibility and farmer acceptance. Details on the character and applicability of these strategies to different environments in Ethiopia are discussed at length in MLUP Technical Report 3.

7. SUMMARY OF CONSTRAINTS AND POTENTIALS FOR AGRICULTURE

7.1 GENERAL

This chapter outlines the main constraints limiting agricultural development in Ethiopia, the main potentials to be realized, and suggestions on policies which could assist development.

Before proceeding in detail, it is worthwhile recapping on the information presented in earlier chapters of the report to reaffirm the nature of the global development problems facing Ethiopia over the next 25 years.

7.1.1 Population

The first and foremost constraint faced by Ethiopia is population growth. It lies at the base of most development problems now facing the country. People require food to sustain them and this dictates that adequate amounts must come from domestic agriculture, or from imports. This will require substantial increases in production of all agricultural commodities, but Ethiopia's present limited capacity to generate foreign exchange (mainly through coffee exports) dictates that subsistence agriculture will underpin food production over the next 25 years.

7.1.2 The extent of potentially arable land.

The demand for food by 2010 will require on the order of 2.0 to 3.5 times the present production, depending on nutrition levels (see Chapter 2), to ensure self sufficiency. At present yield levels, this would mean 2.5 to 5 times the current area under crop in a year. Given the area requirements of cash crops, fallow and livestock production, and the cumulative area lost through degradation (although of limited influence up to 2010), it is unlikely that sufficient arable land would be available in the country to meet these needs at present yield levels. Per hectare yields must therefore increase globally to meet the future food requirements.

7.2 MAIN PHYSICAL CONSTRAINTS AND POTENTIALS FOR DEVELOPMENT

7.2.1 General

Physical constraints are generally more clear cut than those related to policies, but may require substantial investment to alleviate. These are discussed below, together with the potentials for development. Two 1:2,000,000 scale maps, one detailing the main physical constraints and the other the development potentials for the possible expansion or improvement of agriculture, are attached to the report for further clarification. The first (map 1) is titled: "Physical Constraints to Agricultural Development"; and the second (map 2): "Land Development Potential".

7.2.2 Moisture availability for crop production

The extent of arable land, as defined by the MLUP, is strongly influenced by the moisture available for crop growth. The 90-day dependable growing period (DGP) required by the definition, means that only 27 % of the country which is otherwise suitable for agriculture can be classed as arable. Marginally arable land is that with a median growing period (MGP) of more than 60 days and DGP of less than 90 days. Below a 60 day growing period it is unlikely that any significant crop production can take place. Some 13% of Ethiopia is marginally arable according to this definition.

<u>The arable zone</u>

Within the arable zone considerable <u>potential</u> exists for better use of available moisture, as indicated in the previous chapter. Above GPs of 210 days, intensification of cereal based systems is possible, together with expansion of perennial crop cultivation. Roots and tubers, such as sweet potato, white potato and enset offer high per hectare production potentials, of between 30 and 300 quintals. Apart from food crops, this zone also offers the greatest potential for the expansion of cash crops such as coffee.

There is further potential for intensification of cereals and other crops in the zone below 210 day GPs, but this is mainly confined to supplementary forage production, green manure crops, or double cropping systems which include a short season pulse.

Techniques and inputs required for realizing the potentials described are included in MLUP Technical Report 4.

<u>Marginally arable land</u>

Moisture is a serious <u>constraint</u> for crop production in this zone, but there is potential for more intensive land use. Some 13% or 15.9 million hectares of Ethiopia are marginally arable from a soil moisture standpoint. To date in Ethiopia, this is ineffectively utilized. Many crops and cultivars exist which can make use of short growing seasons of between 60 and 90 days. In Kenya, for example, there are short season varieties of maize, sorghum, and millet which yield twice that of cereals currently grown in the moist zones of Ethiopia. Pulses which use such short seasons are also available.

<u>Moisture insufficient for rainfed cropping</u>

Some 49% of Ethiopia is non-arable, mostly because of short growing seasons (less than 60 days), which vary greatly in length and starting date from year to year. Most non-arable land is found in the lowlands and populated by pastoralists, whose livestock herds are confined in their range by the availability of drinking water. The spatial distribution of watering points for livestock varies by season and year, according to rainfall patterns in a given year.

During prolonged dry periods, the movement of livestock herds is strictly limited by the lack of water, and range conditions become degraded around watering points. Some pastoralists have dug deep wells in dry stream beds and other likely sources of groundwater to supplement dry season water supplies and extend the range of their herds to more abundant forage. There is considerable potential to extend water availability in the Ogaden and Borena areas of Ethiopia, both through surface water harvesting in the wet season and groundwater development. The Land Development Potential map indicates where some of these opportunities exist.

Additional agricultural potential exists in the lowland zones of Ethiopia for the development of natural gum and incense production. Appropriate tree species are native to the hot lowland environment. Since there is a substantial domestic and international demand for these products, potential exists for further development of the industry in this zone.

Recurrent drought

The problem of recurrent, severe drought in Ethiopia is a constraint that must be incorporated into any assessment of potential, because of the dramatic effect it has on economic development. The causes of famine are many and complex, but there is no doubt that drought plays a major role in tipping the balance toward widespread starvation and suffering. Marginal subsistence agriculture, land degradation, inadequate strategic reserves and storage facilities, limited infrastructure, low incentives for peasant sector production and numerous other factors, increase the susceptibility of the rural population to famine.

The one variable that cannot be controlled in this scenario is the weather, but it can be both monitored and utilized more effectively. The lack of a widespread reporting network, for example, that can provide daily rainfall data to a monitoring centre for analysis, reduces the effectiveness and reliability of drought early warning. Given daily or 10-daily rainfall data collected over many years, agricultural planners could also devise more appropriate farming systems for drought prone areas.

7.2.3 Tsetse infestation

This represents a serious physical constraint to expansion of agriculture in Ethiopia. Some 9.8 million hectares are infested with tsetse, reducing the sustainability of animal-draught based systems of agriculture. These areas are indicated on map 1, Physical Constraints to Agricultural Development. The substantial impact of removing this constraint on the potentially arable land can be seen from the results of the PSC analyses contained in Annex 1.

7.2.4 Malaria infestation

Malaria is largely responsible, together with the presence of tsetse, for the limited cultivation in the western zones of Ethiopia. It has been, and remains, a serious <u>constraint</u> to sustainable development of all regions of Ethiopia where it is prevalent. The extent of serious malaria infestation is shown on map 1, but it is also present to a lesser degree in most areas below 1800 m. The potential gain from the control of malaria is difficult to measure from available statistics, but it will be near impossible to fully realize agricultural potentials in western Ethiopia in the future without a malaria control program.

7.2.5 Vertisols

Vertisols are a mixed blessing. On the one hand they offer high agricultural potential, on the other, intensive management is required to realize their full potential. The need for drainage protection and the high draught requirements are the main <u>constraints</u> to the widespread use of Vertisols for agriculture. However, their gently sloping topography, depth, and inherent fertility make them candidates for expansion and intensification of agriculture, once the limitations are overcome.

The management of Vertisols has been researched by both ILCA and ICRISAT with considerable success. The use of a broadbed and furrow system to improve aeration of the crop root zone offered the most significant gains in productivity in trials conducted in Ethiopia. Vertisols respond most effectively under this management system when fertilizers are applied. Otherwise the advantages are not substantive, although the construction of broadbeds and furrows where seasonal drainage is particularly poor, may provide sufficiently improved drainage to allow a marginal yield when conventional cultivation does not.

A notable feature of Vertisols in the highlands, is that above 2300 meters they are more frost prone than other soils. The reason for this lies in their common occurrence on bottomlands. Cool air from surrounding mountains tends to flow downhill and create frost problems overnight. Farmers have responded in many high altitude zones by increasing the extent of Vertisols sown to oats, which are tolerant of frost and the somewhat poorly drained character of the Vertisols.

The area of Vertisols in the growing period zone having greater than 60 days MGP, is around 7.4 million hectares. Because of their dual character, Vertisols are shown on both maps 1 and 2. First, as constraints to the intensification of agriculture and, in the second instance, as offering <u>potential</u> for development under appropriate management.

7.2.6 Shallow stony soils

Most of the shallow, stony soils in northern Ethiopia are the result of degradation over centuries of cultivation and poor land management. Little can be done to halt the degradation and reverse the process, short of massive land reclammation and migration of a significant proportion of the population. Soils which are less than 25 cm in depth are particularly prone to the effects of drought, even in reasonable rainfall years, because of their poor moisture holding capacity. This is a serious constraint for agricultural development in the areas affected. With lower pressure on the land, however, considerable regeneration of natural vegetation should take place. Hillside closure, together with cropping under intensive land management schemes, offers potential for improved food, livestock and fuelwood production, provided population pressure is reduced. Certain drought resistant perennial crops such as sisal, olive and grape might be successfuly cultivated in many such areas if appropriate research is first carried out. The extent of shallow stony soils has been indicated on both map 1 and map 2.

7.2.7 Soil degradation

The effect of degradation on land productivity has been discussed at length earlier in the report. It appears that serious problems resulting from continued degradation are mostly confined to the shallower soils of northern Ethiopia, where degradation is advanced. For the remainder of the country, loss in productivity due to degradation will become a critical constraint beyond the 25-year time frame of the MLUP. However, it will become serious in the next 50 years and all attempts to arrest it at the earliest possible time should be made now. The extent of seriously degrading land is shown in map 1.

7.2.8 Steep land

Land over 30% slope, in areas where moisture conditions are suitable for crop production, amounts to some 5% or 6.1 million hectares in Ethiopia. Because of high erosion risks under crop production, this land requires very special management. In most countries in the world land of this slope would not be cultivated, but land pressure has rendered it common practise in Ethiopia. Ideally, steep land should be used for forestry, cut and carry forage production or, at most, perennial crop cultivation. Where not cropped, it is presently used for livestock grazing, often resulting in accelerated erosion because of overgrazing and vegetation degradation and soil disturbance due to animal tracking.

If the demand for land necessitates cultivation of steep slopes in the future, then at least 20% of the area will be required for conservation structures, such as bench terraces. Conventional conservation structures can be replaced by an agroforestry system in many instances, with cultivation taking place between tree lines. This renders the area set aside for conservation productive. Closing hillsides to cultivation and grazing and substituting a system of cut and carry fodder for livestock, has also been demonstrated at several locations in Ethiopia and proved both productive and effective in regenerating degraded land.

Much of the land classed as steep by the MLUP is included in that which is already degrading rapidly. Where the estimated soil loss rate is high (FAO, 1983b), it is shown on map 1 under this guise. Where erosion on steep land is not estimated to be excessive, it has not been separated on the map. Steep land was considered potentially arable in the PSC analysis, but 20% of the land area was deducted from the arable total to accommodate the conservation measures necessary to sustain production in the long term. If otherwise classed as arable, however, the 20% was still considered suitable for forestry and livestock production.

7.2.9 Unique ecosystems

The remaining unique ecosystems in Ethiopia of greatest importance are the closed high forests of Bale, Sidamo and the western Regions of Ilubabor, Kefa and Gamo Gofa. These resources have special significance for the national heritage and should be managed and protected at state level before fuelwood demands cause their total destruction. The various national parks in the country are also unique ecosystems for wildlife preservation with potential for the development of domestic and international tourism. The locations of both forest areas and national parks are shown on map 2.

7.2.10 Land suitable for mechanization

Land suitable for mechanization was estimated from the Phase-I soil data base and information on dependable growing period from Technical Report 5. The minimum dependable growing period was set at 60 growing days, to allow for the future possiblity of high input farming in low rainfall zones, comparable to that carried out in dryland environments such as parts of the United States and Australia. Soil requirements included a soil depth of greater than 100 cm, well drained, without serious toxicities and none to slight stoniness. Vertisols may also be considered suitable for mechanization, but under intensive management. They are prone to compaction and require tractors with special capabilities, such as 4-wheel drive. Another necessary management feature for successful mechanized farming on Vertisols is drainage protection.

The total area of Ethiopia where these criteria are met is approximately 12.9 million hectares, or 4.9% of the country. The area of Vertisols is not included in this estimate. Areas were determined by the GILES geographic information system in the LUPRD. A map of those areas with potential for mechanization is included in Annex 4 to the main report.

7.2.10 Irrigation potential

Irrigation is generally considered to fall into three classes in Ethiopia; large-scale (1000 ha and above), medium-scale (200 to 1000 ha) and small-scale (less than 200 ha). In the case of large-scale irrigation, a number of previous studies on the potentials have been compiled in considerable detail. The results of these studies are incorporated into the Land Development

Potential map attached to this report. Identification of alternative large-scale irrigation potential lies beyond the competence of the MLUP.

Perhaps the most important constraints for large-scale irrigation are the extent of suitable land, particularly in terms of topography and soils, as costs rise exponentially where extensive land levelling works are required. Development costs of recently constructed schemes in Ethiopia are around EB 30,000 per hectare. This makes the production of cash crops a necessity in schemes of this type, in order to obtain a satisfactory rate of return on the capital invested and ongoing maintenance and running costs.

In recent years, the growth of medium-scale irrigation has been substantial, as a follow-up to the drought of 1984. Most activity has been in Regions such as Welo which were badly affected by the 1984 drought. Small-scale irrigation is the responsibility of the SWCMD.

As a general rule, there are considerable opportunities for surface water harvesting in Ethiopia, due to the high levels of runoff which occur during the peak of the rainy season. Elsewhere in the world where long dry seasons occur, maximum use is made of wet season runoff. This is not the case in Ethiopia. The use of innovative methods of irrigation practised in dryland environments, such as Australia, Israel and the United States are worthy of investigation and trial in Ethiopia. These include keyline irrigation and water spreading. The use of small ponds for irrigation of vegetable crops at village-level is another possibility which requires further investigation. Ponds built using ox-drawn scoops and communal labour have been demonstrated viable by ILCA and the MoA for domestic and livestock water supplies. They have further potential for vegetable and fish production.

7.2.11 Fisheries development

Considerable opportunites exist in Ethiopia to expand fisheries production, with a view to both domestic and export markets. The Red Sea and Rift Valley lakes are excellent resources from which to build an industry which contributes significantly to the economy. Asia in and Europe offer opportunities for export, as other African countries have begun to discover. The general location of suitable zones for fisheries development are indicated on map 2.

7.3 POLICY CONSIDERATIONS

7.3.1 General

Agricultural policies generally have a more profound effect on production than most physical constraints and potentials, because their effect can be felt in a very short time frame. A number of policy issues related to the government's objectives for development in Ethiopia are discussed below in relation to the findings of the PSC analysis presented in Chapter 5.

7.3.2 The ten-year perspective plan

Development objectives in Ethiopia are laid down in the the ten-year perspective plan, for the period 1984/85 - 1993/94. In this plan, agriculture is proposed to receive 22.5% of the total investment of some EB 42 million. The plan's summarized objectives for agriculture include:

- food self sufficiency;
- satisfying raw materials requirement of domestic industries;
- promoting producer cooperatives;
- increased foreign exchange earnings through coffee pulse and oilseed exports, improved livestock for better access to world markets, and substitution of agricultural commodity imports (eg tea, tobacco);
- identify more accurately the country's natural resources, and conserve and develop them;
- strengthen links between agricultural research and extension;
- expanding and improving settlement programs.

Production targets include an annual rate of increase of around 5.7% for cereals, pulses and oilseeds. The area under cultivation would expand by 1.6% annually, implying that the remainder would come from intensification. These targets are suggested as overly optimistic by the World Bank (1987b) as agricultural support services would have to expand substantially to provide the fertilizer, improved seeds and other inputs necessary to achieve this goal. It also suggests that the lack of detail concerning production incentives, credit and input supply distribution is a major weakness in the plan.

7.3.3 Agricultural policies and their influence on production

<u>Grain marketing and pricing</u>

This is described by the World Bank (1987b) as the most important disincentive to farmers to adopt new technology. The incentive for farmers to produce marketable surpluses and "invest" inputs and labour in improving their land is largely tied to the economics of production and risk/reward ratio of their farming systems. The existing policies regarding grain marketing and pricing centre on regulated marketing of grain, including compulsory quota deliveries by producers to AMC at fixed prices. The AMC prices have effectively remained static since 1980, and are less than 50% of import parity prices for the main grains (World Bank, 1987b). While providing low-cost food for the urban population, it acts as a disincentive for producers. Input and living costs have also escalated since 1980 and the World Bank estimates that the purchasing power of prices paid to farmers has fallen by 34% since then. This is further exacerbated by restrictions on private and inter-regional trade. The PSC analysis shows there is clear imbalance in food demand between regions which could be eased by a free movement of grain.

Coffee marketing and pricing

Coffee is marketed officially through the Coffee Marketing Corporation (CMC). However, the peasant sector currently accounts for over 95% of production. It is estimated that about 40% of the FOB price is obtained by producers, excluding a small additional amount for exporters (World Bank, 1987b). Improved production for export is therefore unlikely without increased producer prices. Some improvement might also be obtained if inter-regional movement of labour for coffee harvesting were not restricted.

Land tenure

The high population pressure in many areas of Ethiopia has resulted in reduction in the size of the average land holdings over recent years. Unless land productivity is increased this will result in an ever decreasing spiral of minimal subsistence, especially since the opportunities for generating off-farm income are virtually non-existant in many of the marginal production zones. Uncertainties regarding redistribution of land within PAs, and communalization of land through PCs, has a tendency to discourage investment in individual holdings, including conservation (World Bank, 1987b). It further encourages investment instead in livestock holdings, which has negative feedback on conservation and land productivity in general.

7.3.4 Producer cooperatives (PCs)

The formation of producer cooperatives is encouraged as part of the government's ten-year perspective plan. Incentives in the form of inputs are provided to farmers to encourage them to join PCs. Recent pressure on land has encouraged farmers to reconsider their initial reluctance to farm collectively, as the shortage of draught oxen in many PAs can only be solved through shared resources. This is one of the strongest reasons stated by farmers for joining PCs, when interviewed by the LUPRD during semi-detailed surveys in Gojam and southern Shewa (FAO, 1987b,e)

Despite the relative advantages of incentives and subsidies not available to PAs, PCs have not shown considerable production advantages over PAs. As all grain must be sold to AMC at fixed grain prices, incentives are also as limited in PCs as they are for PAs. Provided membership of PCs is entirely voluntary, there is no reason why, with the advantages of shared resources, that PCs cannot perform substantially better than they have in the past.

7.3.5 Villagization

The main purpose of villagization is to improve community access to government services. Associated benefits include reduced soil degradation and generally improved land utilization. The process at the time of writing (February 1988) is well advanced and the impact of this policy is already being seen in some areas. Villigization involves the physical movement of households to one or several central village sites within each PA. In theory these sites will receive the advantages of certain services from the Government, such as social services, roads, extension services and input supplies, and so the overall cost of these shared resources will bring benefit to the majority of people at minimum cost. Apart from improved services, it is claimed by government that relief efforts in time of drought and access to modern methods of cultivation, such as mechanization, will provide improved production and food security. Families retain their existing plots of land and livestock ownership remains individual.

During the translocation stage the process interferes with subsistence production, simply because of the time taken to physically relocate houses. Although attempts are made to time operations in such a way that they cause minimum disruption to farming schedules, the process inevitably causes disruption. This is only acute, however, during the initial stages of transformation from the traditional system to the new, but some disruptive aspects do linger. For example, farmers commonly have several scattered plots. Previously, each one was within reasonable walking distance of his house, as that was part of the reason for choosing his house location in the first place. With villagization taking place, more particularly in moderately populated areas, walking distance to plots is substantially greater, creating and an additional burden for farmers.

7.3.6 Resettlement

Resettlement has been an ongoing process in Ethiopia since the 1973/74 drought and the ensuing famine. Some 46,000 families were resettled by the RRC, formed after the drought, in the ten years to 1984. With the devastating effects of the more recent drought in 1984, the Government has intensified its resettlement efforts aimed at including some 300,000 families in one year.

There is some doubt regarding the self-sustaining capacity of the original settlements, but some have been reasonably successful. Considerable international criticism has been levelled at the GoE for hasty and non-voluntary settlement programs in the past, but the need for redistribution of the population in marginal regions is no longer in doubt. The PSC model substantiates this need. Employment opportunities in sectors other than agriculture are also scarce in drought prone areas, offering no alternative to out-migration if the population is to survive. The problem is to find the least-cost alternative to resettlement, in itself an expensive operation (EHRS, 1986), or to at least minimize the cost to the economy of resettling people.

Expansion of cultivation through voluntary migration, supported by Government, would seem a desirable solution at this time. Site selection for new, sustainable communities should be the responsibility of the GoE, as technical competence for this purpose exists within its various ministries. Unfortunately, this will place additional strains on already overstretched manpower resources in the Government.

Considerable emphasis should be placed on soil conservation in conjunction with new concentrations of population, especially in western Ethiopia where the environment is more susceptible to erosion damage from intensive rainfall once the dense natural vegetation cover is removed. New settlers also need Government support until the settlements become self-sustaining, but all efforts should be made to encourage this at the earliest possible time after their relocation.
Resettlement is, unfortunately, a temporary solution to alleviate a more fundamental problem, over-population. Unless population control measures are taken and agriculture made more productive, food demand will outstrip production by 2010 and the population will again face a food crisis without additional land being available for the expansion of cultivation and resettlement.

7.3.7 Mechanization

The extent of land suitable for mechanization is discussed earlier in this chapter. The GoE wishes to expand mechanization, mainly through the use of tractors (World Bank, 1985b). The main constraint this imposes on the economy is the need for foreign exchange to purchase and maintain the equipment required. With individual peasant holdings diminishing in size, the use of tractors without collective farming would seem contradictory. Also, since labour is concentrated in the agricultural sector alternative employment must be found for those displaced by mechanization. The non-farm economy is not yet growing at a sufficiently high rate to accommodate this movement according to the World Bank.

With only 4.9% of the country suitable for large-scale mechanization, it may be more appropriate to consider forms of mechanization other than tractors. Many developing countries, for example, have had success with hand-held cultivators. Research in this direction might be considered as this form of mechanization is applicable on much stonier and steeper soils than are tractors. Any increase in mechanization should relieve draught animal requirements and, therefore, livestock numbers, with concomitant benefits for land management. Given the cultural importance of livestock for other than draught, this is unlikely in practise. On the deficit side, the cost of equipment and spare parts for mechanization must still come from foreign exchange reserves. Training in maintenance skills would also have to be expanded to sub-Regional level, and possibly SC-level, to make such a scheme practical.

7.3.8 State Farms

State farms are vigorously promoted by the GoE. Their inefficient use of capital and high percentage of skilled manpower required to operate them has raised questions about the wisdom of expanding this sector of agriculture without first improving their profitability (World Bank 1987b). With high levels of skilled manpower and considerable financial resources, their role is probably best confined to specialized aspects of agriculture where they have a comparative advantage, such as cotton production, industrial and commercial crops, improved seed production, and livestock improvement.

7.4 INSTITUTIONAL ISSUES

7.4.1 General

To take full advantage of resource potentials in Ethiopia and to overcome the physical constraints limiting production, not only must policies stimulate the agricultural sector, but infrastructure and institutional support must be available to put the policies into effect. Some of the more significant institutional issues are discussed below.

7.4.2 Land use planning

Scope exists in Ethiopia for land use planning at many different levels; from reconnaissance studies conducted on a national scale, to village level planning. At its inception in 1978, the LUPRD was given, among other things, the mandate to carry out land-use studies, land registration, prepare directives for policy decisions, and to regulate land-use.

Over the past 10 years, the LUPRD has only carried out functions connected with the first of these objectives, by conducting land use studies. The fledgeling department has, unfortunately, not had sufficient experienced staff or time to become involved in the other areas suggested in its charter.

Most land-use studies so far carried out by the LUPRD evaluate the potential of land for agriculture. Suitably generalized reconnaissance studies of the entire country have been conducted with the assistance of the FAO/UNDP, Assistance to Land Use Planning (Phase I) project. Several semi-detailed studies, which cover areas of around 300,000 ha each, have also been completed with FAO/UNDP assistance (Phase II).

These studies provide guidance on land potential for experienced planners, but do not constitute land use plans which can be implemented on the ground. To realize potentials, suggested improvements such as alley cropping, conservation works, or closure of hillsides to livestock, will not be attempted by farmers unless adequate consultation is maintained between farmers and planners, and the benefits of alternative technologies are demonstrated. Thus, a need still exists in Ethiopia for systematic, 'grass-roots' land use planning to the enable the widespread implementation of improved agriculture.

Some attempts at more detailed planning, in both sub-catchments and at SC level, have been attempted by other departments of the MoA (eg SWCCFMD and FLDP), but there is a clear requirement for the coordination of these efforts, a role ideally suited to the LUPRD. Serious consideration should, therefore, be given to attaching additional arms to the LUPRD, to develop land use planning methods which provide SCs and PAs with suitable assessments of their resources and advice on land use.

Only by making use of the regional network of skilled staff in the MoA and cooperation of SCs, can significant change be made in the agricultural sector over extensive areas of the country in the short to medium term. Otherwise, the pool of skilled land use planning staff will be too small to provide sufficient coverage for small-scale planning. Fortunately, the basic skills to train Awraja staff in the fundamentals of conducting sufficiently detailed, yet generalized, surveys of SCs and PAs, already exist in the LUPRD.

7.4.3 Research

IAR. This is the Governmental organization in Ethiopia with primary responsibility for research. Most of the research is concentrated on plant breeding, particularly of cereals and coffee. Limited information, however, is available on the nature and potential of local cereal varieties. In most instances, the advantages of improved varieties over local varieties have not been adequately demonstrated in adaptive trials off research sites. Research in food crops thus tends to demonstrate what is possible, rather than what is feasible for smallholders, who constitute 95% of farmers.

Dissemination of technology is also a problem, because of inadequate linkages between researchers and extension (World Bank, 1987b). In particular, research is most often aimed at the high input farmer, primarily state farms, and conducted in isolation from extension, which is aimed at the smallholder. More adaptive research is therefore recommended by the World Bank (1987b), particularly since most production comes from smallholders and modest improvements in this sector promise the greatest national gains in the short to medium term.

ILCA. Of the non-Governmental organizations carrying out agricultural research in Ethiopia, ILCA is by far the largest and most relevant. Research is not confined to livestock per se, but touches on production systems in which livestock are an integral component, which applies to most farming systems in Ethiopia anyway. Consequently, a number of cooperative programs to transfer improved technology to farmers are already in operation between ILCA and departments of the MoA.

Relevant research programs at ILCA include: the Vertisol program, intensification of cropping systems - including alley cropping, ox-traction studies, pond construction utilizing oxen-drawn scoops, animal health and nutrition studies, improved animal production systems, drought monitoring and pastoral system studies.

7.4.4 Extension

Prior to 1979, extension was carried out through EPID and included MPP projects sponsored by IDA and SIDA. The first project, MMP1, was limited in extent to readilly accessible areas in high potential zones. MPP1 is considered a success by the World Bank (1987b), but the unfavourable terms of trade said to exist by the time MPP2 began reduced incentive to adopt new technology and lessened the impact of the second project. However, EPID is generally considered to have been a success up until it was disbanded in 1979. Extension activities have since been carried out by the ADD.

ADD operates through Regional and Zonal offices, spreading the concentration of suitably trained extension staff throughout the country. At the time of writing (February, 1988), the MoA was preparing to again reorganize according to new administrative boundaries based on 25 Regions and 4 Autonomous Regions. This may cause further, temporary disruption to the extension service which is already hampered by shortages of skilled and experienced staff.

For extension to be more effective, some concentration of manpower resources to areas of high potential has been suggested by the World Bank (1987b). In addition, improved linkages with research and SC level planning activities would greatly accelerate the transfer of proven research results to farmer's fields.

7.4.5 Supply and distribution of inputs

AISCO. This is a relatively new, semi-autonomous organization within the MoA. Formed in 1983, it began operations in 1985. AISCO is responsible for estimating input demand, procurement and distribution of inputs, such as fertilizer and pesticides, for the peasant sector. In addition, it is responsible for the storage and transportation of all agricultural inputs.

AISCO currently acts as an importer and wholesaler and plans exist for further decentralization of retail sales to PA and PC members through SCs. The World Bank (1987b) recommends AISCO regionalize supply and distribution of inputs and progressively transfer MoA marketing to SC ownership and operation.

ESC. This organization has responsibility for producing improved seeds for both the state and peasant sectors. It is estimated that only 2% of farmers use improved seeds (World Bank, 1987b). Most sales of improved seeds are made to state farms (over 60%). Seed production is largely carried out on state farms and only limited amounts of certified seeds are produced. In the past most seed has been classed as improved and not certified. However, the number of certified new varieties coming from IAR has been limited according to the World Bank.

More coordination between IAR, MoA, and AISCO and the extension service will be required before the full benefit can be gained from improved seeds.

7.4.6 Agricultural credit

Government sourced credit is available through the AIDB, CBE and AISCO. Private savings channeled through and informal network supplement that available through Government. Of the credit extended to agriculture in Ethiopia through the AIDB, the peasant sector receives only 4%, with the major share (40%) going to state farms (World Bank, 1987b).

According to the World Bank, AIDB has serious arrears problems, creating cash flow difficulties. The reasons include old inactive loans, inoperative loans to state farms, operating weaknesses in the banking system, unfavourable economic conditions for the peasant sector, and operational problems in industry. Loan status in relation to coffee cooperatives is, however, generally favourable.

Input credit to the peasant sector has so far been administered by the MoA, with the AIDB providing funds. In the future, the CBE may provide credit to agriculture, but does not presently do so. SCs are increasingly a channel for input credit and development funds from AIDB for investments such as oxen, flour mills, and stores. The marketing and input credit role of SCs is particularly important in coffee marketing and providing advance funds to members for cereal purchases by AMC. Improved accounting and administration in SCs will be of particular importance to AIDB and other credit organizations in the future.

8. CONCLUSIONS AND RECOMMENDATIONS

8.1 GENERAL

8.1.1 Global issues

The work undertaken during the MLUP has highlighted several disturbing trends which are undermining not only economic progress in Ethiopia, but will challenge the well being of individual farmers throughout the country over the coming 10 to 25 years. In particular, the population supporting capacity analysis indicates that population pressure will raise the demand for food and energy resources to levels which cannot be met, at present levels of productivity, by the simple expansion of cultivation. This can only result in a declining spiral of nutrition and welfare, exacerbated by the inevitable effects of periodic drought, unless significant change takes place in the agricultural sector in the short to medium term.

The overriding recommendation is therefore that resources should be allocated immediately towards achieving the long-term objectives of increased agricultural output, decreased population growth, and increased nutrition and welfare levels. Many of the subsequent recommendations are directed towards generating these outcomes, either through direct impact or through creating an environment conducive to these developments.

8.2 ECONOMIC AND SOCIAL CONDITIONS

8.2.1 Population and food demand

If present population trends continue, the population of Ethiopia by 1995 will be 57 million inhabitants, and 95 million by 2010. This compares with 42 million in 1985. Depending on assumptions made regarding economic growth in the intervening years, between 2 and 3.4 times as much food will be required in 2010 than in 1985. That is, between 13 and 22 million tonnes of grain equivalents.

To meet this demand, with increased consumption levels to provide adequate nutrition, would require an economic growth rate of around 5% in the agricultural sector and 8% in the non-agricultural sector, over a period of 25 years. Growth rates this high have rarely been achieved in the developing world, let alone sustained over such a long period, even in those countries with substantially greater irrigation resources than Ethiopia. Development goals will, therefore, need to be set at more realistic levels.

Reducing population growth by 1995 would lower food demand significantly by 2010. A reduction in population growth, for example, from 2.9% to 2.7% per annum by 1995 would result in 15 million less people to provide for in 2010. It is therefore recommended that urgent consideration be given in Ethiopia to establishing a population control policy which encourages reduced population growth at the earliest possible time. However, decreasing population growth also requires improved economic growth, in order to increase nutrition, health and education, and this is only possible if prevailing economic conditions permit.

It is also recommended that areas with continuing histories of drought and crop failure receive immediate assistance in relocating significant numbers of families, preferably under a voluntary migration programs assisted by Government. This is a temporary solution to the problem of increasing population, but a necessary one as history indicates and the PSC analysis supports.

8.2.2 Rural income generation

Rural incomes provide an alternative to total dependence on subsistence agriculture. Incomes can be improved by extension of the crop and livestock sectors, infrastructural development and promotion of rural industries. Increased emphasis should be given to the implementation of these options, but care needs to be exercised that emphasis on programs such as 'food-for-work' does not displace farm labour too abruptly and undermine local agricultural production. Various opportunities for rural income generation are identified later in this chapter.

8.2.3 Land tenure

Because of the threat of periodic redistribution of land in PAs, as a result of increasing population and/or the formation of PCs, farmers are reluctant to treat their assigned land as an investment worthy of conservation effort and inputs which will improve its long term productivity. The redistribution of land must be minimized if per hectare production is to rise in the medium to long term.

8.3 ENERGY CONSIDERATIONS

8.3.1 General

Analyses of the demand for fuelwood carried out by the MLUP mission indicate that Ethiopia is currently in a crisis situation with regard to availability of energy for cooking and rural construction materials. The estimated net demand for wood over availability of over 55 million m^3/annum by 2010, indicates the magnitude of the shortfall in available resources. Alternative energy sources to fuelwood have not yet been demonstrated viable in Ethiopia, other than the burning of animal dung, which has negative feedback on soil nutrition and agriculture in general. An energy policy which takes account of these shortcomings must be formulated in the short term to offset degradation of remaining resources.

8.4 MAIN CONSTRAINTS TO AGRICULTURE

8.4.1 Main physical constraints

The main physical constraints to agriculture identified by the MLUP mission include:

- Limited and variable moisture availability for crops;
- Vertisols;
- Shallow, stony soils;
- Soil degradation;
- Steep land;
- Malaria infestation;
- Tsetse infestation;

These factors primarily limit expansion of the area under cultivation in Ethiopia. Each is discussed in greater detail below.

<u>Moisture availability</u>

Below a limit of 60 days DGP there is little that can be done to overcome lack of available moisture for crop production, other than through irrigation. However, it is strongly recommended that research begin immediately into the potential for short season crops and cultivars in the marginally arable (ie with 60-90 day GP) zone of Ethiopia. Demonstration trials to indicate the opportunities for intensification of agriculture through better use of available moisture in more secure cropping zones is also recommended.

Recurrent drought is an inevitable feature of the environment in Ethiopia, but it must be monitored more effectively and improved provision made to ameliorate its devastating effects. Upgrading of the meteorological network to provide more timely and extensive coverage is a first step in better drought monitoring. Inputs from meteorological satellites can also assist. Strategies to limit the effect of drought must include expansion of the rural road network, development of adequate storage facilities and strategic reserves of grain. Much of Ethiopia will continue to experience drought, but degrading farmlands and rising population will exacerbate its effects unless the suggested improvements take place in under 10 years.

<u>Vertisols</u>

Systems of management are available which can render Vertisols more productive than is generally the case in Ethiopia. In particular, the use of broadbeds and furrows should be encouraged through extension and SC level planning efforts. There must be incentive, however, through improved terms of trade and greater security of tenure, before farmers will use Vertisols for other than communal grazing lands.

Shallow, stony soils

The considerable extent of severely degraded lands in northern Ethiopia, where shallow, stony soils predominate, cannot support the population currently living there. This is evident from the continuing susceptibility of the region to famine and the clear indications in the MLUP analysis of the low population supporting capacities in northern Ethiopia.

Outmigration, reafforestation and hillside closure to livestock, combined with cut and carry forage production, are recommended in consultation with farmers. Research into the possible introduction of drought resistant perennial crops and innovative systems of small-scale irrigation is further recommended.

Steep lands and soil degradation

Steep lands are generally foremost among those susceptible to accelerated erosion and for conciseness are discussed here together with soil degradation. Although the most serious effects of soil degradation in as yet productive lands will occur in more than 25 years, the seriousness of the long term problem should not be underestimated.

Action must be undertaken immediately to arrest accelerated degradation, particularly in those Awrajas where is has been demonstrated to be most severe (see Annex 2). Improvements can be made through intensive conservation programs, but emphasis should be placed on the need to use methods such as alley cropping, which increase productivity while at the same time conserving soils. Without increased production, farmers will lack the motivation necessary to voluntarily participate in conservation programs.

Systems of agro-forestry are recommended for steep lands, making full use of perennial crops, livestock exclusion and cut and carry forage production where possible.

Malaria infestation

It is recommended that malaria control programs be intensified in those areas of the country where highland families are being resettled. Highland peoples have little resistance to this disease and serious outbreaks of malaria in new villages have the potential to decimate the population at some stage in the future.

Tsetse control

Cultivation in newly settled areas in the western regions of Ethiopia will remain dependent on animal draught systems for the next 25 years. The control of trypanosomiasis is therefore vital to the future expansion of cultivation in these localities. Control on a modest scale has been demonstrated in Ethiopia, but this program must be stepped up to ensure sustainability of agriculture in the western zone. This should be a priority activity associated with the resettlement of farmers from other areas of Ethiopia.

8.4.2 Terms of trade

To stimulate the intensification of land use the terms of trade must be improved in the agricultural sector. This can be accomplished by:

- providing a more efficient and timely supply of inputs, possibly coupled with input price adjustment by Region, to stimulate regional specialization based on differences in production and transportation costs;

- modifying the role of the AMC from acquiring obligatory quotas from producer and services cooperatives, and peasant associations, to a buyer and seller of last resort; the AMC would set a floor price for farmers and a ceiling price to consumers, thereby stabilizing markets and avoiding excessive marketing margins to traders;

- increasing the AMC prices to levels more in line with market prices;

- allowing traders to buy directly from peasants throughout the country;

- allowing all agricultural products to be moved and traded freely between regions, and

- improving the availability of consumer goods in local marketing centres throughout the country to provide incentive for peasants to earn cash income, and to discourage the buying of animals with surplus cash, a strategy which drives up animal prices and increases land degradation.

8.4.3 Institutional issues

Availability of resources and appropriate policies to stimulate production will have little effect without the necessary infrastructure and institutional capacity to implement improvements. Several important issues are discussed below.

Land use planning

There is an urgent need for grass-roots level, land use planning in Ethiopia. A SC level, consultative planning scheme similar to that being investigated by the FLDP could be coordinated by the LUPRD, with appropriate inputs from other departments of the MoA. This is a role well suited to the LUPRD, but staff and facilities are limited and it is recommended that consideration be given to attaching additional staff to the LUPRD to train Awraja level staff of the MoA to implement land use plans on the ground.

It is also recommended that consideration be given by the LUPRD to the including land utilization types with modest technological improvements which are attainable by peasant farmers, in addition to the high and intermediate levels currently used by the department in semi-detailed land evaluation studies.

Research and extension

It is recommended that more adaptive research be conducted by the IAR and that this include detailed investigation of the potential of local varieties of crops. In addition, investigation of the suitability of short season crops and cultivars in the considerable extent of marginally arable land in Ethiopia. Cooperative research between the GoE and non-governmental organizations such as ILCA is to be encouraged.

Improved dissemination of research results to the extension service is recommended, to ensure that the benefits of research reach farmers' fields at the earliest possible time. This will also require improved links between extension and grass-roots, level land use planning. Some concentration of extension staff in areas of potential will be necessary in the future to avoid the current dilution of manpower resources. Assistance for staff training must also be a priority.

Supply and distribution of inputs

The small percentage of individual farmers using inputs such as fertilizer, herbicides and improved seeds is indicative not only of the cost, but of poor supply and distribution on a national scale. These factors must be improved, together with the availability of credit, if the smallholders presently responsible for 95% of the food production in the country are to achieve substantial improvements in productivity.

8.5 POTENTIAL FOR IMPROVED CROP PRODUCTION

8.5.1 General

Results of the PSC analysis indicate that there is enough potentially arable land in Ethiopia to extend the cultivated area by 2 to 3.4 times the current area. However, the land required to feed the oxen used for draught and supporting livestock has been estimated at 1.7 times that required for human food production. As a result, there is insufficient land to feed both the projected human population and the livestock at current levels of food-crop and forage production. It is thus imperative to intensify agriculture by increasing yields and by raising the feed availability for livestock.

8.5.2 Intensification of crop production

Legume-based technology

The high economic cost of fertilizer suggests that legume based technology offers a more economic alternative which could be easily managed by farmers, but basic research is required before widespread introduction of the technology could be attempted. Appropriate research should therefore be undertaken by the IAR at the earliest possible time. The success of such technology will also depend, to a large extent, on the introduction of policies which stimulate farmer incentive.

Herbicides

Production losses due to weeds are very significant in Ethiopia. Considerable gains can be made by the use of herbicides because current weeding practices, especially in the small grain cereals, are insufficient to contain the weed problem.

There is potential for the local manufacture of herbicides which would alleviate the cost and encourage more widespread use of the technology. if pre-emergence herbicides are used other advantages include reduction in the number of ploughings when preparing the seedbed and consequent reduction in peak draught oxen requirements. The risk of soil degradation is also reduced because there are shorter periods when the soil is bare and unprotected from erosive rainfall.

Intensified management systems

Additional means are available to raise the productivity of rainfed crop production in Ethiopia, through more intensive land management. They include intercropping, relay cropping, undersowing and alley cropping. All of these systems make better use of available moisture. Although there is potential to introduce all of these systems in different circumstances, the potential of alley cropping is particularly high and therefore discussed in more detail.

The growing requirements for food, livestock forage, fuelwood and the need for soil conservation, indicate that alley cropping could well provide significant gains in all of these areas if introduced on a wide scale in Ethiopia. It is therefore strongly recommended that appropriate incentives and extension assistance be provided to farmers to encourage the introduction this technology where possible.

8.5.3 Crop diversification

The land suitability assessment conducted by the MLUP indicates that there is considerable opportunity for diversification of crops and farming systems in Ethiopia.Diversification offers a greater degree of protection from the effects of diseases, pest attack and drought than dependence on a monoculture or limited range of crops. However, basic research and incentives to produce a wider range of crops and cultivars are required before a greater degree of diversification will become attractive across the board to smallholders in Ethiopia.

One area of potential diversification in Ethiopia which deserves emphasis is the expanded production of roots and tubers, including enset. Per hectare yields suggest vastly more favourable returns in terms of carbohydrate than cereals. Drawbacks are that roots and tubers are mainly suited to higher rainfall zones and biproducts for forage are limited for crops other than sweet potato and enset. There social acceptance is also generally less. Despite these limitations it is recommended that farmers be encouraged to include more roots and tubers in rotations with more favoured cereals.

8.5.4 Coffee and other rainfed cash crops

<u>Coffee</u>

The coffee sector can provide an important source of income to a significant section of the rural community as well as to those involved in its marketing. A number of Awrajas identified in the PSC analysis as over supporting capacity have high levels of rural incomes derived from coffee, which ensures their survival independent of subsistence food production. Currently, local demand is suppressed by price policy. Potential exists for further developing export and domestic markets, but production is limited by various factors.

It is recommended that issues suppressing production, such as labour availability, taxation and marketing be investigated to determine their impact on yields and the necessary corrective actions taken. It is also recommended that those Awrajas with coffee potential be further investigated to identify suitable locations for production by Peasant Associations and Producer Cooperatives.

<u>Other cash crops</u>

Other cash crops with potential for increasing rural incomes include, grape, olive, cotton, sugarcane, sisal, oilseeds, fruits and vegetables. In semi-arid areas, incense production is possible.

All of these crops are suited to production in PCs and SCs, where a small amount of preliminary processing can be organized to better utilize available labour and increase rural incomes. An investigation into the potential for such agri-industries, particularly in drought prone areas where dryland perennials such as sisal can be grown, should be instigated to seek out alternatives to out-migration.

8.5.5 Irrigation

Existing studies suggest more than 2 million hectares are suitable for medium and large-scale irrigation development in Ethiopia. However, this figure includes includes substantial areas of Vertisols which require specialized management and equipment to sustain productivity. In addition, the development and management costs of recent irrigation schemes has proven to be high and the time for development considerable. Despite these drawbacks, large and medium-scale irrigation of cash crops should be initiated where it can be demonstrated to have economic potential.

There are also substantial opportunities for small-scale irrigation development, utilizing water harvesting, diversion schemes and groundwater development where appropriate. Developments of this kind should be given priority for credit through PCs and SCs, where shown to be sound.

8.5.6 Mechanization

Because of the high foreign exchange costs involved, limited maintenance facilities, an excess of labour, and limited area suitable for large-scale mechanization, it is recommended that the use of tractors be confined to state farms and cooperatives in the short to medium term. It is further recommended that research be initiated on the potential of alternative forms of mechanization suitable for peasant farmers, such as hand-held cultivators.

8.6 LIVESTOCK PRODUCTION

8.6.1 General

Livestock are integral components of most farming systems in Ethiopia. Their primary role is for draught power in the crop zone, but they fulfill a multitude of other roles, ranging from a means to store of wealth, to transport. Pastoralists in the lowlands of Ethiopia are wholly dependent upon livestock for survival.

One of the most important difficulties inhibiting development of the livestock sector, is the lack of reliable statistics on the types and distribution of livestock, details concerning local livestock productivity and the value of indigeneous forage species.

8.6.2 Feed resources

Existing forage production is both low in quality and quantity, because of heavy over-use and lack of management of grazing resources. There appears to be no short term solution to large scale improvement of communally owned pasture and rangeland.

More intensive crop production, utilizing systems such as alley cropping where forage production is an integral component of the farming system, offer promise of better nutrition for livestock. Undersowing and oversowing of forage species, together with the introduction of early planted leguminous forages which form part of generally intensified use of available moisture, could also contribute usefully to improved livestock nutrition. Hillside closure and cut and carry feed systems also offer improved feed resources, through the positive feedback from reduced grazing pressure and subsequent degradation of land. Both systems are recommended for widescale adoption in Ethiopia.

8.6.3 Health

Livestock are subject to a multitude of parasitic and infectious diseases, many of which can be managed through environmental control or veterinary assistance. Livestock improvement in Ethiopia will be difficult without a simultaneous attack on pests and diseases which reduce animal productivity.

Of the diseases present, trypanosomiasis is the most significant in reducing the expansion of livestock production in the country. Efforts to control Tsetse flies, vectors of the disease, have been successful in western Ethiopia, but the program must be expanded to cope with the livestock requirements of new settlers in this zone. Existing veterinary programs in the MoA must likewise be upgraded to cope with the increasing demand for assistance from the peasant sector.

8.6.4 Improved livestock productivity

The limited genetic potential of local livestock, which are bred as much for survival as production, suggests that a dramatic response to improved nutrition will not be forthcoming. However, useful improvements in draught capability and meat production may be possible through selective breeding within indigenous cattle, and possibly cross-breeding. Selective breeding of sheep for improved meat and wool production is also possible, but cross-breeding with exotic animals must be further investigated to establish the most desirable options. This is also true in specialized areas of production such as dairy. No gains will be made, however, unless provision for the necessary research is made.

8.6.5 Dairying

It is recommended that dairy development be directed towards satisfying domestic demand initially within the framework of the existing livestock sector. Even though individual production levels are likely to be low, establishment of producer confidence will result in the demand for necessary inputs and subsequent development. Following establishment of dairy production on a modest scale, locations where conditions are suitable can be selectively upgraded through extension and the use of improved, cross-bred dairy stock, and on-farm processing of products.

8.6.6 Livestock and land degradation

Livestock cause degradation directly through mechanical damage to the soil and indirectly through removal of protective vegetation. These factors result in increased runoff and erosion. The large numbers of livestock, particularly in highland Ethiopia, are intimately involved in the spiral of land degradation affecting much of the country. Reducing livestock densities on grazing lands is the only way to limit the problem. Hillside closure, cut and carry forage systems, and stall feeding of livestock is recommended in areas suffering from livestock induced land degradation.

8.7 DEVELOPMENT AND PRESERVATION OF UNIQUE RESOURCES

8.7.1 General

Ethiopia is gifted with unique ecological resources which also have the potential to generate foreign exchange if managed effectively. These include forest and wildlife resources, and water resources suitable for fisheries development.

8.7.2 Forest resources

Forestry contributes to the economy in Ethiopia in three main ways:

- soil conservation
- subsistence requirements for fuelwood and building
- industrial products for the growing economy.

Of these, the subsistence requirement for fuel places the greatest demand on the existing forest and woodland resources. Because of these demands, and land clearance for cultivation, little remains of the closed, high forest in Ethiopia and this is a unique resource which should not be allowed to further degrade through indiscriminant harvesting of fuelwood. It is therefore recommended that management policies be drawn up by Government for the state management of each of the remaining areas of high forest before further degradation of these resources takes place. Implementation of these plans will require cost and effort, but the value of conserving the remaining forests in terms of their contributions to soil conservation, wildlife management, and as a future source of industrial wood products are considerable.

8.7.3 Wildlife

International tourism is not currently a major contributor to foreign exchange earnings in Ethiopia, but potential exists to change this situation in the medium to long term through development of wildlife resources. Kenya has managed to do this very successfully, and with appropriate management Ethiopia could eventually benefit in a similar way to its neighbour. It is therefore recommended that development funds be sought to upgrade the development of national parks and wildlife resources, with an eventual aim of increasing earnings from tourism. Long term planning for the upgrading of tourist facilities such as hotels, and restoration of national monuments and other tourist attractions to ensure a comprehensive package for potential tourists is also required.

8.7.4 Fisheries development

The Rift Valley lakes and the Red Sea are of high potential for fisheries development. There is a substantial domestic demand for fish in the major cities which is influenced by the religious calendar. This demand could be expanded if appropriate production, marketing and supply policies are initiated. Export potential is, on the other hand, largely untapped. It is strongly recommended that existing surveys of aquatic resources be updated at the earliest possible time, while at the same time an investigation of the export potential of fish and crustaceans be initiated.

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