Agricultural potentials, constraints and opportunities in the Megech and Ribb rivers irrigation project areas in the Lake Tana Basin of Ethiopia

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Foreward

Agriculture plays the major economic, social and environmental role in Ethiopia. The present pictures of the poor economy, the settlement patterns of the rural population and the intensively cultivated landscapes depict the traditional form of agriculture that existed for millenia. The mountainous landscape of Ethiopia and its variety of climatic factors make the country a water tower of East and North Africa and a center of diversity for tremendous fauna and flora species. The Ethiopian plateau, which is divided into two parts, i.e., western and eastern highlands, flanking the Ethiopian Rift Valley, constitutes about 60% of the African highlands and 46% of the country's land mass.

Ethiopia has eight major river Basins, i.e., Tekeze, Abay, Awash, Baro-Akobo, Wabi Shebele, Ghenale, Omo, and the great Rift Valley. The Amhara region contributes much of the water sources of the first three basins. More than 75% of the region is mountainous with abundant water resources. Recently, the region has been divided into several growth corridors based on watershed concepts and the potential resources each corridor is endowed with. Both the Regional State and the Federal Government have chosen the Lake Tana Growth Corridor as the most viable area for integrated development in irrigated agriculture, agro-industry, hydropower generation, tourism and other rural-urban development schemes.

Currently, intensive development intervention is underway in the Lake Tana growth corridor. Dams and irrigation infrastructure, and large scale hydropower plants are under construction. Modern irrigation schemes require improved technologies such as improved seeds, high value crops, a constant supply of inputs and agronomic packages and knowledge that integrate production and marketing or value chain analysis for the individual commodities. The high cost of the irrigation schemes, the inadequate knowledge and experience of the farmers and other stakeholders in the command area make the role of research indispensable.

Driven and inspired by these encouraging development schemes in the target area, a professionally mixed group of researchers undertook a field survey to identify problems and assess the need for technologies for Rib and Megech sub-catchments of the Lake Tana Basin. A Participatory Rural Appraisal (PRA) survey technique was used. A detailed list of problems on the current farming systems such as lack of technologies to support the new irrigation schemes and opportunities were identified.

First, the problems and the objectives of the study are stated. Second, survey methodologies and approaches are presented in detail. The major thematic areas addressed in this research include the various trophic levels and others such as soil and water, crop, forest and livestock management, fishery, farm implements, and socio-economics of the target area. Finally, in conclusion, a list of recommendations for future research and development intervention are given.

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The research team

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Acronyms

ACSI	Amhara Credit and Saving Institute
AI	Artificial insemination
ARDO	Agricultural and rural development office
AISCO	Agricultural Input Supply Corporation
ARARI	Amhara Regional Agricultural Research Institute
CEC	Cation Exchange Capacity
Co-SAERAR	Commission for Sustainable Agricultural and Environmental Rehabilitation in Amhara Region
CSA	Central Statistical Authority
DAs	Development agents
EARO	Ethiopan Agricultural Research Organization
FTC	Farmers' Training Center
GTZ	German Technical Cooperation
IPM	Integrated Pest Management
IPMS	Improve Productivity and Market Sucess
m a.s.l	Meters above sea level
MoARD	Ministry of Agriculture and Rural Development
MoWR	Ministry of Water Resources
NGO	Non goveremental organizations
ORDA	Organization for the Rehabilitation and Development of Amhara
PAs	Peasant Associations
ppm	Parts per million
PRA	Participatory Rural Appraisal
QPM	Quality protein maize
SSI	Semi-structured interview
Unpub. data	Unpublished data
WARDO	Woreda Agriculture and Rural Development Office
WUA	Water users association

Executive Summary

A multidisciplinary team of researchers (agricultural economist, agricultural extensionist, plant breeder, horticulturalist, plant protectionist, agronomist, forester, soil and water management researcher, animal production researcher, animal feeds researcher, fishery researcher and agricultural mechanization researcher) was drawn from ARARI research centers(Adet, Andasa, Gonder, Bahir Dar Fishery, and Mechanization and Food Science).

The objectives of the study were to characterize and analyze the production systems of Megech and Ribb rivers irrigation project areas, identify major agricultural constraints, potentials and opportunities so as to provide direction for future research and development. The study woredas, i.e., Dembia, Libo Kemkem and Fogera, were selected because they are the beneficiaries of the irrigation projects that are under construction.

The study woredas lie within the Tana basin that is located to the north and east of Lake Tana. Each target area was classified into 2-3 production domains based on differences in scale of land degradation, soil types, vegetation type and cover, crop type, access to irrigation opportunities, fishery and livestock resources.

The study employed a Participatory Rural Appraisal (PRA) tools and techniques to collect primary information from farmers in a participatory fashion. Secondary data were obtained from both published and unpublished sources. The main sources of secondary data were Woreda Agricultural and Rural Development Offices (WARDOs) and NGOs. Information relevant for this study was screened for immediate use. Besides, discussions were made with technical staff of WARDOs, NGOs and key informants to explore more information about the farming systems of the study areas. In gathering primary data, semi-structured interview was administrated to 20-30 group discussants drawn from men, women, elderly, clergy, peasant association heads etc. to collect qualitative data. Focused discussions were also made with farmers organized into four sub-groups: socio-economics, natural resources, crop production and livestock production.

In prioritizing production constraints and understanding farmers' preference and priorities ranking techniques was employed. In doing so, visualizing techniques were employed like transect walks and direct observation were also resorted to gather information on soils, topography, water sources, vegetation, infrastructure, land use, crops, livestock, etc.

Highlights of the findings

Socio-economic aspects

The farming system of the study areas is characterized by crop-livestock mixed farming. Farm households depend mainly on crops both for food and cash income. Uptake of improved technologies is minimal due to primarily weak extension service. Although farmers have good experience and positive attitude towards irrigation agriculture, there is no any organized irrigation extension service provision in the area.

Though cooperatives exist in the study areas, they generally face complex and interwoven problems which includes among others, shortage of capital, marketing problems, lack of storage facilities and poor managerial skills of cooperative committees. A number of traditional Water User Associations (WUA) does also exist across the study areas. These associations are usually organized around traditional irrigation schemes. The water management is dealt by a *father of water* (*Yewuha Abbat)*. The water users adhere to all agreed rules and regulations. One of the ngths of traditional water use associations is that farmers are organized in small and common interest groups, which are effective, though they face poor financial and technical backup.

Credit facilities are available in the study areas. The main institutions that provide credit for farmers are cooperatives and the Amhara Credit and Savings Institute (ACSI). According to the informants, the communities prefer service cooperatives to ACSI because of their easy access, less bureaucracy and low interest rate. The main input suppliers are service cooperatives, unions, AISCO, Ambasel and private traders. They supply fertilizers, improved seeds, farm implements, water pumps and farm chemicals. Farmers pointed out that the input systems are characterized by protracted delays, enforced supply, high prices, poor quality and some inputs are completely unavailable. The study further revealed that the marketing system in the study areas is inefficient due to low product prices, the actor's and middlemen's misbehavior, poor access to transportation and farmers' weak bargaining power.

Crop production and management

The areas are more suitable for cereals, pulses and to a lesser extent to oil crops. Tef, sorghum, finger millet, maize, rice, wheat and barley, among cereals; chick pea, grass pea and lentil among pulses; niger seed and safflower among oil crops. Rice is recently introduced to the lower stream areas of Dembia but in Libo-kemkem and Fogera, it has been grown relatively longer and widely both at the upper stream and lower stream (flooded and upland conditions). Tef and niger seed production is declining since much of the water logged areas are used for rice than drained for main season crops.

Four types of cropping season are known in the study areas, namely main season (rainfed agriculture), residual moisture, full irrigation in the dry season and recession farming. Almost all farmers in the study areas practice crop rotation to restore the fertility status of the soil as well as to minimize the build up of weeds, insect pests and plant diseases. The most common crop rotations are cereal-legume-cereal, cereal-cereal-cereal, oil crop-cereal-pulses, horticultural crops-cereal-pulse and cereal-cereal-pulse. The cereal-cereal-cereal approach is the most widely practiced. In the lower stream, most farmers grow rice for two to three years without rotation.

Different constraints reduce field crop production and productivity in the study area. Low soil fertility, lack of improved varieties (for most crops), insect pests, weeds, diseases, lack of improved agronomic practices such as appropriate seeding rate and planting method, cropping system, frequency and time of irrigation.

Horticultural crops production is a relatively new activity which has mainly been triggered by the commencement of irrigation. The major horticultural crops grown are vegetables, fruits, spices, and other perennials. Among the vegetables, tomato, Allium, hot pepper and potatoes are grown more widely than others. Head cabbage, *Gomen* (the leaves of rape seed), lettuce and swiss chard are the leafy vegetables grown in the study areas of which head cabbage is the most prominent and highly demanded. Sweet potato, carrot and beet roots as well as shallot, onion and garlic are also grown. Both garlic and shallot are traditional crops. Shallot excels both in terms of popularity and extent of production. In Libo Kemkem, shallot appears to be very important because its demand goes as far away as Metema and Gondar. Farmers prefer to grow garlic because it is not perishable and it enjoys good market access to Tigray, Wollo and Sudan. In Fogera areas, onion production (for both seed and bulb) is steadily increasing. The Fogera area is being considered a source of onion seed for the entire Amhara region. Potato is rapidly expanding especially in the bottomlands, where recession farming is common, and is mainly grown after rice in the Fogera and Dembia areas

Perennial horticultural crops are still rare and people rely on vegetables and other annual crops for their livelihood. A few perennial crops like guava, mango, and orange are grown for subsistence in the higher slopes of Megech and Rib irrigation target areas particularly in Libo Kemkem and Fogera Woredas. Fruit production is generally at its infancy especially in Dembia. In this area, a few farmers grow mango, papaya, guava, coffee, etc. In Fogera, lacks of experience and waterlogging problem have significantly undermined fruit production especially in the irrigation target areas. However, some sporadic trees of avocado, orange, coffee and chat are seen.

Fenugreek, white cumin, black cumin, basil, coriander, garden cress and *Ruta chapalensis* are the major spices grown in the study areas of which fenugreek appears to have a wider coverage.

The study revealed that insect pests and diseases were, and still are, the major production constraints in the study areas. To be specific, a few of the major insect pests include stem borers, red tef worm, grasshoppers, sorghum chaffer and army worms on cereals; cutworm, African bollworm (ABW), and aphids on pulses, ABW on tomatoes, and other aphid species on cabbage and root rot on hot pepper, bulb rot on shallot, and late blight on potatoes. Recently, cutworm and red tef worm have become the most damaging insect pests. Root rot of hot pepper was the most devastating disease that was experienced recently. Head blast is a serious problem on both finger millet and rice. Insecticides are widely used against aphids on grass pea and African bollworm on chickpea. However, the use of these chemicals had serious repercussions by killing honey bees foraging in farm crops.

Weed infestation is widispread in the lower stream areas. This is because floods carry the weeds downstream. Farmers practice different weed control techniques depending on the level of infestation and crop type. Most prominent are continuous tillage and one to four hand weeding. Herbicides are sometimes used as witnessed in Dembia.

Animal production and management

Farmers rear cattle, sheep, goats, donkeys and mules. Poultry, fishery and honeybees are also common. Herding of mixed livestock species is a common practice. In *Megech* and *Ribb* rivers irrigation target areas, cattle, small ruminants and equines are herded together on communal grazing lands.

Heifers reach for breeding in four to five years in upstream and four to six years in the lower stream areas of the Lake Tana Basin. The age of the local cattle with the first calf is longer in the lower stream because of depleted feeds, disease prevalence and poor management. Local bullocks reach for working in four years, whereas crossbreds in two and half years in the upstream. This takes five years in lower areas of the basin. Calving interval of cattle is two years in upper stream and two to four years in the lower stream. Crossbred cattle generally reach puberty at younger age and their calving interval is shorter than the local ones. The average lactation length of Fogera cows range from eight to nine months while for other local breed cows lactation length ranges from six months to one year. With adequate supply of quality feeds, Fogera cows yield three to four liters, whereas cows of other breeds give 1 to 1.5 liters of milk per day. When feeds get scarce during the dry season, the yields drop to less than half a liter per day. Most of the improved cows are 25% exotic.

Indigenous chicken production is a common traditional practice of farmers in the survey areas. But the two exotic breeds of poultry, RIR and Lohman White were recently introduced in Dembia and Libo Kemkem, while only RIR breed is found in Fogera. Their number is declining because they are susceptible to different diseases such as Newcastle, Coccidiosis and Gumboro. Beekeeping is practiced in all the three woredas, which are potential areas for beekeeping.

Majority of the beehives in all the surveyed areas are local. However, a few Transitional (Kenya top bar) and *Langstroth* (modern or frame) hives were distributed to farmers.

The major feed sources of livestock in order of importance include crop residues, natural pasture, hay and crop aftermath in upstream and natural pasture, crop residues, crop aftermath and hay in lower stream. Nevertheless, in Libo Kemkem, salt, niger seed cake and urea treated straws are fed as supplementary feed to animals. Improved forage crops are seldom cultivated and utilized.

Different animal diseases occur at different seasons in the upper and lower streams. The most important infectious diseases are those of bacterial and viral origin such as anthrax, blackleg, pasteurollosis, and FMD. Some diseases such as anthrax, pasteurollosis, trypanosomoses, streptothricosis, and coccidiosis affect different animal species in the basin.

In the upstream the major animal production constrains are listed in the following order: feed shortage, animal diseases and inadequate animal health services, low productive and reproductive performance of animals and death of honey bees due to insecticide poisoning. In the lower stream, the problems are the same except low reproductive and productive performance of animals holds the least position.

Soil and water management

The major soil types are vertisols and fluvisols (Alluvial deposits) where the latter dominates close to the lake. Soil fertility is very poor in the upstreamof the study areas. Soil depth continues to diminish in the upstream where is increases in the lower stream, resulting in lower yield in the upstream. Reduced soil depth reduces moisture-holding capacity of the soil, which in turn causes high run off in the upstream areas that carry sand and gravel to the plain and the lake. Gully erosion is common even in the plains.

Irrigation water management practices in the study area are traditional and are based on farmer's local knowledge. Whenever water is available, the farmers irrigate their fields without any gauging mechanism. Hence crops are watered more than required. Most of the farmers irrigate their fields by flooding. Flood irrigation is known for its wastage of much water. However, a few farmers irrigate row vegetable crops along furrows. Farmers never get expert advice about when, how, and how much water to irrigate. In the traditionally diverted rivers and springs, farmers allocate water on rotation. Water user associations (Yewha Abbat) prepare irrigation schedules. However, the schedule does not consider the type of crops irrigated and the size of the fields but it only considers the number of member growers.

The major problems of soil and water management are identified in the following order: flooding, soil fertility decline, water logging, shortage of irrigation water, and limited availability of pumps and lack of pump maintenance services. In addition to these, in Libo Kemkem, farmers mentioned erratic rainfall, soil erosion and lack of potable water to be major problems.

Forestry/ Agro-forestry

The forest and woodland resources of the study areas can be categorized into four major vegetation types, i.e., natural forests, plantation forests, farm forests and shrubs and bushlands. The Agro-Forestry practices of the study areas consist of woodlot, farmland, boundary and roadside plantations. Major Problems of forest are forest land degradation and loss of biodiversity, mono-specific plantation, shortage of forage trees and flooding and water logging. The major indigenous tree species constituted the natural forest resources of the study areas are Sapium ellipticum, Acacia albida, Acacia seyal, Acacia tortilis, Albiza gummifera, Allophylus abyssinica, Calpurina aurea, Capparis tomentosa, Carissa edulis, Cordia africana, Croton macrostachysus, Dodonaea anguistifolia, Entada abyssinica, Erythrina abyssinica, Ficus sycomorus, Ficus vasta, Grewa villosa, Juniperus procera, Millettia ferrugunea, Mimusops kummel, Phytolacca dodecandra, Podocarpus falcatus, Prunus africana and Ximenia americana .

Farm operation, irrigation and transportation

Soil preparation is carried out using a pair of oxen with the traditional beam and plough (*maresha*). Maresha is utilized in all types of soils and even in Vertisols, which severely expand when wet and shrink when dry due to high clay content. Maresha does not turn the soil and in most cases leaves some un-worked patches. Several tillage operations in criss-cross fashion are done before the land is ready for planting crops. The number of passes varies with crop type. The seeding procedure varies with crop and soil type. The most common types of sowing employed in these areas are hand broadcasting, row planting, drilling and transplanting and in most cases using maresha to cover seeds into the soil and protect seeds from birds.

Carrying goods on human head and on women's back, loading and packing on a donkey back are most widely employed transport methods. Appropriate technologies such as animal drawn carts are seldom used in these areas. Water lifting devices and tools are very important in the Ribb and Megetch areas for irrigation. Diesel pumps are seen introduced widely in the area. The major problem associated with the use of water lifting pumps is that the pump casing which is made of aluminium cast breaks down while in operation.

Perceptions of farmers towards the irrigation project

Farmers see the construction of the dam a boon to alleviate flooding problem that will eventually help to put more land under cultivation. It also gives an opportunity to use the limited water resources for multiple cropping through out the year. On the other hand, some farmers fear of land redistribution. They also think that it curtains sediment deposition near the lake(which they think this a disadvantage), makes bridges necessary to cross the big canals, may limit livestock access to water and might affect sand quarry activities.

Interventions

The study forwarded a number of policy, development and research intervention. A few of them are the following:

The study pointed out the need for the demonstration and dissemination of improved crop, livestock, irrigation and agricultural mechanization technologies. For this, there is a need to organize and establish Farmers' Research and Extension Groups (FREGs). It is required to study the value chain of major crops as well as enterprise choice in irrigated crops. It is very pertinent to undertake adaptation/screening trial to select high yielding and disease resistance crop varieties. High emphasis needs to be given to high value crops such as Snap bean, Soya bean and Spices. Management of root rot disease on hot pepper and head blast both on finger millet and rice needs to be given high consideration. There is also a need to conduct experiments on natural pastures and forage crops. Zero grazing should be introduced in the study areas.

It is also important to undertake study on irrigation agronomy and engineering (such as irrigation frequency, methods, requirements and scheduling). It is required to develop/test storage structures, rice mechanization, and mechanical powered soil preparation and weeding technologies, cattle feed processing and handling technologies, mechanical threshing methods using existing water pump engines.

To sum up, as the agricultural constraints in the study areas are complex and interwoven, it needs to be looked in a system perspective approach.

1. INTRODUCTION

Agriculture, the backbone of Ethiopia's economy, contributes about 50 percent of the GDP and employs 80% of the population (Befekadu and Birahnu, 2000). Because agriculture plays such a significant role in the economy, any fluctuation in it can easily shake up the GDP. Much of Ethiopia's agricutlture is rainfed and food deficit and famines frequently occur as a result of erratic rainfall and drought.

Ethiopia has 122 billion m^3 surface and 2.6 billion m^3 ground water resources, and an estimated irrigation potential of about 3.7 million ha. Nevertheless, only 3 to 5% of the nearly 10 million ha of arable land is currently irrigated (WCD, 2000). Up until now, this huge water resource is untapped. With conservative estimates, the country has the lowest irrigated agricutlutre compared with other developing countries (FAO, 2002). The vast majority of the rural poor rely on rain-fed agriculture. The country's dominant agricultural system is the smallholders, who have not benefited sufficiently from improved agricultural water management technologies which could have been used to alleviate food shortage and eliminate the vicious cycle of poverty and famine.

According to Ethiopia's Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) (2006), 38 irrigation projects with an estimated budget of 2.52 billion US dollars will be implemented until the year 2010. Accordingly, nearly 530 thousand ha of land will be irrigated which covers 14% of the irrigated land (Teshome, 2007). To date, modern agricultural water management technologies, which are the best entry points to ensure food-security are believed to be the only ways to increase food supplies and ensure economic prosperity for the rural poor in Ethiopia. Access to water will allow farmers to intensify agricultural production systems and thereby increase production and productivity. Today more than any other time in the past, water supply, both for human consumption and agriculture, has become a global concern.

The Amhara region, with a population of about 18 million, is the second most populous region in Ethiopia. Some drought- prone areas of the region are food insecure due to a combination of factors such as erratic and unreliable rainfall, degraded natural resource base, high population density and low productivity caused by poor agricultural management practices (BoARD, 2003). In the region, an estimated 18-20% of the population is chronically food insecure.

The Amhara region is endowed with a potential irrigated land area of 0.6 million ha within the four major river basins (Awulachew et al., 2005; BoWRD, 2005). In addition, it enjoys a considerable potential for surface water harvesting by small-scale dams and river diversions and also underground water resources. However, the total area under irrigation to date amounts only to about 76 thousand ha, which is less than 2% of the total cultivated land in the region (BoWRD, 2005).

Cognizant of the fact that the region is still food insecure, and given the huge potential of water resources, the Regional Government gave the highest priority for establishing modern irrigation facilities to reduce the impact of drought and associated crop failures, which are the prerequisites for increasing agricultural productivity to reduce the level of household food insecurity (BoWRD, 2005). Furthermore, the Federal Government of Ethiopia is currently implementing irrigation and drainage projects in the Amhara region in Dembia, Libo Kemkem and Fogera districts, which are funded by the World Bank. However, until now such promising endeavors were not fully supported by the research system, mainly due to limited capacity and resources.
In other words, the farming system of the districts were not characterized and described. Moreover, the perception of farmers about the upcoming irrigation was not assessed.

Agricultural production activities are conducted in a rather complex environment, which compels farmers to make decisions at every stage (Franzel and Houton, 1992). The natural environment, socio-economic and institutional factors strongly influence the behaviour of farmers in decision making, such as priority setting, the type of agricultural technologies utilized, and remedial actions taken against certain constraints (Murithi and Shiluli, 1993). By virtue of these principles, some farmers may make decisions not to adopt technologies recommended by the research and extension system. This happens partly because the recommended technologies might be incompatible with the farmers' circumstances such as natural, social, economic and institutional features (Alemayehu and Franzel, 1987). All these necessitate the vital role played by the research system to describe and understand the farming system.

Mixed crop-livestock production system dominates much of the agricultural production systems of the study area. Describing the existing production systems, their management and utilization help to identify possible research and development agenda. Conducting research supported with diagnostic surveys will also help the technology generation and transfer system to be problem oriented and demand driven. However, despite their huge agricultural potential and significant contribution of these study areas to the nation's food supply, no significant effort has ever been made to describe and understand the farming systems, their agricultural constraints and opportunities in order to bring the problems forward for research and development interventions. With this background and justification this survey was initiated to characterize and analyze the production systems in order to identify major potentials, constraints and opportunities to provide direction for future research and development.

2. METHODOLOGY

A multidisciplinary team of researchers was drawn from agricultural research centers operating across the northwestern part of the Amhara Region, i.e., Adet, Andasa, Bahir Dar Fishery, Gondar and Bahir Dar Mechanization and Food Science, which are administered by the Amhara Regional Agricultural Research Institute (ARARI). The team consisted of the following disciplines: agricultural economics, agricultural extension, plant breeding, horticulture, plant protection, agronomy, forestry, soil and water management, animal production, animal feeds, fishery and agricultural mechanization. Each discipline had its own prepared checklist of criteria for the survey. The checklist was intended to give direction for the discussion with different stakeholders.

2.1 Recommendation domains

It was not possible to study the whole expanse of each woreda and each individual farm within each woreda for budgetary and time constraints. Thus each woreda had to be classified into some reasonably homogenious strata, resulting in workable target recommendation domains. Each domain was homogenous and strongly similar. Dissimilar parts of woredas were assigned to different domains. Three steps were followed to identify target domains:

1. **Review of secondary data**: Available secondary data were reviewed to learn about the variability of the farming systems of the study area.
2. **Discussion with Woreda Agricultural and Rural Development Office (WARDOs) staffs**: In-depth discussion was made on general and specific aspects of the farming systems of the study area with the staff of WARDOs. Target domains were also characterized with their assistance.
3. **Key informant interview:** Key informants had also played similar role as WARDO staff in identifying target domains.

4. **Direct observations**: Based on the information obtained from secondary sources and discussion with experts and key informants, the survey team set certain relevant criteria that were used to characterize the farming systems into homogenous units, i.e., target domains, and therby, confirm preliminary target domain characterization that was done with the help of WARDO staff and key informants. A transcect drive and walk were conducted together with WARDOs staff and development agents (DAs) of respective districts. During the transect drive and walk, information was collected on the different aspects of the farming systems from direct observation, unstructured interview with the farmers and development agents stationed at the respective peasant associations (PAs).

The study woredas, i.e., Dembia, Lobo Kemkem and Fogera, were intentionally selected because they are the beneficiaries of the irrigation projects that are under construction. The study woredas lie within the Tana basin that is located to the north and east of Lake Tana. Once the study woredas were purposely chosen, the next step was to identify the actual target domains within them. In so doing, the target area was classified into two major domains based on differences in the scale of land degradation, soil types, vegetation type and cover, crop type, access to irrigation opportunities, the usage of residual moisture, fishery and the type of livestock rearing. Initially the study group expected that the target area would constitute three typologies, i.e., the upstream, middle and lower stream. Later, however, after conducting a transect walk and a thorough observation of each area, and after discussing the situation with farmers in each domain, it was concluded that the target area could broadly be divided into two domains, i.e., upper and lower, that are relatively different form one another, and with a buffer zone that covers the area between them. The buffer zone, i.e., middle domain, contains more elements of the lower domain and it was agreed to be grouped within the lower domain.

In Dembia woreda, the upstream was represented by villages that included Sufankara and Gubaya; the lower domain by Debir Zuria or Robit, Arbaya, Jarjar, Tana Woina and Achera. In Libo Kemkem, representative villages for the upper domain included Birkute, Estifanos, Agita, Angot, Shamo, Bura Egziabher, Yifag and the lower domain included Sheena, Gendawuha, Teza Amba, Kab and Bambiko. In Fogera woreda, upper villages were Dibba and Sefatra and the lower domain included Kokit and Nabega. The variables used to characterize the domains are shown in Table 1.

2.3 Data collection and analysis

Participatory Rural Appraisal (PRA) tools and techniques were employed to facilitate the discussion with farmers. The techniques were used to collect primary information from farmers in a participatory fashion. The important survey tools and techniques adopted by the team are indicated as follows:

2.3.1 Secondary data collection

Secondary data were obtained from published and unpublished sources. The main sources of secondary data for this study were WADROs and to some extent NGOs. Information relevant for this study was screened for immediate use. Along with secondary data collection, discussions were made with technical staff of WADROs, NGOs and key informants to get more information about the farming systems of the study area.

Table 1: Characterization of the target domain

Variables	Upper stream	Low to middle stream
	Megech River (Dembia)	
Topography	Undulating	Plain
Slope	Gentle slope (>5%)	<5%
Altitude	>1800 m	≤1800 m
Scale of land degradation	High	Low to medium
Flooding	None	Medium to high
Type of existing irrigation	Gravity diversion, motorized water pump	Motorized water pump lifting, recession agriculture
Soil type	Red, black grey (nechatie)	Vertic (black, brown), alluvial (dashena)
Vegetation	*Acacia* spp., Cordia, *Ficus* spp., eucalyptus	Acacia spp.; eucalyptus, *Euphorbia* spp., sesbania
Crop	Faba bean Tef Sorghum (Bulle) Maize Wheat Finger millet Chickpea	Sorghum (Issah) Rice, maize Tef, potatoes Chickpea Finger millet Barley Azmud (white cumin) Hot pepper Fenugreek Basil (Beso bila/ Zikakbe)
Livestock	Cattle Sheep Goats Poultry Honey bee Equine Fish (river)	Cattle Sheep Goats and poultry Honey bee Equine Fish (river/lake)
Animal feeds	Poor	Medium
Constraints	Land degradation	Flooding
Access to market	Medium	Very low
	Ribb River (Libo Kemkem woreda)	
Topography	Undulating	Plain
Slope	Gentle slope (>5%)	<5%
Altitude	>1800 m	≤1800 m
Risk of flooding	None	High
Type of existing irrigation	River diversion	Motorized water pump
Soil type	Red, mixture (nechate), black. Stony soil	Alluvial, vertic
Soil fertility	Low	High (alluvial), declining (black soil)
Vegetation	*Ficus* spp., Acacia, Cordia, Croton	Eucalyptus, reeds
Crop	Finger millet, maize, tef, barley, sorghum, chickpea, grass pea, pepper	Rice, hot pepper, maize, finger millet, chickpea, emmer wheat, wheat, lentil, fenugreek
Livestock	Cattle, sheep, equine, goats, poultry, honey bee, river fish	Cattle, sheep, equine, poultry, honey bee, fish (natural ponds and lakes)
Animal feeds	Scarce	Better
Constraints	Low soil fertility	Flooding
Access to market	Better	Poor

	Ribb River (Fogera woreda)	
Topography	Plain, undulating	Plain
Slope	Gentle slope (>5%)	<5%
Altitude	>1800 m	≤1800 m
Risk of flooding	Low	High
Type of existing irrigation	River diversion, motorized water pump from rivers	Motorized water pump (from natural ponds and rivers), recession farming
Soil type	Black, red	Alluvial, black
Soil fertility	Poor	Better
Vegetation	Cordia africana, Croton, Mellitia, Prunus africana, eucalyptus, Gravelia,	Eucalyptus, Cordia africana, reeds
Crop	Finger millet, tef, niger seed	Rice, maize, chickpea, hot pepper, emmer wheat, finger millet, barley, wheat, grass pea, cotton, niger seed, safflower, shallot, garlic, onion
Livestock	Cattle, sheep, goats, equines, poultry, honey bees	Cattle, sheep, equines, poultry, honey bees, fish (natural pond, lake, river)
Animal feeds	Scarce due to shortage of pasture land	Scarce due to flooding
Constraints	Low soil fertility	Flooding
Access to market	Better	Poor

2.3.2 Primary data collection

Different PRA tools and techniques were applied throughout the study such as direct observation, semi-structured interview and ranking.

2.3.2.1 Direct observation

The team used **direct observation** to directly observe the farming systems of the study area. It was an important method for the study team to get acquainted with the present situation of the study area. Through direct observation, information was obtained on soils, topography, water sources, vegetation, infrastructure, land use, crops, livestock, etc. This served mostly as a basis for discussions that followed with the farmers and key informants.

2.3.2.2 Semi-structured interview (SSI)

Semi-structured interview was applied in two phases to collect different sets of data. In the first phase, semi-structured interview technique was employed to collect qualitative data from group discussions using a checklist. The group discussion included all participating farmers and focussed on general issues that were listed in the checklist. In the second phase, focused discussions were made with the farmers using different PRA tools. In the focus group discussions, the multidisciplinary team was divided into four sub-groups: socio-economics, natural resources, crop production and livestock production.

Since the interview was aimed at generating information on certain specific issues, a checklist was used on some of the predetermined questions. Following and depending on the response of farmers, a series of specific follow-up questions were asked on the subject of interest. As per farmers' interest the interview was scheduled mainly on holidays. Generally, the interview took three forms:

- Interview with groups of farmers to obtain information on community interactions
- Interview with individual farmers to obtain representative information
- Interview with key informants to obtain expert knowledge.

Questions posed were open-ended and the interview system was rather informal. Prior to the the interview, the farmers were introduced about the objectives and significance of the study. The study team members encouraged the farmers to speak freely and frankly thereby probing deep into the relevant issues. A considerable number of farmers participated during the interview. A wide range of information was finally collected. Upon collection of a session, religious leaders or elderly people were invited to bless the meeting according to tradition.

2.3.2.3. Direct matrix and pair-wise ranking

Ranking techniques are most important and versatile tools that confirmed their convenience to learn about priority problems and preferences as per the farmers' perceptions. As a result, the pair-wise and direct matrix ranking methods were used as applicable. At this occasion, the farmers' hot debate helped to dig out concealed facts.

2.3.2.4 Diagramming

Diagramming techniques were also adopted to visualize information in an easily understandable way. The most important diagramming techniques used in this study were seasonal calendars and venn diagrams.

2.4 Description of the study area

2.4.1 Administrative location

The Lake Tana basin is located in three administrative zones of the Amhara Region, i.e., North Gondar in the north and northwest, South Gondar in the east and southeast and West Gojam in the south and southwest. It covers five woredas in each of north Gondar and South Gondar and six woredas in west Gojam (Table 2). A large proportion of the surface of Lake Tana, i.e., the reservoir, is located in north Gondar, and some part of it in south Gondar and west Gojam zones (MoWR, 2005).

Table 2: Percentage area of some of the woredas that lie within the Lake Tana basin

North Gondar		South Gondar		West Gojam	
Woreda	In the basin	Woreda	In the basin	Woreda	In the basin
Gondar Zuria	100	Fogera	100	Achefer	100
Dembia	100	Farta	100	Merawi	100
Alefa	30	Libo Kemkem	60	Bahir Dar Zuria	80
Wegera	20	Dera	60	Sekela	80
Chilga	10	Estie	20	Fagta Lokoma	50
				Banja	10

Source: MoWR, 2005.

The study area is situated within Fogera, Libo Kemkem, and Dembia, in the east and north of Lake Tana basin, mainly in Ribb and Megech irrigation command areas. Ribb is found in Libo Kemkem and Fogera woredas; Megech is found in Dembia and Gondar Zuria woredas. Participating farmers came from five rural kebeles of Dembia, i.e., Achera, Debre Zuria, Jarjar, Tana Woina, and Sofankira, three rural kebeles of Libo Kemkem, i.e., Bura, Angot and Shina Tsion and three rural kebeles of Fogera, i.e., Diba Sifatra, Avua Kokit, and Nabega.

Dembia woreda is located in North Gondar zone of Amhara National Regional State. The woreda capital, Kolladiba, is located 750 km North of Addis Ababa and 35 km southwest of the zonal capital, Gondar. The woreda shares borders with Gondar town and Lay Armachoho in the North, Gondar Zuria in the east, Chilga and Alefa woredas in the west and part of Lake Tana in the south. Total area of the woreda is 1490 km^2 with 45 kebeles (of which five are urban centers).

Fogera and Libo Kemkem woredas are located in South Gondar zone. Fogera is borderd by Libo Kemkem woreda in the north, Dera woreda in the south, Lake Tana in the west and Farta woreda in the east. Woreta is the capital of Fogera woreda and is located 625 km from Addis Ababa and 55 km north of the regional capital, Bahir Dar. The Woreda is divided into 25 rural PAs and five urban kebeles. Libo Kemkem is bordered by Gondar Zuria and Belesa woreda in the north, Gondar Zuria and Lake Tana in the west, Fogera in the south and Ebinat in the east.

2.4.2 Geographical location

The geographical location of the Tana basin extends from 10.95^o N to 12.78^o N latitude and from 36.89^oE to 38.25^oE longitude. Lake Tana is the largest lake in Ethiopia. It is located from 11.62^oN to 12.31^oN latitude and from 37.01^oE to 37.64^oE longitude. On the other hand, Fogera woreda is located at $11^0$44'-$12^0$03'N latitude and $37^0$25'-$37^0$58'E longtude, Dembia at $12^0$17'N latitude and $37^0$26'E longitude and Libo Kemkem at $11^0$57'-$12^0$20'N latitude and $37^0$25'-$37^0$58'E longitude.

2.4.3 Topography and land use

The topography of the study area is generally flat or plain. Flat or plain topography constitutes some 51 to 87% of the total area of the woredas.

Individual woredas generally may vary in topography. Plains dominate much of Dembia, i.e., 87%; mountains constitute 5%, valleys 5% and swamps 3% (Dembia Woreda Agriculture and Rural Development Office (ARDO), 2006). The elevation of the woreda varies between 1790 and 2600 m.a.s.l. In the woreda, various land use patterns are recognized. According to the information gathered from the woreda ARDO, out of the total area of about 150 thousand ha, 33% is used for annual crop production, 13% for grazing, 6% for forest plantation, bush and shrubs, 16% is degraded (unproductive) and the residential areas constitute about 4%. The terrain is typically characterized as plain with some hills. The land is gradually being degraded due to pressure exerted by natural causes and human activity. Active deforestation has resulted in severe soil erosion.

In Fogera woreda, plains or flat lands account for 76%, mountains and hills 11% and valley bottoms 13%. Elevations range from 1774 to 2410 m.a.s.l. The total land area of the woreda is 117,405 ha. Average land holding greatly varies, i.e., 0.5 to 3.0 ha with a mean of about 1.4 ha.

The altitude of Libo Kemkem woreda ranges from 1800 to 2850 m a.s.l. Some 7% of the woreda is covered by forest.

2.4.4 Agro climatology

Table 3 shows the mean rainfall and temperature data of Gorgora, Gondar, Makesegnit, Addis Zemen and Woreta, which are meteorological stations in the east and north of Lake Tana, and close to the study area**. These are the closest weather stations that can represent the study area.** The plains surrounding Lake Tana are characterized by mono-modal rainfall pattern, i.e., with single growing season. The growing season on average starts in May and ends in October. The average onset of rainfall is at about mid May which can also vary from early May to the end of May. On average, the length of the growing season (LGS) of crops in most parts of Tana plain is about 180 days. On the other hand, Engida (2003) reported that the mean length of the growing season in South Gondar around Lake Tana extends from 140 to150 days. Lake Tana area of South Gondar lies close to the current study area.

The agro ecology of Dembia and Fogera plains is traditionally classified as *Woina Dega*, i.e., mid-altitude. The mono-modal *meher* (main) rainy season extends from June to September with average annual rainfall of about 1067 mm in Dembia, 1123 mm in Libo Kemkem and 1296 mm in Fogera (Table 3).

The mean annual potential evapotranspiration is about 1600 mm. A mean annual maximum temperature of 29^{o}C and a minimum of 13^{o}C, and an overall mean of 21^{o}C is reported. This indicates that Tana Plain belongs to the mild thermal zone (Engida, 2003). According to the Ethiopian Ministry of Agriculture sub-agro ecological zonation (MoARD, 1998), the Tana plain is classified as Tepid to cool moist plains.

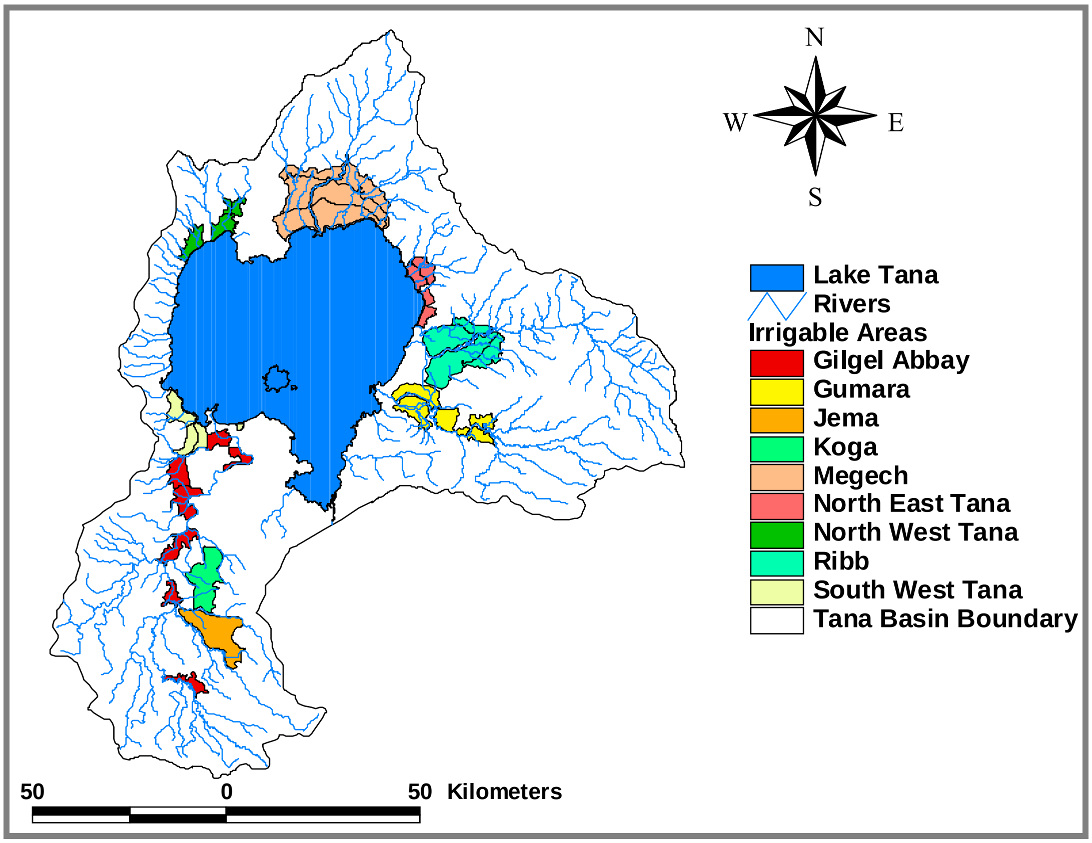


Fig. 1: Proposed irrigation projects in Lake Tana basin by MoWR

2.4.5 Population density

According to the population projection of Central Statistical Authority (CSA) for the year 2008, the total population size of Dembia was 335,641, Libo Kemkem was 209,755 and Fogera was 251,714. Throughout the study areas, the sex distribution shows a slightly higher male population than the female population (Table 4). The population density of Dembia was 225, Libo Kemkem was 179 and Fogera was 233 people per km^2. This is a rather high population density that exerts severe pressure on natural resources of the area.

2.4.6 Proposed irrigation developments in Lake Tana Basin

The Ethiopian Ministry of Water Resources (MoWR) is currently developing a number of development proposals around Lake Tana. As many as five dams are proposed within about nine projects that include projects on the Rib, Gumara and Megech rivers (Fig. 1). Construction of dams in Ribb and Megech rivers has started since 2008. The proposed irrigated command area of Megech is about 7 thousand ha and Ribb is 20 thousand ha. Pump irrigation potentials in the northwest of Lake Tana is under detailed study, which is intended to irrigate some 5 thousand ha. With a World Bank support, a feasibility study of a further 80 thousand ha is proposed in the basin.

3. RESULTS AND DISCUSSIONS

3. 1 SOCIO-ECONOMICS

3.1.1 Institutions

Institutions play a vital role in promoting people's participation in the supply of services and resources for human devlopment, improving resource allocation and for ensuring effective public service delivery. Grassroots instituations have proved to be the most effective partners in the fight against poverty. The Extension Service, cooperatives, credit and market organizations, and water user associations were some of the major institutions that were observed in the study areas.

3.1.1 Extension service

Agricultural and Rural Development Offices are engaged mainly in technology transfer and dissemination in their own mandate areas. To disseminate technologies, these offices currently use the Training and Advisory Extension System. At the time of the study, family package and mimimum package were being delivered to farmers.

Family package-Under this approach a set of extension packages is prepared, organized and offered to the farmers. The socio-economic status of the household is studied in advance to assess the impact of the package on the livelihood of farmers at a later date. However, a household can implement more than two packages at once. The target is to meet certain income level within a year. The package considers factors such as capacity, market, availability of inputs and profitability. The extension agents are responsible for close monitoring of the households until the end of the project, which can last for a few years.

Minimum package-Majority of the farmers are included within this package. They implement this form of package based on their need, economic status, and input supply. A farmer can choose any package, which he must implement according to the the recommended standard package. Farmers obtain inputs from the market through credit and/or using their own resources. Development Agents (DAs) constantly train and advise farmers who are using the minimum package. They also advise farmers to gear them towards market-oriented packages.

These extension packages are implemented at the grass roots level. Three extension agents are assigned at each kebele. One of them specializes in the field of crop science, the other on animal science and the last one on natural resources conservation. One Farmers Training Center (FTC) is established in each kebele of the study areas. However, most of them are not functional yet.

DAs use the group and individual extension method. Venues to transfer messages include worship places such as churches and community meetings. The ratio of extension agents to farmers in Dembia was 1:445, in Libo Kemkem 1:409 and in Fogera 1:419 (Table 5). This implies that one extesion agent serves more than four hundred househoulds. Each district of the study areas has a shortage of qualified extension personnel.

In most of the study areas, the adoption level of improved technologies is minimal due to poor extension service. Case in point is the extensive growing of old sorghum varieties in much of Dembia. Although this sorghum variety tolerates waterlogging, a common problem in the area, which appears to be the reason why farmers have grown it for centuries, it, on the other hand, has poor plant stand and it is extremely low yielding and late maturing. Recently, farmers in the lower catchments bordering the lake are shifting to rice production. Farmers generally have a good experience and positive attitude towards the promise of irrigation activities. Nevertheless, they are not receiving organized irrigation extension service.

Table 3: Meteorological data in weather stations in and around Megech and Ribb irrigation command areas

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
Gorgora													
Mean rainfall (mm)	0.9	1.3	13.0	24.5	78.6	200.7	275.0	248.0	131.1	78.5	13.9	2.2	1067.7
Minimum temperature (^{O}C)	19.9	21.1	20.7	22.5	19.2	17.1	16.8	16.2	16.6	18.3	16.3	15.2	18.3
Maximum temperature (^{O}C)	31.0	32.3	32.5	31.5	31.0	27.8	25.5	25.2	26.5	28.4	29.2	29.2	29.2
Mean temperature (^{O}C)	25.5	26.7	26.6	27.0	25.1	22.4	21.1	20.7	21.5	23.4	22.7	22.2	23.7
Maksegnit													
Mean rainfall (mm)	1.6	0.2	14.4	37.5	64.4	142.3	311.5	303.6	90.8	42.3	20.4	3.1	1032.2
Minimum temperature (^{O}C)	10.5	13.0	14.4	15.6	15.5	14.4	14.2	14.2	13.4	13.1	11.7	9.7	13.3
Maximum temperature (^{O}C)	28.8	30.5	32.0	31.0	30.6	27.6	24.4	25.3	26.8	28.3	29.2	25.3	28.3
Mean temperature (^{O}C)	19.7	21.7	23.2	23.3	23.1	21.0	19.3	19.8	20.1	20.7	20.5	17.5	20.8
Gondar													
Mean rainfall (mm)	2.2	3.5	16.8	36.8	84.4	154.3	285.1	269.6	109.4	71.1	19.9	7.8	1060.9
Minimum temperature (^{O}C)	11.8	13.3	14.8	16.0	16.1	14.3	13.7	13.6	13.1	13.2	12.5	12.0	13.7
Maximum temperature (^{O}C)	27.7	29.2	29.9	29.8	28.7	25.4	22.7	22.8	25.2	26.6	27.4	27.5	26.9
Mean temperature (^{O}C)	19.8	21.3	22.3	22.9	22.4	19.9	18.2	18.2	19.2	19.9	20.0	19.8	20.3
Humidity (%)	37.8	34.0	37.2	39.3	47.9	66.4	79.4	79.8	70.4	54.4	48.2	40.0	52.9
Sunshine hours	9.1	9.3	8.2	7.6	7.8	5.1	4.4	4.9	7.0	7.5	8.6	7.7	7.3
Wind speed (m/s)	1.4	1.5	1.6	1.5	1.7	1.7	1.2	1.1	1.2	1.1	1.1	0.9	1.3
Addis Zemen													
Mean rainfall (mm)	0.0	1.1	9.9	26.8	45.4	168.3	399.0	306.8	112.9	44.7	8.2	0.3	1123.4
Minimum temperature (^{O}C)	4.5	6.4	8.0	9.1	10.0	11.4	9.8	10.1	10.7	8.7	7.8	3.7	8.3
Maximum temperature (^{O}C)	30.9	33.0	33.0	32.7	31.7	28.0	25.2	25.5	27.2	28.9	29.7	19.4	28.8
Mean temperature (^{O}C)	17.7	19.7	20.5	20.9	20.8	19.7	17.5	17.8	18.9	18.8	18.8	11.6	18.6
Woreta													
Mean rainfall (mm)	0.3	2.2	1.7	15.0	58.0	204.7	334.9	425.0	171.4	61.6	15.7	5.8	1296.46

Table 4: Population size, composition and density of the study areas

Woredas	Total population	Male	Female	Total area (km^2)	Population density ($\#/km^2$)
Dembia	335,641	170,417	165,224	1,490	225
Libo Kemkem	209,755	106,497	103,257	1,174	179
Fogera	251,714	129,093	122,621	1,082	233

Table 5: Ratio of farmer to development agents across the study areas

Woredas	Number of rural Pas	Number of households	Number of DAs	Farmer:DA ratio
Dembia	40	57070	128	445:1
Libo Kemkem	29	45811	112	409:1
Fogera	27	41949	100	419:1

Source: Woreda Agriculture and Rural Development Offices

3.1.2 Cooperatives

Farming communities in eastern Lake Tana basin are organized in different cooperatives. In the study areas, an aggregate number of 76 cooperatives with close to 45 thousand members are identified (Table 6). Cooperatives specialize in certain areas of interest. Some of them may generally be multipurpose, but some are found focussing on irrigation, honey production, livestock fattening, fishery, diary, credit and savings and finally consumer's cooperatives. Overall, the majority of the cooperatives are multipurpose. These ones have more members and larger capital than other copperatives. Multipurpose cooperatives provide milling service, sell basic household goods, and distribute agricultural inputs in collaboration with the state owned Agricultural Input Supply Corporation (AISCO), the private owned Ambasel and the Unions. Moreover, these cooperatives play a great role in the marketing of grains by supplying agricultural inputs and by offering a competitive price for the products of farmers.

The second most important cooperatives are irrigation cooperatives. These ones provide inputs such as fertilizer, improved seeds, farm implements, etc., and play a role in the management of irrigation water. They also buy products from farmers, sell and distribute profits to members. Other cooperatives like honey processing, fattening, fishery and diary cooperatives are not common. However, the actual production and the potential is considerable.

Unions of service cooperatives such as Merkeb in Bahir Dar, Tsehay in Gondar and Megenagna in Debre Tabor were recently established. They have become strong input suppliers replacing the functions of regional giants AISCO and Ambasel. Megenaga Union members include six service cooperatives from Libo Kemkem, Merkeb Union includes two from Fogera Woreda and Tsehay Union includes eight from Dembia Woreda. These unions provide a back up service for basic cooperatives.

Cooperatives generally face complex and interwoven problems. These include among others daunting problems such as shortage of capital, marketing problems, lack of storage facilities and poor managerial skills of cooperative committees. Nevertheless, cooperatives still play a great role in economic development by organizing farmers, delivering agricultural inputs and buffering markets. Cooperatives are indispensable to transform subsistence farming to commercialization in the study areas. They need to be strengthened and assisted.

3.1.3 Water user's associations (WUA)

A number of traditional Water User Associations (WUA) are found across the study areas. These associations are usually organized around traditional irrigation schemes. The traditional irrigation schemes built by farmers are based on traditional water use rights that are recognized and respected by the local communities. These informal associations have their own bylaws for water allocation, operational standards and also they have provisions for penalties in case there happens to be water theft and provisions for failure to participate in maintaining the schemes. The traditional irrigation schemes possess good water management practices. The water management is dealt by *Yewuha Abbat* or a water committee. *Yewuha Abbat is* assisted by a group of water distributors. Conflicts are usually resolved by *Yewuha Abbat.* The water users adhere to all agreed rules and regulations. One of the strengths of traditional water use associations is that farmers are organized in small and common interest groups, which are effective, but they face poor financial and technical backup.

Table 6: Type and number of cooperatives in the study areas

	Dembia		Libo kemkem		Fogera	
Type	Number	Members	Number	Members	Number	Members
Multipurpose	29	16,937	12	13,668	17	12073
Irrigation	1	31	3	203	5	620
Milk	1	35	1	26	1	25
Honey	1	423	1	210	-	-
Fish	1	87	-	-	-	-
Fattening	3	168	-	-	-	-
Consumer	-	-	1	143	-	-
Saving and credit	-	-	-	-	1	112

Source: Dembia, Libo Kemkem and Fogera Offices of Agriculture and Rural Development

3.1.4 Credit

Farmers mainly require credit to purchase agricultural inputs, i.e., improved varieties, fertilizers, chemicals, water pumps, oxen, to practice crop production, fattening and rearing of animals and also for off and non-farm activities. The main institutions that provide credit for farmers are cooperatives and the Amhara Credit and Savings Institute (ACSI). Interest rates vary from 12.5% for cooperatives to 18% for ACSI. According to the informants, the communities prefer service cooperatives. The reasons are easy access, less procedure and low interest rate. However, the microfinancial institution ACSI is also operating in this area. It charges higher interest rate than service cooperatives. Farmers are reluctant to ask credit from ACSI because of its long procedure, peer group collateral requirement and monthly meetings.

Currently engine powered water pumps are being distributed to the farmers for irrigation. They are distributed with credit and some down payments. But because the majority of farmers are very poor, they cannot afford the down payment, and they simply fail to use the opportunity. The resource poor farmers organized themselves and requested the government, but did not receive positive response. This condition is creating a situation whereby the well-to-do farmers siphon off the benefit of the poor. Furthermore, those farmers who somehow managed to acquire the pumps still face a grave setback due to engine failure, which has become very common since the introduction of the Chinese brand of the pump. Many farmers complained that not even a liter of water was lifted with the new Chinese model. Maintenance service is also hardly available.

3.1.5 Inputs suppliers

The main input suppliers are service cooperatives, unions, AISCO, Ambasel and private traders. They supply fertilizers, improved seeds, farm implements, water pumps and chemicals. Farmers may obtain these technologies on credit and/or in cash. Particularly, the use of fertilizers is constantly increasing from time to time across the study areas. During the group discussions done in this study, farmers pointed out that the input systems are characterized by protracted delays, enforced supply, high prices, poor quality and some inputs are completely unavailable. They also revealed that the motor water pumps, which are imported from China, are not durable. Some relatively richer farmers buy inputs directly from input supplies in cash rather than through credit. This allows them to choose freely the best quality with no one dictating them. The study group has witnessed that some agricultural equipment, i.e., technologies such as broad ber maker (BBM) and pedal pumps were shelved in agriculture offices due to incompatiblity of the technologes with the real situation of farmers. Some preliminary observations and satellite tests need to be done in each area ahead of mass application of a technology. Enforced application of technologies won't bear fruit. Table 7 shows the list of agricultural inputs available in the area.

3.1.6 Non-governmental organizations (NGOs)

Given the fact that the study area is generally surplus producing, the number of NGOs in the study area is very minimal indicating their low contribution to the development efforts. In Dembia, there are a few NGOs such as SOS Sahel which is involved in beekeeping, the Ethiopian Orthodox Church involved in rural water supply and World Vision which has just started integrated rural development activities. In Libo Kemkem, World Vision and Organization for Rehabilitation and Development for the Amhara Region (ORDA) are involved in some rural development activities.

In Fogera, a project run by Improving Productivity and Market Success (IPMS) is trying to contribute to the reduction of poverty of the rural poor through market oriented agricultural development. The project creates an interface among farmers, extension agents and researchers. It also assists in input supply, marketing and financial institutions, including cooperatives. Such institutional support is delivered in the form of technical assistance, capacity building, demonstration and supply of training materials, and through some limited funds for developing innovative institutional arrangements.

2.1.7 Institutional analysis at the grassroots level

The major stakeholders in the overall development of the community were identified at the grassroots level in the study areas. Apart from identifying the types of institutions working in the area, the objective of the present study was to determine their roles and linkages and also understand the perception of farmers towards these institutions. Farmers identified different stakeholders along with their level of importance and degree of linkage amongst themselves (Appendex 1). Institutions operating at the grassroots level in the target area are listed in Table 8 in descending order of services they render to the communities. Table 8 shows institutions identified in the study area.

The major findings of the institutional analysis include the following:

- The church received the first priority for the community with regard to level of importance as well as linkage with the community in all woredas. This implies that the church has a great contribuation to the socio-econimic development of the community.
- According to farmers in Fogera, elders play significant role in the overall community development. Youth and women's leagues provide trainings and work for the good of the society.
- Sand mining cooperatives are considered as institutions since some farm families are earning cash in the name of landless youth. The new farmer generation is landless.
- The credit institution ACSI took the last position because of its unfairly exorbitant interest rate and lengthy procedure and bureaucracy.

3.2 Marketing

Marketing of agricultural outputs plays an active and critical role in economic development. Any improvement in the agricultural marketing system is a means of stimulating agricultural and economic development at regional and national level.

3.2.1 Cereal, pulse and spices crop marketing

In the study areas, agricultural activities are mostly subsistence. However, some part of the grain is supplied to the market. Crops are sold under normal conditions to fulfill the immediate cash needs of the rural families. In Dembia, there are six major crop market places and tef, chickpea, sorghum, faba bean and spices (white cumin, fenugreek and hot pepper) are the major cash crops. In Libo Kemkem, nine major market places are found and tef, finger millet, and hot pepper are the major cash source in the upper catchements of the woredas. In the lower stream, rice, finger millet and fenugreek are used as cash crop.

Since 1999, rice has become one of the best cash crops in Fogera district especially in the lower catchment (Tesfaye et al., 2005). Farmers sell the rice grain through different channels mostly to consumers, traders and processors. Local open markets are the most important means for rice marketing. Farmer traders (petty traders) are the ones who purchase rice from producers in rural markets and sell it in urban markets to consumers, traders and processors.

In the study areas, a large quantity of grain is sold and purchased from December to March, i.e., soon after harvest. Supplies of grain drop off and reach the lowest level from May to October. In local markets, assemblers, retailers and consumers are commonly involved as marketing agencies but in district market whole sellers are the part and the parcel of the system.

Men and women are involved in the marketing process of different agricultural products. Farmers reported that men are mainly involved in the marketing system especially where market places are far away from farmer's village. Decision making among the family on what, where and when to sell the agricultural products is mostly made by the wife and the husband.

Table 7: Agricultural inputs distributed in the study areas in different years

Dembia			Libo Kemkem			Fogera		
Year	Inputs	Amount (q/no)	Year	Inputs	Amount (q/no)	Year	Inputs	Amount (q/no)
1997/98	DAP	2651.8	2000/01	DAP	3093.0	1997/98	DAP	3817.5
	UREA	3729.8		UREA	3230.0		UREA	4140.5
1998/99	DAP	3075.3		Wheat (HAR-1685)	200.0		Maize (Awasa 511)	15.4
	UREA	4119.0		Wheat (HAR-604)	170.0		Wheat (1685)	38.1
1999/00	DAP	3800.0		Malt barely	320.0		Hot pepper (Marekofana)	0.2
	UREA	5075.0		Tef (DZ-01-354)	44.5	1998/99	DAP	3868.0
	Rice (X-jigina)	43.0		Chickpea	13.2		UREA	4110
	Hot pepper (Paperican)	75.0		Motorized pump	65.0		Wheat (1685)	26.3
	Maize (QPM)	50.0		Pedal pump	173.0		Maize (Awasa 511)	26.3
	Motor pump	40.0		Drip irrigation	497.0		DAP	3392.0
	Geo- membrane	4.0		Geo-membrane	73.0		UREA	2982.5
						1999/2000	DAP	4379.0
							UREA	4195.0
						1997-2000	Motorized pump	640.0
							Pedal pump	66.0
							Queen excluder	554.0
							Wax	5.2
							Geomembrane	9.0
							BBM	81.0
							Drip Irrigation	27.0

Source: Dembia, Libo Kemkem and Fogera Office of Agriculture

Table 8: Institutions identified by Informants in each woreda

	Dembia	Libo Kemkem	Fogera
1	Church	Church	Church
2	ADO* (kebele level)	ADO (kebele level)	Health post
3	Health post	Local Adminstration	Market
4	School	School	Adminstration
5	Farmers cooperatives	Health post	Land administration
6	Local Administration	Water use association	Mills
7	Animal health post	Farmers cooperatives	ADO
8	Water use association	Animal health post	School
9		ACSI (Amhara Credit and Savings Institute)	Veterinary
10			Elders
11			Telephone service
12			Youth league

* ADO stands for Agricultural Development Offices

3.2.2 Livestock and livestock products marketing

In the study areas, when crop production becomes vulnerable to calamities, livestock make momentous bestowal to the livelihoods of farmers and serve as sources of self-reliance against income shock. Under normal conditions, farmers sell small ruminants (sheep and goat) and chicken followed by heifers and bulls for immediate needs of cash. Farmers commonly sell butter, which is the most important livestock product. They also sell eggs and honey. In the study area, farmers don't sell milk.

Two main fish products are supplied from the study areas, i.e., fresh and dried fish. Dried fish marketing is a new phenomenon in the study areas. Dried catfish from the seasonal ponds of Fogera is suppled to Northern Ethiopia and Sudan. In Fogera, two large seasonal ponds are found, which are connected to the lake and are flooded during the rain season. As the water recedes, the ponds become more productive especially for catfish. Five years ago, catfish was never eaten by the local people because of social taboos and the fish had to die and rot in the pond. However, improvements in the market link to Sudan led to better trader interest in dried catfish.

Before the opening of the export market in Sudan, most of the cattle were mainly supplied to Gondar and Bahir Dar markets. Following the resumption of cross boarder trade with Sudan, a large number of cattle from these areas are supplied to Sudan markets through Ethio-Sudan border. The cross boarder trade with Sudan involves predominantly male cattle and a few medium to high quality female animals. Cattle marketing system of the study areas follows a complex web of relationships among key participants, namely farmers, traders, butchers and exporters. Livestock transportation is undertaken by trekking or trucking. Trekking results in quality deterioration of animals due to live weight loss for the long distance transportation.

3.2.3 Horticultural crops marketing

Vegetables are rigorously introduced to the farming system of the study areas in connection with the introduction of irrigation agriculture. The major marketable horticultural crops supplied in greater quanitity are shallot, onion, tomato and potato. Farmers are producing these crops using water pumps and river diversions. Farmers have three major alternatives for selling horticultural crops, i.e., right in the field (common for onion and tomato), selling at nearby markets, and small quantity is sold to distant markets. Tomato, onion and shallot are also sold by the road side by retailers and few farmers. The main receivers of horticultural crops from farmers are rural assemblers, retailers and wholesalers. Brokers have a great role in horticultural crop marketing. The marketing channels of horticultural crops in the study areas have more intermediaries as compared to other crops.

3.2.4 Marketing problems

In the study areas, various factors constrain the marketing of agricultural produce. Much of the study area is characterized by soils that are vertic in nature and once the rains start there is no going out of the villages to even the nearest market place. The road network (lack of all weather access road) is therefore one of the factors that hinder easy transportation of agricultural products resulting in low producer price. For example, the Tana Woina kebele farmers of Dembia do not have road access to dispose their horticultural crops grown under irrigation. During the rainy season, farmers cannot visit distant markets because rivers overflow and become difficult to cross.

The very poor transportation facilities further limit the number of farmer's market outlets. Prices are neither fixed nor announced particularly in rural markets. It is only when the farmer brings his/her products to the market that he/she will gain knowledge of current price development. Due to lack of recent market information; the farmers sell their products at low prices. Moreover, there is competition amongst farmers in the market since they produce more or less similar crops with both rainfed and irrigated agriculture.

Vegetable production in the study areas is mainly with irrigation where glut at harvest products is the main characteristics. This has resulted in low producer's price. The nature of the product on the one hand and the lack of organized marketing system on the other had frequently resulted in low output price. The perishable and bulk nature of the products forces the farmers to dispose off their products at any price offered to them. This exposes farmers to a wide range of cheating such as cheating on prices, grain weighing, and more. Moreover, constant influence of speculators and brokers reduces the bargaining power of farmers.

Generally, the marketing system in the study areas is inefficient due to low product prices, the actor's and middlemen's misbehaviour, poor access to transportation and the farmers' own weak bargaining power. The market imperfection prevailed because of information asymmetry. Measures have to be taken to improve the situation. The system can be successfully commercialized only if it is supported with an efficient marketing system.

3.3 Income source

The farmers in the study areas are subsistence farmers. They need cash to pay tax, settle credits, buy clothes and other household goods and purchase some agricultural inputs. Farmers get cash by selling grains (rice, tef, sorghum, chickpea), small ruminants, and by practicing off-farm activities.

Currently horticultural crops (onion, shallot and tomato) have become a source of income of farmers as a result of improving irrigation activities.

In the Tana watershed, around 23% of the households participate in non-farm and off farm activities (BoARD, 2003; BoFAD, 2004). The major non-farm and off farm activities (alternative livelihoods) of the study areas are extracting and selling sand along the river banks, working as a casual labourer; handicrafts, petty trading, and service delivery. Extracting and selling sand is a major source of income for the youth, the landless and the poor. The rivers serve as the major source of sand for construction projects in Bahir Dar and Gondar towns.

Alternative livelihood activities of the areas are also constrained by marketing problems as a result of poor development of infrastructure, poor market outlets, absence of information network and the poor purchasing power of the supposed clients. Moreover, practitioners of off-farm and non-farm activities are constrained by lack of training (extension support) to upgrade their skills, lack of raw materials specially for blacksmiths and weavers in nearby markets and lack of enterprunership skills (Akalu and Tesfaye, 2007).

3.4 Labor

Labor is the main input in the overall agricultural activities. It plays a significant role in the production and productivity of smallholder farmers. Efficient use of agricultural labor implies the use of available household and/or community level labor in all agricultural activities production-marketing continuum.

3.4.1 Labor sources

In most areas, the major sources of labor are family, group work and hired labor. Family is the most available labor source while group work/*webera*/ is usually held during peak periods of weeding and harvesting. The labor shortage during peak periods such as weeding time creates job opportunity to the neighboring farmers who are in most cases at slack period.

3.4.2 Labor demand

Tasks performed by men and women farmers of the study areas are assessed on monthly bases. Both men and women farmers appear to be involved in all of the agricultural activities. Table 9 shows the roles of men and women farmers.

3.4.3 Intensity of labor demand

Assessing the labor inputs over work types enables to identify the months of the year when farmers of the two gender groups become busy or enjoy slack times. In other words, knowledge of labor demand intensity helps to plan interventions over appropriate months of the year. After listing the activities of men and women farmers on monthly bases, farmers of the study area identified months of the year that demand high, or low, labor force based on workloads. In Dembia and Fogera, ranks varied with gender. In Libo Kemkem, rankings were the same between men and women because there was no significant specialization. Both sexes demand labor equally throughout the year. However, women may need extra labor to accomplish home duties. Men also practice some duties that are traditionally regarded as women’s duties. In Fogera, women can be seen ploughing fields. Using labor demand calendar, farmers of both groups outlined peak and slack seasons (Tables 10 and 11).

Table 9: Role of men and women farmers in the study area

Women	Men
January	
o Preparation for annual occasions o Cutting and collecting sorghum o Preparing animal feeds o Irrigating and weeding o Harvesting and threshing (chickpea and fenugreek) o Collecting cotton	o Harvesting and threshing crops (sorghum, chickpea, grass pea) o Ploughing o Preparing animal feeds o Irrigating and weeding o Collecting cotton o Preparation for annual occasions
February	
o Collecting emmer wheat, maize o House construction o Livestock care o Harvesting, cutting and marketing of onion o Irrigating o Focus on normal household chores o Preparation for annual occasions	o Collecting emmer wheat, maize o House construction o Livestock care o Holiday preparation o Harvesting, cutting and marketing of onion o Collecting and preparing animal feeds o Irrigating
March	
o Irrigating, hoeing,weeding o Marketing (onion, potato) o Harvesting and threshing safflower o Preparation for annual occasions	o Irrigating, hoeing, weeding o Marketing (onion, potato), o Ploughing/*tigat* o Harvesting and threshing safflower o Preparation for annual occasions
April	
o Seed bed preparation o Collecting sorghum stubble o Focus on normal chores more on preparing edible pepper/ “chew”	o Ploughing/tigat o Planting if it rains o Ploughing for secondary irrigation
May	
o Seed bed preparation o Seed exchange o Planting rice o Weeding and ploughing o Home duties o Transplanting pepper	o Seed bed preparation o Ploughing for maize, pepper o Aquiring and preparing seeds o Planting (finger millet, sorghum, maize, rice)
June	
o Seed delivery o Seed bed preparation o Weeding o	o Ploughing o Planting o Weeding depending on rains o Weeding (finger millet, rice)
July	
o Seed bed preparation o Transplanting pepper o Collecting animal feed o Weeding	o Land preparation for tef o Transplanting pepper o Preparing animal feed o Collecting animal feed o Weeding

August	
o Seed bed preparation Transplanting pepper o Weeding o Preparing irrigation checks o Water harvesting/blocking for rice	o Transplanting pepper o Weeding o Preparing irrigation checks o Land preparation for chickpea o Water harvest/blocking for rice o Planting (white cumin, red and white tef)
September	
o Focus on household duty o Preparing irrigation, preparing compost, transplanting pepper o Weeding (tef, finger millet, sorghum) o Collecting animal feeds o Harvesting barley	o Weeding (tef, finger millet, sorghum) o Ploughing (chickpea, fenugreek, safflower, lentil, grasspea) o Harvesting (rice, barley)
October	
o Weeding (finger millet, tef, sorghum) o Irrigating (pepper, cabbage, tomato, onion) and guarding o Pepper transplanting o Weeding (finger millet, tef, sorghum, pepper) o Household duties (*sifet*-crafting or basketry of household utensils), pepper planting o Preparing threshing plot and storage	o Planting, weeding (finger millet, tef, sorghum, onion) o Harvesting tef (*fesho, bukri*), barley, faba bean, rice o Irrigation (pepper, cabbage, tomato, onion) o Weeding (finger millet, tef, sorghum) o Preparation for irrigation o Irrigating (pepper, cabbage, tomato, onion), guarding
November	
o Collecting and piling the rice crop o Taking care of livestock o Weeding, irrigating and guarding birds o Harvesting red tef, rice o Threshing, cooking and serving food for threshers o Transporting straw	o Harvesting, collecting and stacking o Threshing o Weeding, irrigating and bird scaring o Harvesting (rice) o Taking care of livestock o Transporting straw home
December	
o Threshing, cooking and serving food for threshers o Irrigating o Collecting and stacking	o Harvesting sorghum, finger millet, tef /white/ o Irrigating

Source: Interviewed farmers. Normal household duty refers to the day-to-day activity of women regardless of the time of the year

Table 10: Labor demand intensity of male and female farmers in descending order

Dembia		Fogera	
Women	Men	Women	Men
1. July	June	July	July
2. August	July	October	November
3. November	August	August	October
4. December	September	September	August
5. January	November	November	September
6. June	October	June	March
7. September	December	January	June
8. October	January	December	December
9. March	May	May	May
10. February	February	February	January
11. April	April	April	February

Table 11: Demand for labor of men and women in Libo Kemkem woreda in descending order

Months	Main Activities
September	Working on both rainfed and irrigated agriculture
October	Pepper planting, preparing water canals for irrigation
June	Planting
November	Irrigating, harvesting, weeding, transporting of straw
July	Planting tef and pepper, weeding
January	Threshing grasspea, harvesting chickpea
December	Harvesting, threshing
August	Transplanting pepper
February	
March	Onion harvesting, marketing
May	Household duties
April	Seed bed preparation

3.5 Gender

Timeline and calendar are the tools that help to collect data related to gender issues. In this survey, the calendar tool was employed to collect and organize gender data in relation to labor specialization and access to and control over resources. Eventually gender division in the surveyed areas is minimal or insignificant especially in Fogera and Libo Kemkem. This is an advantage to efficiently utilize available labor in the rural areas and increase productivity. However, the upcoming irrigation projects are expected to impose more burden on women than on men. The effects of the irrigation projects on labor, resources, time and culture of the society of the study areas were analyzed. The gender analysis matrix of the target society for whom the intervention was proposed is shown in Table 12. The negative and positive effects of the development intervention on the society are summarized in Table 14. Despite minimal labor specialization based on the sexes, it is essential to introduce labor saving technologies (home appliances like improved stove) for women. Women also raise children and shoulder the burden of reproduction and other activities. Availabe labor should be utilized efficiently to avoid overload and stress especially on the part of women.

Table 12: Effect of irrigation on labor, resources, time and culture of the communities

Category	Labor	Time	Resources	Culture
Women	More labor required	Additional time needed	More food and cash	More and useful change in opinion (gender blindness, balanced dietary habit, etc.)
Men	Labor used for longer period	Whole day business	More cash	
Household	More	Longer	Improved living standard	
Community	More	More	Better community	

Table 13: Effects of irrigation on the community

Category	Positive	Negative	Possible action
Women	Access to living necessities enhanced	Workload	
Men	More cash	Work load	Hire labor and/or introduce technologies
Household	Better living standards	”	
Community	Good living environment	“	

3.5.1 Resource access and control

The type of the household (male or female headed) may affect the pattern of access to and control of resources. Farmers of the study areas described that men and women enjoy almost equal access and decision power over household resources. However, men usually have more decision power over the types of crops to be grown due to their better experience and knowledge of their fields.

4. CROP PRODUCTION AND MANAGEMENT

4.1 Field crops production

4.1.1. Types of crops grown

The farming system of the study areas is characterized by crop-livestock mixed farming. Crop production remains the main stay of farmers. Farm households depend mainly on crops both for food and cash income. The areas are more suitable for cereals, pulses and horticultural crops and to a lesser extent to oil crops. Tef, sorghum, finger millet, maize, rice, wheat and barley, among cereals; chick pea, grass pea and lentil, among pulses; niger seed and safflower among oil crops; potato, pepper, tomato, shallot, garlic, black and white cumin among annual horticultural crops are commonly grown in the area. Growing a diverse group of crops helps farmers to minimize potential risks of crop failure and helps them to fulfill their household requirements. Major field crops grown in the study area are listed in Tables 14 and 15.

Table 14: Major field crops grown, their area coverage and productivity in the three woredas

Dembia			Libo Kemkem			Fogera		
Crops	Area (ha)	Yield (q/ha)	Crops	Area (ha)	Yield (q/ha)	Crops	Area (ha)	Yield (q/ha)
			Cereals					
Tef	12570	14	Tef	5575	11	Rice	11085	63
Sorghum	9101	17	Rice	4961	55	Maize	10338	26
Maize	5110	26	Finger millet	2605	18	Finger millet	10257	22
Wheat	2800	19	Maize	2537	23	Tef	8090	9
Barley	2080	13	Wheat	2500	26	Barley	2487	18
Finger millet	1672	16	Barley	2311	20	Sorghum	389	20
Rice	93	40	Sorghum	1704	21	Wheat	287	22
			Emmer wheat	11	15	Emmer wheat		
Total	33426			22203			42933	
			Pulses					
Chickpea	6517	19	Faba bean	1966.9	9	Chick pea	520	15
Faba bean	772	12	Chick pea	1089	25	Grass pea	438	18
Grass pea	450	16	Field pea	925	10	Lentil	404	5
Field pea	50	7	Grass pea	541	20	Field pea	384	9
Lentil	30	7	Lentil	111	9	Faba bean	225	12
			Haricot bean	2.25	15			
Total	7819			4635.2			1971	
			Oil Crops					
Niger seed	360	5	Niger seed	1117	5	Niger seed	3779	5
Safflower	30	7	Linseed	331	5	Groundnut	115	12
Linseed	10	5				Linseed	66	5
Gomenzer	7	7				Rapeseed	28	8
Total	407			1448			3988	
			Horticultural Crops					
Potato	1200	116	Potato	1645	160	Potato	547	200
Shallot	870	84	Garlic	298	60	Pepper	1751	12
Pepper	1700	13	Shallot	295	70			
			Pepper	557	11			
Total	3770			2795			2298	
			Spices					
		13						
Fenugreek	238	10	Fenugreek	137	5	Fenugreek	5	5
Black cumin	980	10						
White cumin	2250	30						
Total	3468			137			5	

Source- Respective Woredas of Agricultural and Rural Development Office

Table 15: Major crops grown in Megech and Ribb rivers irrigation command areas by typology (recommendation domain)

Recommendation domain (typology)	Dembia	Libo Kemkem	Fogera
		Cereals	
Upstream	Tef, finger millet, sorghum (*Bulie*), maize, barley, wheat	Tef, finger millet, sorghum, wheat, barley, maize	Finger millet, tef, maize, emmer wheat, wheat
Lowstream	Rice, finger millet, tef	Rice, finger millet, tef, wheat, emmer wheat, sorghum, barley, maize	Rice, finger millet, maize, barley, wheat, emmer wheat, tef
		Pulses and oil crops	
Upstream	Faba bean, chickpea, grass pea, lentil, fenugreek, niger seed, safflower	Chickpea, grass pea, niger seed, safflower, field pea and faba bean	Grass pea, chickpea, Safflower, lentil
Lowstream	Chickpea, grass pea, safflower	Chickpea, grass pea, fenugreek, lentil, safflower mixed with barley and chickpea, nigers seed (reduced due to rice)	Chickpea, lentil, grass pea, fenugreek, ‘Feto’(*Lepidium sativum)*, safflower mixed with chickpea

Varieties

Seeds are one of the most important inputs to increase crop productivity. Farmers grow several varieties of crops with different traits that fit various needs and circumstances.

In the study area, farmers grow mainly their own varieties of most crops. A few other crops such as maize, wheat, rice and rarely tef are exceptions. The reason for not using improved varieties widely by farmers is that improved seeds are not available at planting time. In Dembia, local crop varieties have different names and characters. For example, sorghum; ‘*Issah’* and ‘*Abat Zengada’* is loose panicle sorghum that is planted on black soils, ‘*Demoezie’* ‘*Bulie’* and ‘*Amedo’* are with small compact panicles grown on red soils. Tef varieties include white, red, and ‘*Sergegna*. Only white barley variety is cultivated while finger millet varieties include white, red and black. Both white and red colored chickpea varieties are available..

Improved varieties grown in Dembia include Pioneer, BH 540, BH 660, BH 542 (quality protein maize) of maize and HAR1685 of wheat. In Libo Kemkem, the varieties include HAR 1685 and HAR 604 of wheat; x-jigna of rice; BH 540 of maize and a short unknown variety of tef.
In Fogera, x-jigna and ‘Gumara’ varieties of rice are common. The white (ivory) rice variety is preferred to the red one for both consumption and market value. X-jigna is not a released variety; it is a local variety found in *Jigna kebele* of Fogera woreda and newly expanded to the entire Northwestern Ethiopia rice growing belt. The Koreans are believed to have introduced it to the area during the *derg* regime.

4.1.2 Cropping pattern

Cropping pattern is the system by which farmers' grow crops in a particular sequence, mixture or rotation. Among several cropping systems, farmers in the study areas mainly practice crop rotation and intercropping. Some farmers at the lower stream (on black soils) practice double cropping by using residual moisture with some supplementary irrigation.

4.1.2.1 Crop rotation

Almost all farmers in the study areas practice crop rotation to restore the fertility status of the soil as well as to minimize the buildup of weeds, insect pests and plant diseases. The most common crop rotations are cereal-legume-cereal, cereal-cereal-cereal, oil crop-cereal-pulses, horticultural crops-cereal-pulse and cereal-cereal-pulse. The cereal-cereal-cereal approach is the most widely practiced. In the lower stream, most farmers grow rice for two to three years without rotation. This might be because cereals are the major food crops for the community. Absence of rotation can contribute to soil fertility depletion and buildup of diseases, weeds and insect pests.

The most common crop rotation systems across the surveyed areas is:

- Tef-fingermillet/sorghum-chickpea/grass pea
- Niger seed- tef- finger millet/sorghum
- Pepper-maize/finger millet/sorghum
- Sorghum (*zengada*)-tef

Though not as widely as crop rotation, some farmers in the study areas practice some mixed cropping of different crops. Intercropping of sorghum (*zengada*) with barley is widely practiced in Dembia area. Intercropping of safflower with barley, grass pea and chickpea are common practices in all the study areas. Farmers believed and justified that they practice intercropping to reduce environmental risk and to increase yield per unit area. In all cases the main and companion crops are planted simultaneously by broadcasting method.

In Fogera and Libo Kemkem woredas, farmers rarely practice relay intercropping of rice and finger millet with grass pea. In both cases the rice and finger millet are planted in June, and at the time of weeding in August or September, grass pea is over sown. When the garss pea is at the vegetative stage, the main crops (rice or finger millet) mature and they are harvested. Sometimes, the grass pea continues to grow, which is harvested later.

4.1.2.2 Double cropping

Some farmers at the lower stream of the surveyed areas practice double cropping on black vertisols by using residual moisture. The most common double cropping system in these areas is:

- Rice - chickpea/ grass pea/ maize
- Tef - chick pea/ grass pea/ maize/ fenugreek
- Finger millet - chickpea/ grass pea

4.1.3 Land preparation and planting

Farmers allot a field to a given crop depending on soil fertility, soil type and the precursor crop. The local oxen-drawn implement, i.e., *maresha,* is used for ploughing at a shallow depth. Priority in land preparation is given to cereals (tef, sorghum, rice, finger millet, barley, wheat) and horticultural crops (pepper, garlic, shallot, potato). Less priority is given to pulses and oil crops. Land preparation starts right after harvesting crops of the previous season. Depending on the precursor crop and the degree of weed infestation of the fields, for most crops the number of ploughings significantly varies, which ranges from 2 to 5 until the seedbed becomes fine and ready for planting. Farmers are not aware of recommended seed rates for most crops. Poor land preparation and low or high seed rate reduce productivity.

4.1.4 Crop calendar

A crop calendar is very important in understanding the farming system as it shows the priorities of the farmers in allocating their limited resources. Table 16 shows the schedule for the operations of the major crops starting from land preparation to harvesting and threshing.

4.1.5 Cropping seasons

Three types of cropping seasons are known in the study area, namely main season (rainfed agriculture), wet season with supplementary irrigation (residual moisture) and full irrigation in the dry season. Farmers near the lake are not used to growing crops using irrigation because the fields remain moist and boggy most of the year. Instead, they use the residual moisture that is always available and also use the land that is freed as the water recedes during the dry season (a system known as recession agriculture).

4.1.5.1 Main season cropping

The main cropping season is the most dominant system in the study area, when crops are entirely grown under rainfed condition. Each household who own irrigated land also has rainfed land inside or outside the irrigation scheme. Sorghum, tef, finger millet, maize, rice and barley, faba bean, field pea, niger seed and linseed are the most important crops grown in the main season. The cropping operation (from land preparation to harvesting/threshing) is accomplished from February of the first year to December of the next year, i.e., after the wet season and after the residual moisture crops are harvested (Table 16).

4.1.5.2 Residual moisture cropping

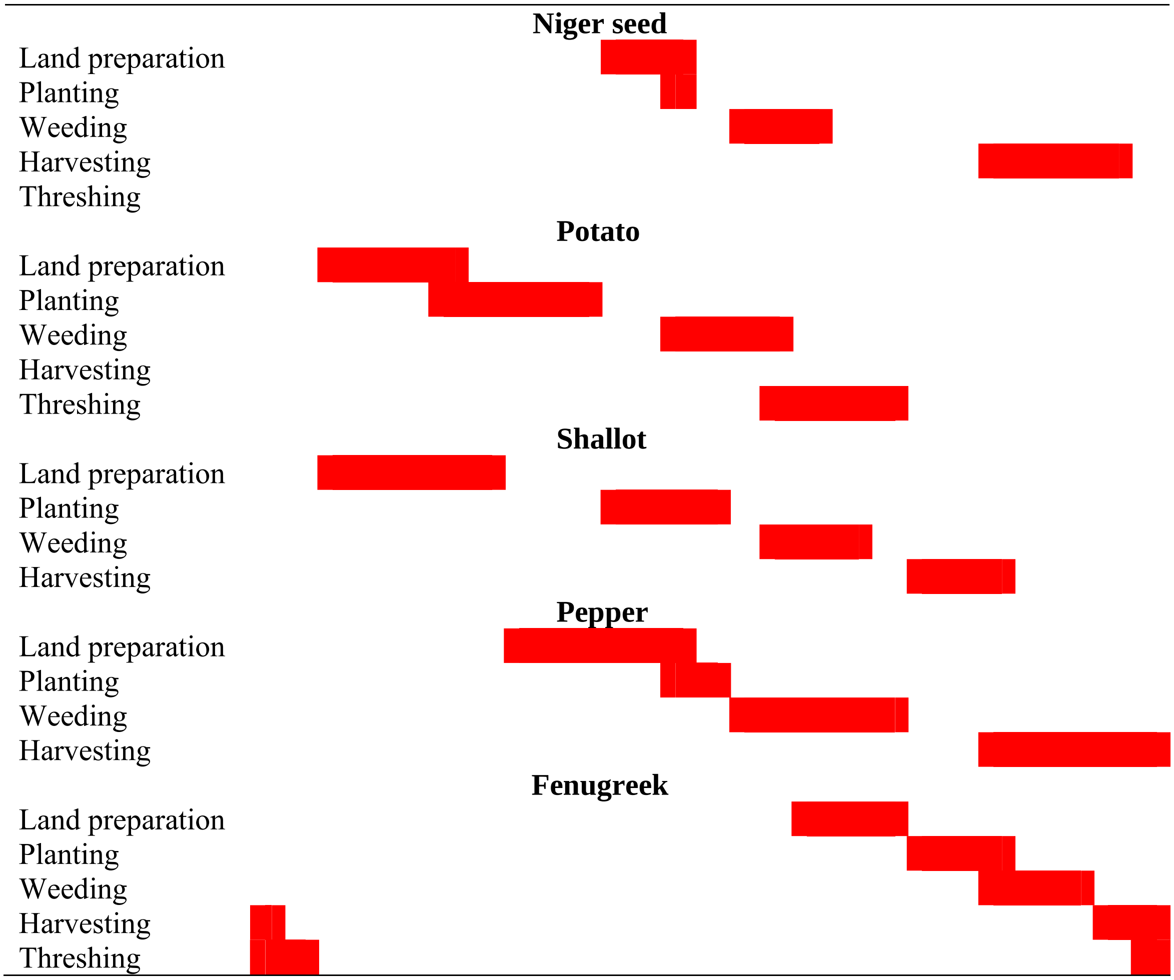
The wet season irrigated cropping is the crop which is planted with residual moisture in September. The residual moisture cropping system is mainly practiced more in Fogera and Libo Kemkem than in Dembia. The most common crops grown are chickpea (also mixed with safflower), grass pea, fenugreek, wheat, emmer wheat, '*Fetto'* (*Lepidium sativum),* tef, barley and maize. Supplementary irrigation may be given during the growing season as required.

4.1.5.3 Dry season cropping

Irrigation during the dry season starts with land preparation soon after harvesting the crops grown on residual moisture in December. The fields then become ready for planting after two to three passes of *maresha* around January. Planting dates can be staggered from January to March depending on crop type. Maize and vegetables (tomato, potato, onion, shallot, garlic, head cabbage and beet root) are planted with irrigation water during the season.

Table 16: Cropping calendar of major crops

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Tef												
Land preparation		X	X	X	X	X						
Planting						X	X					
Weeding								X	X			
Harvesting										X	X	X
Threshing											X	X
Rice												
Land preparation		X	X	X	X							
Planting					X	X						
Weeding						X	X	X				
Harvesting										X	X	
Threshing											X	X
Finger millet												
Land preparation		X	X	X	X							
Planting					X	X						
Weeding							X	X				
Harvesting										X	X	
Threshing	X										X	X
Maize												
Land preparation		X	X	X								
Planting					X							
Weeding						X	X					
Harvesting									X	X	X	
Threshing										X	X	
Wheat												
Land preparation		X	X	X	X							
Planting						X						
Weeding							X	X				
Harvesting										X	X	
Threshing											X	X
Barley												
Land preparation												
Planting					X							
Weeding							X	X				
Harvesting								X	X			
Threshing										X	X	
Chickpea												
Land preparation								X	X			
Planting								X	X			
Weeding										X		
Harvesting	X											X
Threshing	X											X
Grass pea												
Land preparation								X	X			
Planting								X	X			
Weeding										X		
Harvesting	X											X
Threshing	X											X



4.1.6 Crop management

Crop management practices contribute a great deal to production and productivity. Farmers manage their crop fields starting from tillage up to harvest. Management practices include tillage frequency, planting system, sowing date, weeding time and frequency, herbicide application, fertilizer application, selection of crops in need of chemical fertilizer and compost, '*shilshallow'* (maize, sorghum and finger millet at Libo Kemkem), timely irrigating, harvesting and threshing. Farmers at the lower stream do not use chemical fertilizers. This is because the soil is fertile alluvial soil that has been transported by floods downstream and deposited. Based on resources, farmers at the upstream may use fertilizer for maize, wheat, tef, finger millet and rice. The recommended rates are not strictly followed. They also use compost for maize, barley, tef and finger millet. In Dembia area, herbicides are used against broad leaved weeds on finger millet, barley, wheat and rice.

4.1.6.1 Weed management

Weed infestation of the cropping and grazing land varies from place to place depending on their abundance, crop type, farming system, rainfall and the intensity of floods. According to farmers, weed infestation and diversity is rapidly increasing in the lower stream areas. Floods carry the weeds downstream. A huge build up and expansion of thorny weeds infesting grazing lands and farmlands in the study area is a common scene. These thorny weeds are brought to the lower area by floods from upstream.

Farmers practice different weed control techniques depending on the level of infestation and crop type. Most prominent are continuous tillage and one to four hand weedings. Herbicides can also be used as witnessed in Dembia. Table 17 shows important weeds according to farmers.

Table 17: Major weeds reported by farmers in the study areas

Dembia	Libo Kemkem	Fogera
o Amekela (*Hygrophyla aurigulata*) o *Gizotia scabra* o Yewuha ankur (*Commelina* spp.) o Ager atfa (*Galinsoga parviflora*) o Gorteb (*Plantago lanceolata*) o *Argemon mexicana*	o Amekela o Orobanche (on tomato) o Striga o *Cuscuta* spp, o *Cynodon dactylon*	o Amekela *()*, o Kumhe o Yeberie sar o *Eliusine* spp. o Chanfa o *Argemon mexicana* o Amkenit o Arbeso o Kimza

o Note: some names given in common names o

4.1.7 Crop production trend

The production trend of the newly introduced crop, i.e., rice is increasing (Table 18). Rice is recently introduced to the lower stream areas of Dembia but in Libo Kemkem and Fogera, it has long been grown widely both at the upstream and lower stream. On the other hand, tef and niger seed production is decreasing because of water logging and decling soil fertility. Expanding irrigation practices are also increasing the diversity of crops. Maize, shallot, onion and tomato are added to the list of crops that are grown in the study areas, where these crops were little known in the past.

4.1.8 Crop production constraints

Different constraints reduce crop production and productivity in the study area. Low soil fertility, lack of improved varieties (for most crops), inappropriate time of seed supply, insect pests, weeds, diseases, lack of improved agronomic practices such as appropriate seed rate and planting method, cropping system, frequency and time of irrigation are wel known constraints. The use of the low yielding and long maturing local sorghum (*zengada*) variety is one of the production constraints for not using their land effectively, such as for double or triple cropping systems, because zengada stays in the field for up to 9 months before being harvested.

There is no rice dehulling machine close to the production area. Farmers either carry the grain far away to a place where they can find the machine and get their grain dehulled for a certain premium fee or they sell it at a low price to those who have the machine.

Table 18: Trend of area coverage, production and productivity of rice in Fogera woreda

Year	Area, production and productivity			Percent difference		
	Area (ha)	Production (000 q)	Productivity (q/ha)	Area	Production	Productivity
2000	1968	60	31	48	69	14
2001	2907	102	35	5	4	0
2002	3037	106	35	10	10	0
2003	3346	117	35	19	19	0
2004	3980	139	35	60	60	0
2005	6378	223	35	8	39	29
2006	6872	309	45	17	11	-4
2007	8014	345	43	15	-	-
2008	9213	-	-	-	-	-
Average	5079	175	37	23	30	5

Source: IPMS in Fogera Woreda

4.2 Horticultural crops production and management

4.2.1 Types of crops grown

Fruits and vegetables are an important component of a healthy diet and, if consumed daily in sufficient amounts, could help prevent major diseases and improve nutrition and health (Barany et al., 2001; WHO, 2005). Fruit and vegetable production, which can easily be undertaken by unskilled people, may play an important role in poverty reduction programs and food security initiatives, and also they can provide employment opportunities and a source of income. Horticultural crops are well adapted for small-scale production units and can provide relief for people at the individual household level while they also offer opportunities for trade and earnings of foreign currency (WHO, 2003).

In the study areas, horticultural crop production is a relatively new activity (taken up from 2004 onwards in the Dembia area), which is mainly triggered by the commencement of irrigation. Perennial horticultural crops are still rare and people rely on vegetables and other annual crops for their livelihood. Nevertheless, a few perennial crops like guava, mango, and orange are grown for subsistence in the higher slopes of Megech and Rib irrigation target areas particularly in Libo Kemkem and Fogera Woredas.

The list of major horticultural crops grown (vegetables, fruits, spices, and other perennials) is given in Table 19. However, only a few of the principal types of fruits are produced in significant amounts. Among the vegetables, tomato, Allium, hot pepper and potatoes are grown more widely than others.

Table 19: Vegetables, fruits, perennials, spice/ condiments and medicinal crops grown in the study areas

Scientific (botanical) name	Common name	Family
	Vegetables	
Allium cepa var ascalonicum	Shallot	Alliaceae
Allium cepa L.	Onion	Alliaceae
Allium sativum L.	Garlic	Alliaceae
Lycopersicon esculentum Mill	Tomato	Solanaceae
Capsicum frutescens	Hot pepper	Solanaceae
Solanum tuberosum L.	Potato	Solanaceae
Ipomoea batatas Lam.	Sweet potato	Convolvulaceae
Brassica oleraceae var. *capitata*	Cabbage	Crucifereae
Brassica carinata A.Br.	Rape seed (Gomen)	Crucifereae
Beta vulgaris	Beet root	Chenopodiaceae
Daucus carota	Carrot	Umbelliferae
Lactuca sativa	Lettuce	Compositae
Beta vulgaris var. *cicla*	Swiss chard	Chenopodiaceae
	Spice and medicinal crops	
Trigonella foenum-graecum L.	Fenugreek	Leguminosae
Ocimum species	Basil	Lamiaceae
Cuminum cyminum L	White cumin	Umbelliferae/Parsley/ Apiaceae
Nigella sativa L.	Black cumin	Apiaceae
Lepidium sativum L.	Garden cress	Cruciferare
Ruta chalepensis L.		Rutaceae
	Fruits	
Psidium guajava L.	Guava	Myrtaceae
Mangifera indica L.	Mango	Anacardiaceae
Musa paradisiaca L.	banana	Musaceae
Carica papaya(Linn)	Papaya	Caricaceae
Citrus sinensis Osbeck	Sweet orange	Rutaceae
Citrus reticulata Blanco	Mandarin	Rutaceae
Citrus limon Burm.	Lemon	Rutaceae
Citrus aurantifolia Swingle	Lime	Rutaceae
Citrus aurantium L.	Sour orange	Rutaceae
Citrus medica L.	Citron	Rutaceae
Persea americana Mill.	Avocado	Lauraceae
Prunus persica L.	Peach	Rosaceae
Coffea arabica L.	Coffee	Rubiaceae
Rhamnus piroindes L' Herit	hop	Rhamnaceae

4.2.1.1 Fruit bearing vegetables

The irrigation target areas generally enjoy warm (tropical) climate and are ideal for the growing of warm season crops like pepper and tomato.

Hot pepper. Hot pepper is one of the most widely grown crops in the study areas. It is produced both for its green vegetable and dry uses mainly for seasoning of foods. The major hot pepper production comes from rainfed than irrigated fields. Production area coverage of hot pepper is higher in Fogera (1,751 ha) and Dembia (1,700 ha) woredas than in Libo Kemkem (557 ha). In the low lying areas of Dembia, apart from the main season, pepper is planted from August to September and is grown with the residual moisture which is later supplemented with irrigation water to garuantee a continuous harvest of fruits till March and April. If the flooding and disease problems are successfully tackled, this crop seems to have a high prospect of expansion.

Tomato. Tomato is a major vegetable crop especially in Libo Kemkem and Fogera areas. It is grown staggered between about June and March. It is not grown in the rainy season because of disease problems. In the rainy season, the performance of tomato is generally very poor. In the Dembia area, farmers claim that staggered planting is difficult even in the off-season because the fields become excessively wet and are occupied by other crops. Tomato production peaks towards the mid dry season causing a market glut and falling prices. In contrast, in the rainy season, supply suddenly falls and the prices soar up.

4.2.1.2 Leafy vegetables

Head cabbage, *Gomen* (the leaves of rape seed), lettuce and swiss chard are the leafy vegetables grown in the study areas. Head cabbage is the most important leafy vegetable, which enjoys high demand from the consumers.

4.2.1.3 Bulbs, roots and tubers

Bulbs, roots and tubers consist of four crops, i.e., potato, sweet potato, carrot and beet roots. In the genus Allium three types of crops, i.e., shallot, onion and garlic are grown. Both garlic and shallot are traditional crops. Shallot excels both in terms of popularity and in the extent of production. In Libo Kemkem, shallot appears to be very important because its demand goes as far away as Metema and Gondar. Garlic is a major food seasoning agent grown rainfed or under irrigation. Todate, farmers prefer to grow garlic because it is not perishable and it enjoys good market access to Tigray, Wollo and Sudan. Onion, on the other hand, is a relatively new crop in the area, and its area coverage and relative significance varies from location to location. For instance, onion is not very popular both in Dembia and Libo Kemkem woredas mainly because of its low market demand, lack of access to seeds and low pungency (taste). On the other hand, in Fogera, onion production (for both seed and bulb) is steadily increasing. It is reported that the Fogera area is being considered as a source of onion seed for the entire Amhara region.

Potatoes are becoming one of the most important crops in the study areas especially with the introduction of rice cultivation. They are grown both in the main and off-seasons. Potato production is rapidly expanding especially in the bottomlands, where recession cultivation is common, and it is mainly grown after harvesting rice in Fogera and Dembia areas. Outside the recession farming area, potatoes are grown under irrigation long after the residual crop is harvested. Another variant evident in the Libo Kemkem area is the growing of potatoes under residual moisture. It completes its life cycle in the next main rainy season. Generally, this crop is increasing in the Dembia area.

Another crop introduced to the highlands of Libo Kemkem area for human consumption was enset. Nonetheless, because people in the area are not used to eating it, currently the crop is being used to make ropes.

4.2.1.4 Fruit crops

Fruits contain almost all known vitamins and many essential minerals (Simitu, 2005), give more yield per unit area and are more lucrative than ordinary farm crops (Gill et al., 1998). In the study areas, fruit production is at its infancy especially in Dembia. In this woreda, a few farmers grow mango, papaya, guava, coffee, etc. But, in Libo Kemkem, some 128 ha of tropical fruits are grown. Papaya and mango are the principal fruits produced in this woreda. It was also learned that there is high demand for orange, banana and guava.

Attempts are underway to produce temperate fruits such as apple and plum in the highlands that have been introduced by non-governmental organizations such as Winrock International and World Vision. In Fogera, lack of experience and the problem of waterlogging have significantly undermined fruit production especially in the irrigated areas. However, some sporadic trees of avocado, orange, coffee and chat may be found.

4.2.1.5 Spice/condiment, medicinal and other perennial crops

Fenugreek, white cumin, black cumin, basil, garden cress and *Ruta chapalensis* are grown in the study areas of which fenugreek appears to have a wider coverage. Some 238 ha of fenugreek is grown in Dembia, 137 ha in Libo Kemekem and 5 ha in Fogera. Generally, fenugreek followed by white cumin and basil in this order are the most important spices in the Dembia area. Basil and garden cress are widely grown in Fogera and Libo Kemkem woredas. The highest area coverage under white cumin (2250 ha) followed by black cumin (980 ha). is recorded in Dembia. It is reported that GTZ has introduced turmeric at Ambomesk nursery site.

Widely known for its medicinal value garden cress has wide area coverage in the Fogera area. Currently, this crop commands an attractive price, which according to growers is processed into oil. Citing Siegenthaler (1960), Amare (1976) listed the common medicinal values of this species: as a cure against livestock stomach disorders, chapped lips, sunburn, and other skin disorders. Also, mixed with honey it is used as a treatment for amoeba, as a repellent for mosquitoes and other insects, with black cumin and salt against stomach cramps, as an appetizer, etc. Other crops grown to a smaller extent in the study areas include coffee, sugar cane, chat and hops.

4.2.2 Productivity

In the study areas, fruit and vegetable crop productivity is far less than the potential. Based on estimates from the total area and production in 1999 and 2000 across the three woredas, tomato yields vary from 221-300 q/ha, shallot from 97-122 q/ha, garlic from 77-110 q/ha, onion from 118-210 q/ha and potatoes from 90-180 q/ha. Apparently, this is much lower than what is reported by the research centers from improved varieties of these crops. Research centers have reported tomato yields varying from 300-450 q/ha, shallot from 170-250 q/ha, garlic from 100-130 q/ha, onion from 300-400 q/ha and potatoes from 300-350 q/ha (EARO 2002, 2003, 2004). Similarly, according to reports the productivity of fruit crops varied with crop types: papaya from 180-220 q/ha, orange from 210 q/ha, guava from 150-210 q/ha and banana from 100-250 q/ha. Among spices, white cumin yields 25-40 q/ha, which is better than both black cumin, 8-12 q/ha, and fenugreek, 3-12 q/ha (Table 20).

Table 20: Productivity of horticultural, spice and other cash generating crops based on estimates from total area and production of 2007 and 2008

Crop type	Yield range (q/ha)	Crop type	Yield range (q/ha)
Shallot	97-122	Pepper	8-13
Garlic	77-110	Papaya	180-220
Onion	118-210	Orange	210
Tomato	221-300	Guava	150-210
Potato	90-180	Banana	100-250
Cabbage	175-201	Coffee	2-5
Carrot	110-204	Sugarcane	1250-2634
Lettuce	80-186	Fenugreek	2.6-12
Swiss chard	80-167	White cumin	25-40
Beet root	110-207	Black cumin	8-12
Sweet potato	160-271	Garden cress	5

4.2.3 Access to and use of improved varieties

Farmers in the study areas have limited access to improved varieties. Most of them use their own local varieties, which are generally low in productivity. Attempts were made to introduce the improved hot pepper variety *Mareko Fana*, which is known as *Gomade Keto* by local farmers. Because this variety was not grown widely, it could not advance well because of theft, and the perceived fruit drop problem and perceptions that the the local variety is more yielder than the improved variety. Thus, growers resort to their own local variety known as *Agere Qeto* (in Dembia) or *Sirba* / *Habesha Berbere* (in Libo Kemkem). This might need future investigation.

Onion varieties introduced to farmers include Adama-red in Dembia and Bombay red in Fogera. In Dembia, farmers do not want to grow Bombay red because of its poor germination. There is no improved shallot variety. Farmers in Libo Kemkem woreda identify two local varieties: *Dega shinkurt* and *Gojam shinkurt*. Improved varieties are not known in garlic either. Two tomato varieties: Roma VF (processing type) and Marglobe (fresh market type) are known across the study areas. Roma-VF (locally called *Sembersa*) is relatively early maturing and remains a major variety. In Libo Kemkem, farmers reported another variety known as *Acharo* (pear-shaped), which they claim is tolerant to pest attack and sun scorching. Growers do not have access to improved potato varieties. Nevertheless, in Libo Kemkem farmers identify two potato types known as Debre Tabor and Adet, which might perhaps be improved varieties.

Use of improved varieties in fruit crops is no different from vegetables. With few exceptions, the local fruits grown are never grafted. However, a few farmers grow some mango varieties namely Kent, Kett and Tommy Atkins in Dembia and Libo Kemkem. These are international varieties with varying periods of maturity, which if they are systematically exploited, could lengthen the production period. In Libo Kemkem, there is evidence that the following fruit species and varieties have been introduced to growers: papaya (local), coffee (7454, 74110, 7441,741, 75227), orange (Washington navel, valencia, hamlin, pineapple, campbell), avocado (unknown), mango (tommy atkins, kent, kett, local), banana (poyo, cavandesh), mandarin (temple, orlando, clementine, fairchild) and lime (Finote Selam). The orange variety, Washington navel has reportedly better performance but does not ripen properly which is perhaps due to inadequate heat. Improved varieties are completely absent in spice crops.

4.2.4 The production system

Horticultural crops flourish in moist and fertile soil. Four types of vegetable production systems could be distinguished across the study areas:

Rainfed. Hot pepper is a major vegetable crop grown under rainfed conditions. Closer to the lake, vegetables are commonly grown under rainfed conditions and using the land that becomes free as the lake water recedes during the dry season.

Residual moisture.Crops grown under residual moisture include shallot, garlic and garden cress. In Dembia, pepper is also grown under this system, but it needs some supplemental irrigation to extend the harvest as the dry season progresses.

Irrigation. Two cycles of irrigation production are practiced; October to January and February to May. Typical irrigated vegetable and spice crops include Allium species, tomato, leafy vegetables and fenugreek (Table 21). Tomato and Allium are the first in area and production under irrigation. Previously these two crops used to be grown from January to February. Later, their production period has dramatically extended through staggered planting. Nevertheless, since water becomes limiting as the dry season advances, and due to the upcoming main season rains, their production time could not be extended any further. On the other hand, in Dembia, staggered planting was reported difficult as the land gets too wet to cultivate or because the fields remain occupied by other crops.

Following receding water. Some vegetable crops, and not others, are particularly grown following the receding water of the lake. The principal crop under such system, grown after harvesting rice, is potato. To some extent, tomato and fenugreek are also produced under this system.

Others. Apart from the above systems, it was reported that ponds and hand wells have been used to grow horticultural crops. Some of the vegetables are grown in one or more of the above systems. Potato is grown under all the systems discussed. Fruits are normally started in the rainy season and given supplemental irrigation water as needed in the dry season.

4.2.5 Horticultural crops by woreda and typology

The types of horticultural crops grown also slightly varied by Woreda and typology (Table 21). In Dembia and Libo Kemkem, potato followed by shallot and pepper appear to be dominant especially in the lower slopes (plains). Among the spices/condiments, fenugreek is also grown widely in Dembia. In Libo Kemkem, hot pepper is grown mainly in the upper slopes in the main season; in the plains it is grown in rather few kebeles from November to December. Tomato, shallot and garlic are grown in the off-season in both typologies while garlic remains uncommon in the lower slopes. Fenugreek is produced in the lower slopes in the main season and in a limited extent in the off-season at the upper slopes.

In Fogera area, hot pepper appears to be the major crop during rainy season in both typologies. But, the two typologies vary in the type of other vegetable crops grown. Hot pepper, shallot and onion are grown in both typologies during the off-season. Tomato, potato and garlic were reported only in the lower slopes. Tomato is not grown in the upper slopes reportedly due to transportation problem. In addition, the lower slopes grow fenugreek and garden cress in the off-season.

Generally, the upper slopes across the study areas appear relatively well drained while the lower slopes are seasonally waterlogged. The upper slopes have the potential for growing most horticultural crops including fruits. Likewise, in the low lying areas the alluvial deposits near the river courses, which are deposited by rivers flooding the area during the main rainy season are suitable for horticultural crop production especially vegetables. These areas have triggered several people to take up horticultural crops production rather seriously. On the other hand, in poorly drained soils especially in clayey soils of the bottomlands, most crops particularly fruits could succumb to anaerobiosis and/or Phythophtora root rot, which could lead to poor root functioning or death. Besides, the wet stress may reduce tree growth and fruit production. Hence, these areas appear less suitable especially for the growing of fruit crops and force farmers to choose vegetable crops and spices instead of fruits. Fruits generally are well adapted to well-drained soils.

Table 21: Vegetable and spice/condiment crops grown by woreda and typology

Up-stream		**Down stream**	
Main season	Off-season	Main season	Off-season
Libo Kemkem			
Pepper	Shallot, garlic	Fenugreek	Tomato
	Potato	Pepper	Shallot, onion
	Tomato		Garlic (minimal amount)
	Fenugreek (limited)		Leafy vegetables
			Carrot, beet root
Fogera			
Pepper	Shallot	Pepper	Garden cress
	Pepper		Tomato
	Onion		Garlic, shallot, onion
			Potato
			Pepper
			Fenugreek
			Leafy vegetables
			Carrot, beet root
Dembia			
Potato	Cabbage	Potato	Potato
Hot pepper	Tomato	Hot pepper	Hot pepper
	Shallot		Shallot, garlic, onion
	Beet root		Tomato
	Carrot		Leafy vegetables
	Lettuce		Carrot, beet root
	Swiss chard		Fenugreek, basil, cumin (black, white)

4.2.5 Agro-techniques

4.2.5.1 Cropping calendar

Seasonal calendar of horticultural crops is shown in Table 22. Because of the various production systems, which give opportunities to grow vegetables most of the year, horticultural products especially vegetables are accessible all year-round indicating that they have great potential to contribute to food and nutritional security. Generally, rainfed vegetables are planted as the main rainy season commences in June. On the other hand, most residual vegetables are planted at the end of the rainy season in September while irrigated crops are pushed further until around January.

Table 22. Cropping calendar of some vegetables grown in the East Lake Tana basin

Vegetable/Month	J	F	M	A	M	J	J	A	S	O	N	D
Shallot	H	H	H	H	H	P	P	-	H	PH	P	P
Onion	H	H	H	H	H	-	-	-	P	P	-	-
Garlic	H	H	H	H	H	-	-	-	-	P	P	P
Potato	P	H	PH	PH	PH	-	H	H	H	-	P	P
Sweet potato	-	H	H	H	H	-	-	-	-	-	P	P
Tomato	H	H	H	-	-	-	-	P	P	P	H	H
Cabbage	H	H	H	-	-	-	-	P	P	P	H	H
Lettuce	H	H	H	-	-	-	-	P	P	P	H	H
Swiss chard	H	H	H	-	-	-	-	P	P	P	H	H
Carrot	H	H	H	-	-	-	-	P	P	P	H	H
Hot pepper	H	H	H	H	-	P	P	P	P	PH	PH	PH

Legend: P = planting, H = harvesting, PH = planting and harvesting

4.2.5.2 Cropping system, sequence and rotation

Vegetable crops are grown both in rows and randomly. Tomato and onion are normally planted in rows. The following crop sequence is followed:

- **Potato-pepper**-barley
- Tef-maize/barley/wheat- **potato** supplemented with the next main season rain (in Libo Kemkem)
- Tef-**allium**- maize
- Finger millet-tomato/**allium**/chickpea
- Rice- chickpea/ Lathyrus/ Lentil- **potato**
- Millet- maize/**fenugreek**/ chickpea- **potato**
- Barley- **fenugreek**
- Chick pea/ **fenugreek**/ **pepper** followed by maize, barley (in the upstream)

4.2.5.3 Intercropping practices

Intercropping is very common in vegetable crops like allium. In the Fogera area, the common intercropping practices are the growing of pepper with basil or cotton or all the three together. Pepper is also grown with garden cress. In the kebeles of the upper slope of Fogrera, tomato is grown intercropped with pepper. The practice of intercropping of black cumin with pepper was also reported in Libo Kemkem. Farmers reported that black cumin and pepper intercropping was widely practiced, which currently declined due to the newly emerging pepper diseases.

In Dembia area, mango trees were planted within garlic fields. Likewise, in Libo Kemkem, chat (*Catha edulis*) is intercropped with fruit crops. Generally, horticultural crops are intercropped randomly with no concern for spacings, compatibility and management of both the principal and companion crops. Overall, the high gestation period of fruit crops justifies that intercropping is a commendable practice provided careful crop combinations and regimes are made available.

4.2.5.4 Fertility management

Most fields especially towards the lower slopes are endowed with fertile soils, and the use of chemical fertilizers is negligible. Instead, compost is commonly applied on horticultural crops like hot pepper. However, fertilizers are commonly used in tomato, onion and pepper nurseries. Farmers reported sporadic use of urea in fruits in Libo Kemkem and DAP on pepper in Fogera.

4.2.5.5 Seedling and seed supply

For sustainable horticultural crop production, the key is, almost always, whether quality and sufficient planting materials are available. In the study area, the market, the NGOs and nurseries that belong to WoARDO supply planting materials. Each woreda has one or more nurseries: Aberjeha, Girarge and Dirma in Dembia; Addis Zemen in Libo Kemkem and Quhar Michael and Bebeks in Fogera. Both grafted and non-grafted fruit seedlings are distributed. Until now, neither private nor community nurseries operate in the area. Consequently, the price of some good seedlings is exorbitant. For instance, seedlings of improved mango varieties (as tommy atkins, kett and kent) are sold up to 18 birr per seedling.

4.2.5.6 Production trends

Generally, there is a greater tendency and surge of horticultural crops production in recent years. This must have been caused by the commencement of irrigation culture in the area. However, production trends among the different woredas, typologies and crop types are different. In Dembia, tomato, shallot and potato production exhibit an increasing trend. Nevertheless, in inaccessible areas like Tana Woina kebele shallot and potato production are becoming discouraging because of lack of transport and the perishability of the products. Unless measures are taken to connect these areas by roads as soon as possible, a full scale decline is expected. In Libo Kemkem, although reduction in production appears to be insignificant, area coverage under garlic, tomato and pepper tend to decline (Fig. 2 and 3). On the other hand, area and production under shallot and potato has increased.

In Fogera, unlike the other two Woredas, onion is gaining momentum in importance and is being widely grown. For instance, area under onion production has increased from more than 1.4 thousand ha in 2005/06 to over 2.4 thousand ha in 2007/08, while the corresponding figure for shallot was close to 1 thousand ha in 2005/06 and 651 ha in 2007/08 (Fig. 3 and 4). Expensive planting material, lower productivity and narrowing price gap are some of the reasons why shallot is on decline compared to onion. In contrast, cheaper planting material, higher productivity and low price gap compared with shallot made onions attain a rising trend in production. These days, consumers are also getting used to the taste of onions, which contributed to its expansion.

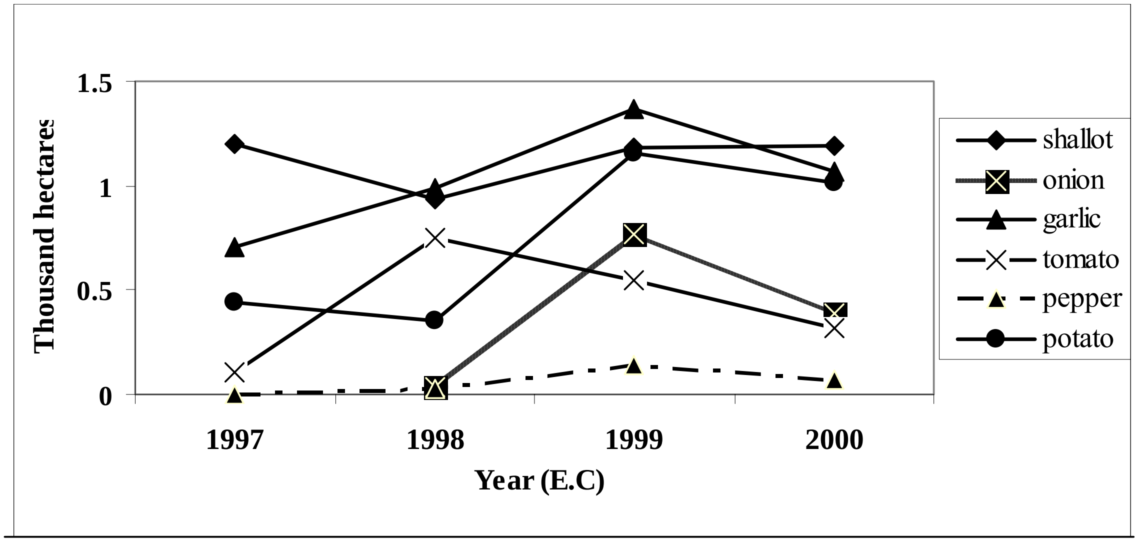


Fig. 2: Trend of area coverage of major horticultural crops in Libo Kemkem woreda

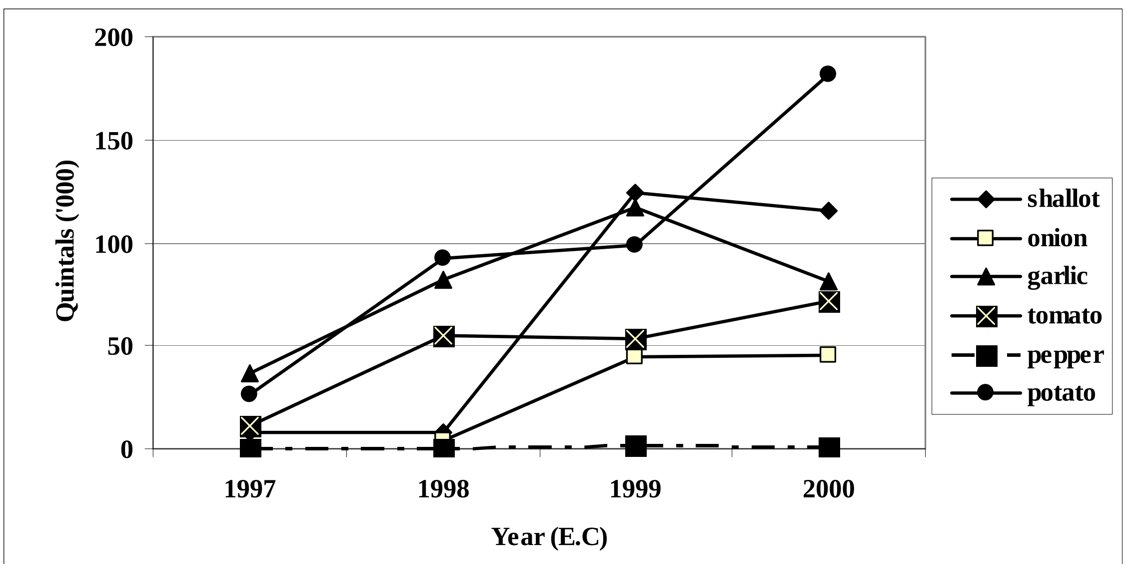


Fig. 3: Trend of production of major horticultural crops in Libo Kemkem woreda

This trend is commendable because onion offers relatively better advantage to shallot since both bulbs and seeds can be harvested. There is also an opportunity to generate foreign currency by exporting onion flowers. Tomato production is declining in Fogera due to marketing problem. A complex of diseases that appeared recently casued widespread decline in hot pepper production.

4.2.5.7 Challenges to horticulture development

Horticulture is one of the areas of the greatest challenge and opportunity in the study areas and in the region as a whole. Triggered by the commencement of irrigated agriculture, horticultural crops production raised a lot of hope that encouraged many farmers to enter into the business. Nevertheless, the venture did not fully succeed as yet due largely to various factors as bio-physical, socio-economic and cultural impediments. Some of the major constraints are discussed as below.

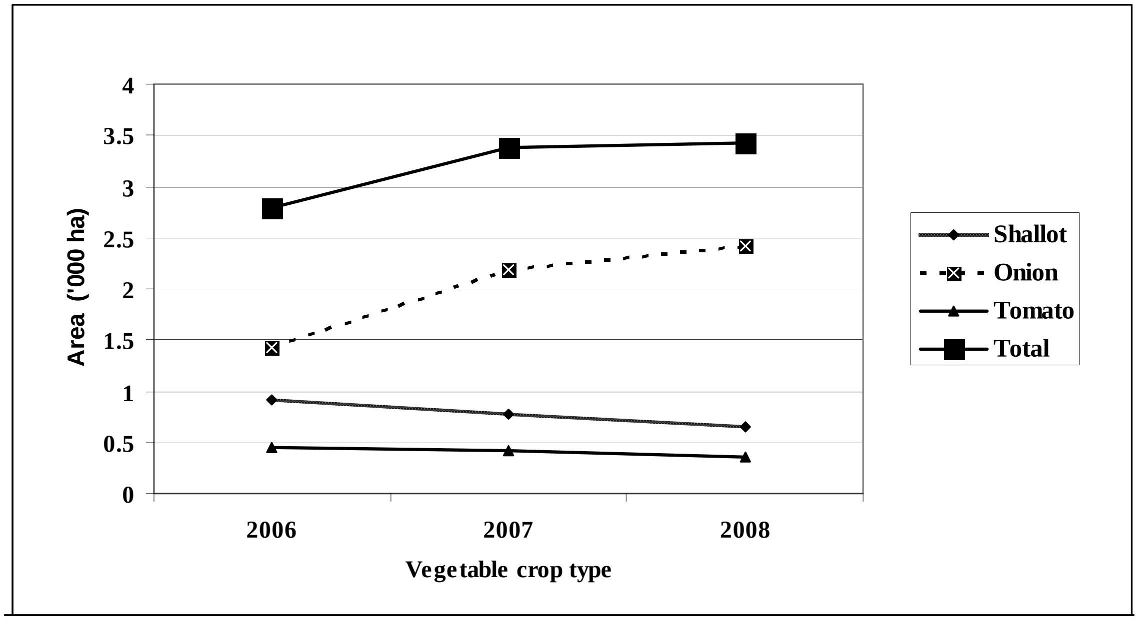


Fig. 4: Comparison of area coverage of tomato, onion and shallot in Fogera woreda

Bio-physical

Climate. When it comes to climatic factors rainfall pattern and unpredictability appear to be the major hurdle for the production of horticultural crops. Production of some horticultural crops such as tomato is not entirely taken up in the main season for the heavy rainfall that predisposes crops to the ravage of pests and diseases. Crops like the bulbs of allium become rotten right in the field because of the unecessary and rather detrimental rainfall that commonly falls during crop maturity. Moreover, excessive irrigation, drainage impediment, flooding from rivers that swell and overflow during the main rainy season, and moisture stress at the critical stages of crop growth are quite common problems, which play major role in undermining horticultural crops production. Residual crops face moisture shortage towards the middle of the dry season. However, most important of all is the flooding problem caused by river overflow that raises the water table and cause seasonal waterlogging.

Seasonality of production. Currently available early maturing tomato and Allium varieties are not only limited but they also mature at the same time. They are, therefore, disposed off to the market within a narrow period of time that often results in market glut. On the other hand, in the rainy season, because of rainfall and ensuing pests and diseases, the supply of some crops especially tomato dramatically declines. As a result, the price of tomatoes shoot up to more than three times compared to that of normal seasons.

Low production and productivity. Despite the high production potential of horticultural crops in the study areas, so far they are taken up as subsidiary commodities in diminutive scale. Besides, their productivity is far from ideal.

Lack of improved varieties. As mentioned earlier in this report, a steady supply of improved varieties does not exist, which forced most farmers to grow local varieties that are inferior in yield and quality.

Lack of knowledge of management practices. At present, horticultural crops production is undertaken based on farmers` local knowledge. This is particularly true for most fruit species, which are recently introduced. Their management is new to most people in the study areas as the case is true elsewhere in the region. There are a multitude of technical problems that need to be tackled as early as possible.

Pests and diseases. Aggravated by the widespread waterlogging condition and high atmospheric humidity, horticultural crops suffer from severe pest and disease damage than any other crop grown in the area.

Socio-economic

Competing priorities are a common problem. Irrigated horticulture faces stringent competition from field crops. This is because of concerns of food security of the family and the long gestation period and low prices of fruits. Therefore, farmers traditionally prefer cereals and pulses to horticultural crops. This suggests that keeping fruit production more remunerative is a necessary condition. When vegetable crops are produced in abundance, prices dramatically fall and fail to fetch the right price. Because horticultural crops are highly perishable commodities, they need to be marketed right after harvest. In the study areas, feeder roads are not available. Therefore, farmers have no access to markets (to sell products and also purchase inputs) during the entire rainy season. Other socio-economic factors include: lack of attention to product quality and prevention of physical damage, lack of post harvest technology such as storage facilities and inadequate research and extension support.

Cultural

People in the study areas, as elsewhere in the region, are accustomed to cereal and pulse-based diets. As a result, they have developed certain stereotype against other commodities. They therefore give priority to the production of traditional low-value crops such as sorghum and grass pea. Many horticultural crops and their utilization are all new to many inhabitants in the area . This has a huge negative impact on the expansion of these crops. People are not well aware of the benefits of fruits and vegetables.

Opportunities and threats

Opportunities

Major opportunities include:

- Farmers great interest and aspirations to pursue on horticultural crops production and modest experience on irrigation culture
- Favorable agro-ecology. The climatic and edaphic conditions of the study areas are within the range of the requirements of most horticultural crops growing environment. The elevation is 1800 m and above, which is conducive for growing most horticultural crops.
- The opportunity to plant horticultural crops at any time of the year as long as moisture is adequate. This gives an opportunity for all-year-round production.

- Locational advantage- the irrigation target areas have the advantage of asphalt road near-by so that they have good market prospects including access to foreign market outlets. Besides, they are near to ports of Djibouti and Sudan by road or by air from Bahir Dar and Gondar airports to European markets.
- As agricultural chemicals are hardly used there is a possibility for niche market exploitation under the brand name of organic produce
- NGOs give a leverage and synergy for horticultural crops promotion attempts by farmers and the Government institutions
- Strong political will in the promotion of horticultural crops and irrigation culture

These opportunities indicate that it is possible to establish a vibrant, rather successful horticulture business in the study areas more than anything else.

Threats

Looking into factors that might provide alternative future development of events concerning irrigated agriculture, it is assumed that there is a high prospect for horticultural crops production in the study areas. Nevertheless, in the face of escalating food prices, there is also a danger of shift towards cereal crops production so that the opportunity to promote fruit and vegetables would be lost. There is also a possibility that salinity will develop and restrict the growing of sensitive crops like tomato and can change the cropping system altogether.

Development and research needs

Development options

Both research and extension gaps exist in the study area, which are to be filled to increase horticultural production and productivity apart from developing basic infrastructure and recourses like drainage, storage, processing and marketing. Some of the existing conditions that need to be improved in the production of horticultural crops and suggested development strategies are briefly discussed as follows.

Related to agro-ecological conditions

- As a rule, vegetables of underground edible parts as onion, garlic, carrot, beet root, potato, and sweet potato should not be grown on black heavy soils in the low lying slopes, in the rainy season as this condition adversely affects quality. Alluvial soils are better suited for them.
- Sensitivity of fruit crops to flooding or high water tables varies with species. By having the capacity to survive several days of excessively wet or flooded soil conditions, guava appears to be the best alternative in the low lying high water table areas followed by grafted citrus species, mango and banana. These fruit species that are relatively tolerant to deluge or waterlogging should be grown. Since trees may sustain heavy damage or be killed by one to a few days of waterlogged conditions, avocado and papaya should not be grown in low slope areas. Well drained areas of the upper slopes are ideal for growing avocado and papaya.
- Practicing activities that help minimize the effects of seasonal flooding or high water table.

- For instance, to reduce the leaf water loss by transpiration from the root system so the remaining leaves do not desiccate and die, a portion of the tree canopy or fruits might need to be removed.
- Relieve soil compaction by digging deep
- Condition the soil by adding manure and household wastes.
- Use resistant root stocks.

Technical /management aspects

- Improved seed/seedling supply. Current sources of planting material are the government nurseries or the market, which are insufficient,. Seeds/seedlings obtained from the market are often time bound, low yielding and poor quality. The quality of planting materials is generally mediocre and its supply far from adequate.
- Develop vegetative propagation techniques and nursery procedures. For a sustainable supply of quality planting material, therefore, establishment of community nucleus or privately owned nurseries would be imperative, which will provide easy and cheap access to seedlings. Farmers should be able to produce vegetable seeds of their own consumption and even some need to be encouraged to specialize on this venture. Special attention may be given to onion because it requires cooler conditions for flower stalk development and dry and sunny conditions for maturity. In Dembia area, onion seed production would appear less productive because the temperature there is slightly higher than required. In Libo Kemkem, minimum temperature ranges between 3.7 to 11.4°C in December to February and this appears suitable for flower stalk development and seed production. Likewise, in Fogera plain, the temperature ranges from 10 to 27°C, which is suitable for onion seed production.

- The government nursery sites should be strengthened to serve as source of mother stocks for fruit planting materials. Extensively demonstrate and promote the already available improved technologies.

- Explore new economically feasible vegetable and fruit species, which would provide opportunities to diversify the resource base and achieve a better economic return. Lessons can be drawn from the success story of rice. By virtue of its water loving nature, sugar cane does seem to be doing well in the lower slopes, which needs to be verified. In relatively well drained areas, green beans can be grown for both domestic and export markets. Green beans are less bulky and can easily be air transported with a reasonable profit. Other crops that need testing include egg plant and sweet corn. Also, despite the sub-optimal situation for their proper growth, fruits like coconut and date palm may be tested along the shore of Lake Tana especially in the Dembia Woreda.

- To enjoy fresh products through a steady supply to the market as well as the would-be processing plants and prevent the boom and bust economy, some options that need to be adopted include:
    - Extending production period through staggered planting. However, in the rainy seasons this needs intensive management like pesticide application, staking (plant support), use of raised beds, tall or intermediate varieties, high seed rate, etc.
    - Growing of varieties of varying maturity. In tomato varieties of different length of growing season as Roma VF (early), Margobe (indeterminate), Melka salsa and Melka sholla (late) can be grown.
    - The use of plastic tunnels for off-season production of vegetables. This practice of protected cultivation is popular in advanced countries because it protects plants

from low winter temperatures. These are simple and less expensive plastic-covered structures, which resemble greenhouses used for the production of fruits and vegetables. Such tunnels were reported to enhance the yield, quality and earliness of the tomato crop (Khokhar, 2002). Provided that appropriate soil media is used, plastic tunnels are a possibility in the study areas for a steady supply of vegetable products especially tomatoes and onions during the rainy season.

- For promoting fruit crops production, which might be difficult for the longer precocity otherwise, intercropping needs to be seriously considered. The ground and lower layers can be devoted to root crops, vegetable crops, spices and herbs for both home use and for the market.
- As horticulture is a relatively new venture, farmers exhibit a clear deficiency of technical know-how. They need to be technically assisted such as by making available an improved itinerary on horticultural crops production and management. These might include:
  - Awareness creation through the distribution of production technique manuals and leaflets
  - Building the capacity of farmers with respect to planting material handling like grafting, budding and pruning techniques and most basic nursery and orchard management practices, access to, and management of, improved varieties, post-harvest handling, pest and disease management, etc.
  - Putting in place a mechanism for knowledge flow among farmers on aspects like appropriate varieties, production technologies, integrated pest management, price of produce, etc., like through establishment of IPMS's knowledge center at each kebele.

Socio-economic aspects

- Because fruits and vegetables are high value commodities, they can represent an important area of potential income growth for growers. Apart from home consumption, the promotion of horticultural crops should also target income generation. Once the new irrigation scheme becomes fully operational, it will inevitably boost horticultural crop production. As such, the present study team found no shared and coherent vision of marketing strategy for the bumper vegetable crop production that is expected. Looking for appropriate markets that can absorb the products at the early stage is mandatory.
- Also establish agro-processing plants. These processing plants need to be designed in such a way that they can process multiple species. If managed correctly, tomato is a rewarding prospective raw material for industries.
- As horticultural crops production expands, not only the domestic market but also the international markets will enter the system. In such a scenario, complementary responses would be needed such as improving the capacity of small farmers to help them meet the quality and supply standards of foreign markets. Quality needs to be developed and optimized; the base of utilization be broadened and the marketability of products enhanced. Should products enter and compete world markets, quality definition and criteria (international standards) need to be made available to farmers. Often it is the customers who set the standards for the growers.
- Look for niche market opportunities and add value to products
- Encourage the growing of comparatively profitable crops such as onion instead of shallot
- Farmers should be organized into groups and associations. This will enable them to enter into partnerships and collaboration with other key players in the market chain. Purchase of inputs in bulk and working in groups will reduce costs of production. Selling in bulk will increase the bargaining power for better producer prices and ensure quality, quantity and consistency in the supply.

Cultural aspects

- Improving the culture of horticultural crops utilization by the rural and urban communities could contribute to food and nutritional security while it enhances the price for which public awareness through strategies as social marketing is needed.
- Currently, low value crops such as sorghum are grown, which takes eight months to mature. Such a system does not allow the growing of other crops afterwards since the moisture declines. Farmers claim that sorghum offers other qualities that cannot be found in horticultural crops. Apart from grains, it is also used as fuel and thatched roofing and it tolerates bird damage and waterlogging. Farmers need to be encouraged step by step to shift to the growing of high-value horticultural crops and maximize their income.

Generally, as the immediate production constraints are lifted a suite of new problems would likely emerge on irrigated fields. Irrigation removes the primary constraint to productivity, but plant nutrition is quickly revealed as the next constraint of fast growing, often shallow rooted crops grown in soils leached by irrigation. Once the two major abiotic factors which limit production have been taken care of, the way is opened for a new set of biotic constraints; the now lush but defenseless horticultural crops must face the onslaught from competition (weeds), herbivory (insects) and parasitism (diseases). Thus, an array of other inputs is needed to back up the investment in irrigation (Stirzaker, 1999). Research and development options should address this problem before it is too late.

Summary

Horticultural crops have comparative economic advantage over the production of field crops and can offer alternatives to livelihood to cereal-based subsistence economy. However, at present horticultural crops production is largely traditional. For their short-cycle and comparatively favorable growing environment, farmers focus much on vegetable crops than fruits. Tomato, allium, hot pepper and potato are among the most widely cultivated vegetable crops in the study areas that have high production prospects. Fruit production, on the other hand, is poorly developed as it is the case in most other places of the Amhara region.

Generally, the production of horticultural crops appears to be a feasible undertaking in the study areas. However, its development is constrained by a multitude of technological and management factors such as lack of appropriate varieties, poor management practices, soil related factors, pests and diseases, poor post-harvest management and marketing.

Development and promotion of technological options that enhance productivity, quality and management of crops could help the horticulture business to be more widely adopted so that food security and income generation will be ensured and thereby improve the living conditions of growers.

Given that a multitude of factors are interacting in restraining horticultural crop production, this calls for integrated intervention in order to deal with the problems effectively. Future development of fruits needs to draw on the identified constraints and opportunities to re-enforce and build upon farmers' present endeavors for improved efficiency and productivity of the system. Technical backstopping and encouragement of growers, at its minimum, to access quality planting material, adequate water supply, markets and trainings would be vital.

4.3 Crop pest management

4.3.1 Introduction

Cereals, pulses, vegetables and spices are grown in the three *woredas* we covered in the study, i.e., Dembia, Libo Kemkem and Fogera. The dynamics of crop types and the varieties grown is changing with time largely due to the introduction of new crops (such as rice) and small irrigation systems. The study revealed that insect pests and diseases were, and still are, one of the major production constraints in the study area, as the case is true of other areas in the region. Farmers ranked pest problems from 3rd in Libo Kemkem to 5th in Fogera and 8th in Dembia out of a list of constraints that were as many as 19. Despite the relatively medium ranking of pests in Dembia, farmers unanimously concluded that pests are the limiting factor in more moist areas that border the lake.

The species composition of pests was more or less the same among the three woredas. All of them lie within the same ecological set up, i.e., the Tana basin. In this document crop pest is defined to encompass both insect pests and diseases. In Ethiopia, nine of around 30 Insect Orders in the Class Insecta are known to cause damage to agricultural crops. Only five of the nine orders, i.e., Lepidoptera, Homoptera, Isoptera, Coleoptera and Orthoptera, were reported to have caused damage in the study area. To be specific, a few of the major insect pests include stem borers, red tefworm, grasshoppers, sorghum chaffer and army worms on cereals; cutworm, African bollworm (ABW), and aphids on pulses, ABW on tomatoes, and other aphid species on cabbage and root rot on hot pepper, bulb rot on shallot, and late blight on potatoes. The list of pests and their management is given in Table 23.

Recently, cutworm and red tefworm have become the most damaging insect pests. According to farmers, cutworm is more serious on crops grown on residual moisture bordering Lake Tana than the upper part of the catchment area. These crops include, among others, wheat, emmer wheat, maize, chickpea, lentil, grass pea and safflower. Attack starts immediately after crop emergence. According to local farmers' beliefs, cloudy weather condition exacerbates cutworm attack. Likewise, red tefworm is increasing its presence and damage every year.

Root rot of hot pepper was the most devastating disease that was experienced recently. One woreda expert believed that *Phytophtora infestans* was the causative agent for it.

Other vertebrate pests include porcupines (damaging potatoes), birds (attacking hot pepper pods) and rodents attacking wheat and emmer wheat.

According to the interview, the farmers did not notice any change in the dynamics of pests as a result of the recently enhanced irrigation practices. They also noted that they are not aware of such possibilities with growing irrigation practices in the future. However, they agreed that pest incidence has increased over years. This shows that little pest management has been done in the past. Ignorance of farmers about the possibility of pest resurgence as a result of changing farming systems is a grave concern for experts and researchers alike since changes in farming systems, i.e., the introduction of irrigation in the near future, definitley invites unforseen consequences, especially pests.

4.3.2 Existing pest management practices of farmers

While acknowledging the seriousness of pests, most farmers are unaware of the need for pest control. Many of them reported that they do nothing to control pests. For a few of them, such unwelcome pests were simply God's punishment. However, other farmers conduct some traditional control practices and they even use some modern chemical pesticides. Traditional practices include hand picking of larvae and beetles, uprooting and removing infested plants, applying livestock urine, smoking with hot pepper as a botanical insecticide against storage pests, etc.

Insecticides are widely used against aphids on grass pea and African bollworm on chickpea. However, their use had serious repercussions by killing honey bees. According to farmers, the bees did not return home (to the beehive) after their foraging trip. Farmers reported that long time ago they used to harvest honey in November because pesticides were not used as widely as to date and bees did not die of insecticide poisoning. It is common knowledge that pesticide drift not only harms bees and other biodiversity but also pollutes the larger ecosystem. Up until now, the use of pesticides is extremely controversial among the concerned professionals and at the higher policymakers' level alike. This indicates that insecticides should be used judiciously only as a last resort, and when other options fail or when infestations turn epidemic (outbreak) proportions. Besides, specificity of pesticides is not taken care of. For example, aphids are very important on grass pea in the study area, which farmers routinely spray Malathion against. In fact, a very specific insecticide against aphids is available commercially such as dimethoate and pirimicarb. No efforts are being made to adopt more specific insecticides, which could contribute for better efficacy and lower pollution. More concerted effort should be paid to other pest management components including biological, cultural, physical, botanical, behavioural and other non-chemical based alternatives.

4.3.3 Physical environment that favoured pests

The crop types and their pests varied with soil type and the level of soil moisture. Farmers reported severe pest damage close to the lake where alluvial soils dominate and soil moisture is abundant. Moist soils and alluvial soils favour cutworms and red tefworm, which are the key pests in the study area. Moist soils allow cutworms to move around easily within the soft soil, which they find it easy to dig. Moist soils also allow red tefworms to be able to easily dig and hide in the soil, diapause during the dry season, eventually pupate and emerge as adults in the following season. Both cutworm and red tefworm are lepidopterous larvae, which are not designed to dig tough soil material, as a few other insects do. Therefore, they can only thrive well in moist environments like close to the lake. Abundant moisture also accelerates root rot of hot pepper, according to observation by farmers.

4.3.4 The dynamics of major pests that have become prominent recently

A few of the major concerns of farmers are that cutworms attack a wide range of crops grown particularly on residual moisture close to the lake. Other important pests include red tefworm on tef, root rot on hot pepper and aphids on pulses.

4.3.4.1 Cutworm

As reported by farmers, cutworms start damaging crops as soon as seedlings emerge. This is especially severe close to the lake. Rice is planted in these fields and stays much of the main rainy season under water. Theoretically, this indicates that cutworms find it difficult to stay alive in such submerged fields. The paradox is that they somehow manage to evade that trouble and they are able to resume attack soon after the new crop succeeds the rice harvest. This also indicates that the larvae were already present when the new crop was planted and these larvae waited until the crop emerged. There was no sufficient time for the cutworm adults, had there been any, to lay eggs, the eggs to hatch into larvae and start attacking the crop. Therefore, the larvae were already there when planting was done and once the new crop emerges they will resume attack. They are seedling pests afterall, although they can continue attacking branches and leaves of fully grown plants. But how did the larvae manage to survive the flood water during the rainy season? Since this is largely unknown, one can only give an educated guess. They may have used some unknown mechanism such as raised spots of weed piles that were above the surface of the water level, or something else.

4.3.4.1.1 Cutworm management

Ecological management- Cutworms are often difficult to control, especially when populations are epidemic in proportion. Large populations may cause severe crop damage. Unfortunately, by the time the pest is identified, the cutworms would have already developed into a life stage which is not as susceptible to insecticides as the early larval stages. The sporadic nature of cutworm populations can make preventive treatments futile in some areas. We have failed to make valid recommendations on cutworm control in a trial we conducted in Bichena and Mertule Mariam in the mid 1990s. We investigated three application techniques of the insecticide trichlorfon along with an untreated check. Treatments included trichlorfon spray directly on the soil at planting, applied it with baits one month after planting or sprayed it direct to the plants when the symptoms were first noticed. The results were inconclusive. An additional problem for control is the soil-dwelling habits of the larvae, often beneath heavy foliage, making it difficult for insecticides to reach the target insect.

Check for symptoms of attack caused by cutworms in the surrounding weeds before planting a field or before the crop emerges. One thing that can be done is to irrigate as much a plot as possible to force larvae to come out to the soil surface. This may be possible because water is available in the study area. The water will exclude oxygen from the soil depths. The larvae that are driven to the surface by the suffocation of the water will be exposed to the vagaries of weather and prerdators and also man’s control activities.

Cutworms often recur in the same field or area from year to year. Areas that have had a dense stand of weeds, crop residue incorporated soon before planting, or located near forage crop field often have high populations. The worst damage occurs where large numbers of larvae are present before planting. It is the larvae that were in the field before planting that cause the damage. The second (subsequent) generation larvae don’t harm as much. This indicates the importance of clearing fields long before we dare to plant our crops in a field where weeds and other volunteer plants were growing. Weed hosts on outlying areas are often preferred sites of oviposition and serve as food for the younger larvae. Destruction of these weeds may help reduce cutworm populations by disrupting their life cycle. Reduce the feed for cutworms by keeping fallows and or grazing lands, if there are, free of weeds and vegetation at least 3 weeks before planting. This provides the cutworms enough time either to pupate or starve to death before you plant your crop or the planted crop emerges.

After crop emergence, adult densities can be monitored using pheromone traps and can be checked if there are wilted plants with completely or partially damaged stems. Pheromones are marketed in Europe, America, India or South Africa. Researchers or agricultural experts may order cutworm pheromones from these countries. Cutworms can be monitored also by digging around the base of the damaged plants and by sifting the soil for caterpillars, the emerging larvae can be squashed. Most larvae feed at night and during the daytime they hide beneath the soil. Therefore, monitoring cutworm activity is best done at night; also soil scratching around damaged plants may reveal the larvae.

Delay the planting so that the crop might escape damage from the first batch of larvae, which are always the worst. Maintain crust over the land during egg laying to discourage egg laying adults. Deep ploughing of fields between crops turns up larvae and pupae to the soil surface making them exposed to predators and the sun.

Depending on the crop, flooding of the infested field may be a feasible control method in some cases. Flooding causes larvae to come out to the surface and be killed by different mechanisms that include exposure of larvae to adverse weather conditions and predators. In small fields of horticultural crops, or those in the backyard, manual collection of the larvae may be sufficient for control.

Cutworm is polyphagous. Therefore, the strategy of growing non-host crops (crop rotation) to break the life cycle is unlikely to help. All the plants grown by farmers in the study area are perfect hosts of the insect. There is little chance to find any crop that is not attacked by this pest. The continuous growing of suitable host crops will be unavoidable. In summary, the strategy of 3- week clean period before planting, clearing nearby weeds and vegetation before planting, and if available flooding the field can help to reduce attack substantially and eventually bring the population below the economic threshold. Some research is required to determine the impact of some of these strategies on cutworms in the hotspot area. There is no all-weather road to access cutworm hotspot areas, which are very close to the lake, challenging future research and development efforts.

Chemical control. When the infestation is severe and insecticide application becomes necessary, irrigate the field two days earlier to drive the larvae closer to the soil surface and expose them to the insecticide. Apply carbaryl, chlorpyrifos, or trichlorfon following rates suggested by the chemical companies or research results. Repeat irrigation every four or five days to allow chemical movement in the soil. Spraying in the evening is likely to be more effective since larvae will emerge to feed and insecticide degradation is minimized.

4.3.4.2 Red tefworm

The most effective method to fight red tefworm is to plough the soil immediately after harvest of tef. This is possible since the soil close to the lake is sufficiently moist and is easy to plough. This will expose the larvae to the vagaries of weather and natural enemies. Their number will decline gradually from year to year since fewer than the previous year will manage to dig in the soil and stay the dry season (diapuase) until the next planting season. Flooding after harvest and the destruction of wild grass hosts in the area will help reduce the inoculum. Since the fields are bordering the lake, some of the wild hosts, which are all grasses, might be able to grow all year round along the banks of the lake. These hosts need to be destroyed. Some study should be carried out to identify the hosts that support the worm. The biology of the pest should also be studied as it happens in the area. Since red tefworm is specific to tef and some related grasses, growing non-host crops, i.e., crop rotation, may reduce the occurrence of the pest. In the event of major outbreaks, insecticides approved for this pest might be the last option.

4.3.4.3 Aphids

Aphids attack pulses especially grass pea. We have done a lot of work on the management of aphids on pulses and to some extent on cereals. Given the grand scale of infestation caused by aphids on pulses, the single most effective control method that proved successful so far was spraying aphicides (dimethoate, pirimicarb, pirimiphos-methyl) twice, i.e., when it is about to flower and once at pod stage.

4.3.4.4 Grasshoppers

Tens of thousands of grasshopper species are known worldwide. Virtually all farmers and agricultural experts alike have complained of severe damage by grasshoppers.

The intensity of grasshopper infestations varies from year to year. Generally large populations occur for two to four years. After this cycle infestations decline for the next three to four years. The cycles often repeat in this manner.

Grasshoppers usually begin to hatch after seedling emergence. The warmer and drier the weather the earlier the hatching and the better the nymphs will thrive. Late onset of rains and colder weather will disrupt the cycle, killing the young hoppers. Early onset of rainfall followed by cloudy, damp weather encourages diseases that sicken and kill hoppers. Long, warm seasons provide a bountiful food supply for them. This encourages early maturing of grasshoppers and an extended period of egg-laying. Cool and short growing seasons slow down grasshopper maturity resulting in a reduced time for laying eggs. Once the nymphal stage is completed, one to three week old adult hoppers begin to lay eggs. The eggs are laid in the soil covered with a foam-like liquid which forms a hard, protective shell that helps the hoppers to withstand adverse environmental conditions.

Modeling of hopper dynamics with weather variables may be good tool to predict grasshopper infestations ahead of time.

4.3.4.4.1 Grasshopper management

Predators

- Some blister beetles and ground beetle larvae attack the egg pods of grasshoppers. They both consume between 50 to 60% of grasshopper egg pods
- Snakes, toads, and cats feast on hoppers
- Bird predators include bluebirds, crows, hawks, and sparrows, etc.
- Large nematodes up to several inches in length parasitize and kill hoppers
- Robber flies and spiders feed on grasshoppers
- Field mice and many types of rodents dig up and eat the egg pods. They also feed on the adults

- Chickens, ducks and other domestic poultry are good consumers of hoppers
- Preying mantis make a delicacy of grasshoppers
- Fish eat hoppers. They can even be used as baits and the bigger the hopper, the bigger the catch

Repellents

- Some plants are repellent and efforts should be made to identify them in the target area or import such plants from other sources
- Spray a heavy mixture of garlic oil as a repellent
- Practice crop rotation because grasshoppers prefer monocultures to nitrogen-fixing crops like peas and clover

Biological control

- *Nosema locustae* is a one celled parasite that infects and kills the hoppers when they ingest it. A single treatment can last for several years. Hoppers are cannibalistic and will eat the dead parasite infected bodies. This creates a chain reaction passing the parasite from generation to generation. In other countries, *N. locustae* is available for sale. It is sold mixed with branmeal or the user can mix it with branmeal to attract the hoppers. It should be applied as soon as hoppers begin to hatch, otherwise they won't work. That means you need to know the biology and ecology of the pest before you can apply *N. locustae*.

Botanicals

- Farmers can use organic botanical products like pyrethrin and neem to knock down nymphs in the first or second instar
- Molasses and water combined in 4:1 ratio can be sprayed directly on to hoppers. This will clog hopper pores making them unable to breath and it will eventually kill them
- Tall grasses should be left uncut to give hoppers food and a refuge. Then the treatment of choice can be used to kill them in the localized area
- To guarantee success, control measures should always be targeted to the nymphal stage. Once hoppers have grown to adulthood, it is difficult to manage

Physical

- Ploughing the soil immediately after harvest will expose buried egg pods to the weather and discourages egg laying adults. The tillage makes the field unsuitable for egg laying. This will reduce the carry-over that will overwinter as eggs and hatch and infest fields the following season
- Physical destruction of hoppers

4.3.4.5 Termites

Termites attack crops only when the soil is devoid of the necessary organic matter that they need for their survival. They also turn to cultivated crops only when humans deny them of their own ecology by cultivating it. Termite damage generally is simply a symptom of environmental degradation.

- Promote conditions for healthy plant growing to prevent termite damage. Termites more often attack sickly or water stressed plants than healthy plants
- Avoid unnecessary injury to the plants as this may facilitate entry of termites
- Plough fields to destroy the termites' nest, runways, and tunnels and to expose them to predators, such as ants, birds, chicken, etc.
- Practice crop rotation to reduce the build-up of termites. Planting the same crop every cropping season makes it susceptible to a termite attack
- Practice intercropping to lessen the termites' damage to their favored plants. Know and make a list of the annual crops that are attacked by termites
- Remove plant residues and other debris especially moist and decaying woods. However, take into account that termites may attack plants if there is no other food available, for instance if there are no other sources of organic matter such as soil humus and mulch. Therefore ensure there is plenty of soil humus; avoid bare, dry disturbed, organic-matter-deficient, residue-free soil
- Inspect plants, especially the pruned fruit trees, for termite attack. Do this either early in the morning or late in the afternoon. Remove affected plant and kill the termites, they are normally found inside the hollowed parts
- Harvest at the right time, as termites often attack maize, sorghum, millet and rice left in the field after maturity. The attacked stalks may fall down and the termites may attack the cobs and panicles
- Where there is risk of termite infestation, avoid leaving the crop in the field after harvest on stalks and stacks
- Burn plant residues on top of termites' mound to suffocate them. However, this does not give long lasting results, as it does not penetrate deep enough to kill the queen
- Locate their soil runways/tunnels and destroy the worker termites either by hand, tilling or by flooding. This is not a long lasting solution since the termites would eventually re-infest the plants
- Destroy termite mounds manually. However, this method is labor intensive since the building material of the mounds is very hard, and some mounds are large. To be effective the queen has to be found and destroyed; the queen maybe hidden deep inside and it is not easy to locate. After killing the queen, pour boiling water or burn dried grass straws (any plant debris) to kill the rest
- Certain regions have their own age-old termite management traditions; this necessitates investigating them for wider application.
- In the 2007/08 annual conference of the Plant Protection Society of Ethiopia, it was concluded that previous termite management efforts in Ethiopia have failed. Quite a lot of toxic insecticides have been dumped in many areas especially in western Ethiopia in an effort to eradicate termites, with no avail. The consensus that was agreed in the conference was to work on restoring the ecosystem that was destroyed as a result of man’s interference. The destruction of the naturally balanced ecosystem denied the termites their right to forage on naturally growing vegetation and instead they shifted towards cultivated crops, starting the never ending conflict with humankind. Termites stay in the soil as long as the soil is rich in organic matter. They are not interested to eat crops grown by man unless the soil in which they are based lacks the organic matter, or the food, they need.

4.3.4.6 Root rot

- Given the fact that root rot is a new addition to the list of diseases on hot pepper, the researcher knows little about it. This is a crisis that overwhelmed the nation with no readiness to fight back. Therefore, the first thing to do is to let the researcher do some literature survey locally and internationally. Other research institutions should be consulted and information gathered about what they know about this predicament. Moreover, some active study should be conducted by existing research centres within ARARI. This may include studies of the identity of the disease and its epidemiology, the symptoms and signs and the driving environmental (biotic and abiotic) factors, how and where it came from (foreign or local origin). Whatever information might be available about this disease should come forward.

4.3.4.7 Head blast

- This is a serious problem on both finger millet and rice, although the causative agents that attack the two crops are different. Despite the large scale of attack, these diseases did not receive research attention in the past. The problem seems to be enough to warrant a research attention. Basic studies like epidemiology and management activities need to be done. Varietal resistance, crop rotation, other cultural practices are easy to implement. The research should focus in these areas.

Table 23: Major insect pests, diseases and their management as reported by farmers

	Favourable conditions	Control measures
	Cereals	
Cutworm		
Finger millet, maize, wheat, emmer wheat	o Cloudy weather favours cutworms o Dies when it rains (farmers claim) o It starts in waterlogged fields close to the lake and then it spreads to nearby fields	o Replanting o Sometimes you can squash it under your shoes o Agriculture experts advice farmers to use insecticides (malathion) and it is sometimes effective o It used to be sprayed by aircraft during Haile Selassie regime
Stem borer		
Sorghum, maize	o All growth stages	o Diazinon, endosulfan o A pint of urea applied in the funnel o Livestock urine applied o Uprooting infested plants
Red tefworm		
Tef	o Getting more damaging recently o Especially damaging on more moist and damp plains close to the lake	o Diazinon 35% o Livestock urine
Grasshoppers		
Tef, sorghum, barley	o In June when the weather is dry o Occurs when it rains in March o At seedling stage	o Smoking o Hand picking

Termites		
All crops	o All growth stages	o Digging and removing queen
Army worm		
Rice, finger millet	o It was serious in July 2008	o Control campaigns were implemented o If on grazing land, farmers squash larvae by driving animals on them o Malathion, endosulfan, diazinon
Degeza		
Cereals	o Sporadic	o Physical
Sorghum chaffer		
Sorghum	o Sporadic	o Physical
Wheat rust		
Wheat	o Rainy and hot weather favours rust and crop becomes red	o Clean seed
Blast		
Finger millet	o 100% destruction this year	
Rice	o The stem dries first	
Smut		
Sorghum	o Transmitted by seeds	o Clean seed
	Pulses	
Cutworm		
Pulses, spice crops (nech azmud), safflower, *feto*	o Severe at seedling stage o Heavy damage on crops planted on residual moisture and recession agriculture o Moist soil favours it	o Hand picking in early morning o Cultivation
African bollworm		
Chickpea, grass pea, fenugreek	o Cloudy weather favours it o It feeds the seeds inside the pod and empties it and moves away to the next plant o Right at the time of this study, there was an outbreak	o Birds eat them o Hand picking o Farmers were spraying insecticides in Libo Kemkem
Aphids		
Fenugreek, grass pea, safflower, lentil, chickpea, *feto*		o Dimethoate o Malathion o Livestock urine and soap

Wilt root/rot		
Chickpea	o Sporadic o Mostly at pod formation	o New variety did not do well, some farmers reported o However, varieties such as Marye are 50% tolerant. Need to be extended

Horticultural crops

Root rot		
Hot pepper	o All stages of the crop attacked (seedlings, pod stage). The roots decay and plants die o The roots were dry and there were no symptoms of pest attack o Moisture favours the disease o Was planted in July, weeded 3 times, and it grew well but it was dead at the end of August	No control available according to farmers
Potato tuber moth		
Potato	o In store	
African bollworm (ABW)		
Tomatoes		
Downy mildew		
Onion	o 1st seen last year o Covered by white powder	o Mancozeb was applied which stopped it effectively
Bulb rot		
Shallot	o Spreading at a grand scale o Farmers are losing a lot	
Garlic		
Rust	o Severe during the rainy season	o Plant in offseason
Late blight		
Potatoes	o Main season potatoes, not irrigated ones, attacked o Serious in the hills o Serious in rainy season o Blight occurs when the weather stays dry and sunny for two days o The red variety is more tolerant	o Resistant varieties available
Aphids		
Cabbage, shallot		

Storage pests		
Maize weevils		
Sorghum, maize, rice (with husk)		o Actellic 2% dust o Smoking with hot pepper
Bruchids		
Pulses (lentil, chickpea, grass pea)		o Chemicals are used in store o Smoking with hot pepper
Termites		
Wheat, tef, rice	o In storage	

5. ANIMAL PRODUCTION

Livestock contribute very much to the livelihood of farmers in the study areas. They serve as source of draught power, milk, meat, income, fuel and manure in both the upper and lower streams. Donkeys play a very crucial role in the transportation of goods and riding. Mules and horses are very few in the study areas. Poultry production and beekeeping are also an integral part of the animal husbandry in the study areas. Although the woredas have a large number of livestock populations, which significantly contribute to the regions' overall economic growth, the development of the livestock sector has been hindered by the lack of feed, both in quality and quantity, and better health services. Furthermore, the absence of good management practices, the traditional and inefficient breeding system and the lack of improved genotypes have entailed for the poor performance of animals.

In this section animal production systems, feeds and feeding management, health and veterinary services, housing and watering situations, disposal and marketing and beekeeping practices in Megech and Ribb rivers irrigation target areas are discussed. Possible solutions or interventions for both the upper and lower streams of the target areas are also briefly indicated.

5.1 Livestock production system

Farmers rear cattle, sheep, goats, donkeys and mules in the study woredas. Poultry and honeybees are also common. Diversity of livestock species is intended to minimize the risk of vulnerability. The proportion of livestock species varies with the woredas depending on the type of vegetation and the terrain. Cattle and goats dominate the **upstream** and cattle and sheep dominate the **lower stream**. This means that cattle are equally important in both domains. Goats are more common in the upstream than in the lower stream. Browse species are available and water logging and flooding are not a problem in the upper stream, which are critical for goats to graze and stay healthy.

Farmers practice mixed crop-livestock system, characterized by sedentary system whereby animals can move a very short radius from a permanent base. Animal husbandry and crop production systems are complementary to each other. Animal rearing is traditional, i.e., without stall feeding or other intensive management practices. The traditional rearing systems include free grazing and scavenging. Indigenous breeds of cattle, sheep, goats and poultry dominate the area, as the case is true in other parts of the region.

Herd structure is composed of cows, oxen, heifers, bullock and calves; flock structure of sheep includes ewes, lambs and rams of goats include kids and bucks at decreasing order.

Farmers reported that breeding female cattle and small ruminants dominate the livestock composition.

Cattle, particularly oxen, are considered as the most important component in the farming system. Farmers have started rearing crossbred dairy cattle in peri urban areas of Kolla Diba, Yifag and Woreta towns. However, crossbred dairy cows do not exist in the rural kebeles of the study woredas. On the other hand, improved breeds of chicken such as Rhode Island Red (RIR) and Lohman White are relatively common in the areas because they have been distributed.

Local breeds acquire certain positive attributes through natural selection. They possess adaptive traits that help them to overcome stress and water logging and the ability to feed on poor quality feed. However, they are poor yielders. Farmers in both upper and lower stream areas of Dembia and Fogera woredas do not have access to Artificial Insemination (AI) or bull service closer to their domicile. Farmers who want to have crossbreds have to trek their animals to Kolla Diba town and Shaga and Kokit kebeles, where the service is available. In Libo Kemkem, farmers have to take their animals to Yifag for bull service. Generally, lack of access to AI and bull service or their confinement around specific areas, lack of feeds, disease prevalence, and improper management practices have hindered the development of the livestock sector.

5.1.1 Management practices

Herding of mixed livestock species is a common practice. In *Megech* and *Ribb* rivers irrigation target areas, cattle, small ruminants and equines are herded together on natural pasture. Animals walk together long distances in search of available forage. Farmers reported that cattle are the most vulnerable domestic animals in the free grazing system. They mainly depend on grazing and are strongly associated with the residues of crops. Thus, supplementary feeding is administered in the morning and evening. Some of the farmers said that they tether and feed their livestock in most months of the year.

Water supply is generally adequate in the rainy season. During the dry season, rivers and springs serve as source of water for animals in the upstream. In the lower stream, animals get drinking water from the Lake, springs, rivers, ponds and hand dug wells. In Libo Kemkem, farmers reported serious water shortage during dry seasons.

At night, livestock are housed in separate houses or both humans and animals can share the same house. Cattle and equines can be kept together in separate shelter constructed behind the main residence house. Sheep and goats are housed in a separate room within the same house of the household. The separate room is partitioned by bamboo or eucalyptus and plastered with mud and cow dung. Animals under fattening are kept together with other animals in Libo Kemkem and separately tied in the house in Dembia.

Farmers from upstream reported that during the dry season, some farmers keep cattle in a barn made of wood and stone piles placed around the residential house. They keep them in residence houses during the rainy season. Dogs help farmers in herding and watching out thieves and predators particularly at night.

5.1.2 Management of young stock

Calves, the future replacement stocks, are not given more attention. In both upper and lower streams, calves are kept separate until weaning age. They are placed in the same house of the family. Most of the time, they are left to stand by their own and thus they rely on grazing for their maintenance and growth. They are normally allowed to graze and drink separately without any supplement. However, some times, one month old calves are offered grass and hay or straw. As the age advances, they are allowed to graze at the backyard and around the village. Weaning of calves is usually dictated by lactation length and conception status of the cow. On average, one year old calves are weaned, according to farmers.

Lambs and kids are allowed to stay with their mother for about one to two week(s) after birth and then kept together with the flock. Four to six month old lambs and kids are weaned.

5.1.3 Reproductive features

Heifers reach puberty in four to five years in upstream and four to six years in the lower stream. The age of the local cattle with the first calf is longer in the lower stream becaue of depleted feeds, disease prevalence and poor management. Local bullocks reach puberty in four years, crossbreds in two and half years in the upstream and in five years in lower stream. Calving interval of cattle is two years in upstream and two to four years in the lower stream. Crossbred cattle generally reach puberty at younger age and their calving interval is shorter than the local ones.

Small ruminants usually reach puberty between six months and one year of age. Lambing interval ranges between six and nine months. Average age at first lambing in both lower and upstream is one year. First kidding of goats ranges between eight months to one year and the kidding interval is eight months. Rams and bucks reach puberty in seven to eight months of age. Twining is common in both sheep and goats. Docking is not known for the ewes are thin tailed, which does not inhibit mating.

Onset of first postpartum oestrus is influenced mainly by the season of calving. The anoestrus period gets longer if cows calf during the dry season. The length of anoestrus period is also strongly associated with the availability of adequate and quality feed. In general, the anoestrus period after calving ranges from 10 to 12 months, while the average anoestrus period for sheep and goats is about one to two months.

Uncontrolled mating is the traditional breeding system, generally influenced by feed supply. The genetic potentials of sires used for breeding propose are not known. However, some farmers try to choose breeding bulls. Mating season is distinct for cattle. Cows mate mainly from January to February (upstream) and November to March (lower stream). At this time grass is relatively plenty. The number of improved breeds of cattle is low because AI and bull service are inadequate and/or absent. Sheep and goats do not have distinct mating season. However, sheep and goats breed in January and June in the upstream and December and July to August in the lower stream.

5.1.4 Livestock productivity

Farmers believe that animal performance between the past and present time is different. Gradual ecosystem degradation resulted in deteriorating livestock productivity. The reasons include depletion of feed resources. Only the adaptable Fogera cattle breed survived the water logged condition at the expense of productivity. Feed shortage problem is serious and as a result large frame size cattle of Fogera breed are crossed with other small size local breeds, because small breeds relatively consume less amount of feeds.

The lactation period of cows varies with genotype, management and health of the animals. Indigenous cows in general have shorter lactation length than crossbreeds. Generally, the average lactation length of Fogera cows range from eight to nine months and local breed cows from six months to one year. Farmers believe that milk production is associated with availability of feed resources. With adequate supply of quality feeds, Fogera cows yield three to four liters and cows of other breeds give 1 to 1.5 liters of milk per day. As when feeds become scarce during the dry season, the yields drop to less than half a liter per day. Most of the improved cows are 25% crosses. In Libo Kemkem, these animals give an average daily milk yield of 12 liters at early lactation, 6 liters at mid lactation, and 3 liters during late lactation in the upstream areas.

5.1.5 Fattening practices

Farmers seldom practice fattening in the study areas. If at all present, farmers fatten oxen in both the upper and lower stream, while sheep fattening is also practiced in the lower stream of Fogera area. In Libo Kemkem and Dembia, oxen fattening is a recent introduction, according to farmers. Farmers usually buy castrated oxen from the market for fattening. Sometimes they purchase uncastrated oxen and get them castrated in nearby veterinary clinics. Fattening is carried out for three months. Moreover, some farmers also fatten their own oxen during the slack seasons. Uncastrated oxen and sheep are also fattened for two months in Kokit, Nabega and Diba kebeles of Fogera woreda. Female animals are not fattened in the survey woredas.

In Fogera, the woreda animal production and forage development expert pointed out that the fattened animals both in the upper and lower streams are not supplemented with feeds other than allowing them to graze in areas where feed is moderately available. In Libo Kemkem, treated and untreated straws of different crops, niger seed cake and salt are fed to fattening animals. In Dembia, hay, maize stover, and a mixture of grass pea flour and brewery residue are offered to fattening oxen. A handful of the mixture is given to the animal every morning. Moreover, animals for fattening are dewormed using *Albendazole* to destroy endoparasites that affect their performance.

5.2 Poultry production

Smallholder farmers rear chicken mainly for immediate income source and as protein source in the family diet. Indigenous chicken production is a common traditional practice of farmers in the survey areas. But the two exotic breeds of poultry, RIR and Lohman White were recently introduced in Dembia and Libo Kemkem, while only RIR breed is found in Fogera. Their number is declining because they are susceptible to different diseases such as Newcastle, Coccidiosis and Gumboro. Crossbred chicken are not common in the study areas. Recently chicken production has become a profitable enterprise. Mostly women take the initiative to start rearing chicken. Flock population structure includes chicks, hens and cockerels in decreasing order. In the upstream, a separate poultry cage is constructed that is located adjacent to the main house of the family to keep predators away at night. In the lower stream, a night perch is constructed in the same house of the family on which chicken are kept at night.

Traditionally, birds roam around the village and scavenge in a typical free ranging style. They feed on whatever feed resources are available around the village with little regular offering of supplements. Chicken are always offered water during dry seasons and the type of supplements are cereal grains and foodstuff leftovers of the family.

Pullets and cockerels normally reach puberty from six to seven months of age, according to farmers. A local hen can lay 12 to 15 eggs per clutch and the broody period ranges from three to four weeks. On the other hand, RIR lay an average of 150 eggs and Lohman White lay 200 eggs per annum under farmers' management conditions. The mortality rate of chicken is high in all the three woredas. As a result, the number of chicken and eggs consumed in the household and the income generated has fallen dramatically. Diseases and predators are the principal problems associated with poultry production, according to farmers.

5.3 Beekeeping

Beekeeping is an age-old tradition in the farming communities of the region. It is an integral part of the smallholder farming system. It provides additional income and nutrition for many subsistence farmers. Beekeeping is practiced in all the three woredas, which are potential areas for beekeeping. The number of honeybee colonies is staggering with over 16 thousand colonies in Dembia, over 10 thousand in Libo Kemkem and around 22 thousand in Fogera.

Majority of the beehives in all the survey areas are local. However, Agricultural and Rural Devotement Offices have distributed a few Transitional (Kenya top bar) and *Langstroth* (modern or frame) hives to farmers on credit basis. Red Cross Society (Dembia) and ILRI-IPMS project (Fogera) have also distributed some of the improved hives to farmers.

Honeybees are usually acquired by catching swarms from trees. The second sources of honeybees are gift from parents and relatives. Farmers also purchase honeybee colonies from the surrounding markets and neighbours to start beekeeping. Beehives are kept at the backyard in all kebeles of the survey woredas. They are either attached to the wall with a rope or they are placed individually on a branched wood (hive stand). Sometimes colonies are also placed on stones and covered on top by thatched roof, plastic sheet or *secha*, which is made from papyrus to protect honeybees from sun heat and rain. Sometimes farmers put the hives underneath a loose house made of corrugated iron sheet. Ash is commonly dispersed under the hives to prevent ants.

Two types of bees are common in the study areas: *Wanzie* (red colour) and *Shanko* (black colour) bees. *Wanzie* is gentle and relatively good honey yielder, while *Shanko* is rather defensive, high reproductive capacity (of swarms) but less honey yielder. The swarming (normal reproduction) seasons of honeybees are September to October in upstream and November to January and June in lower stream, where feed is relatively available. This is the critical time that farmers need to patrol the emergence of new queens that create swarms.

Trees species (like eucalyptus and acacia), shrubs and herbs (such *Acanthus sennii*, *Guizotia scabra*, *Trifolium* species) and grasses (like *Andropogon abyssinica*) are used as source of pollen grain and nectarines. Crops like niger seed, sorghum, maize, chickpea, grass pea, safflower, hot pepper and *Trachyspermum ammi (azmud)* are also used as feed sources for honeybees in both the upper and lower target areas of the study areas. Table 24 gives a list of major honeybee flora that set flowers at different seasons of a year.

Table 24: List of honeybee flora with their botanical and local names

No	Botanical name	Local name	Habit	Density of occurrence	
				Upstream	Lower stream
1	*Acanthus sennii*	*Kosheshla*	shrub	**	**
2	*Accacia spp.*	*Girar*	tree	*	*
3	*Aloe berhana*	*Iret*	herb/shrub	*	
4	*Andropogon abyssinica*	*Gajja*	grass	**	*
5	*Bidens macroptera*	*Adey abeba*	herb	***	**
6	*Brasica* sp.	*Gomenzer*	crop	*	*
7	*Calotropis procera*	*Tobbiya*	shrub	*	*
8	*Capsicum annuum*	*Berberie*	spice/crop	*	**
9	*Carissa edulis*	*Agam*	shrub	**	*
10	*Carthamus tinctorius*	*Yahyasuf*	crop	*	**
11	*Cicer artietinum*	*Shimbra*	crop	**	**
12	*Cordia africana*	*Wanza*	tree	*	
13	*Croton macrostachys*	*Bisana*	tree	*	
14	*Eleusine floccifolia*	*Serdo*	grass	**	**
15	*Eucalyptus* spp.	*Bahirzaf*	tree	**	***
16	*Euphorbia tirucalli*	*Kinchib*	shrub/tree	*	*
17	*Euphorbia abyssinica*	*kulkual*	shrub/tree	**	*
18	*Ficus sycomorus*	*Bamba (Shola)*	tree	*	*
19	*Ficus vasta*	*Warka*	tree	*	*
20	*Gossypium hirsutum*	*Tit (Cotton)*	crop		*
21	*Gravilia robusta*	*Gravilia*	tree	*	
22	*Guizotia abyssinica*	*Nug*	crop	*	*
23	*Guizotia scabra*	*Mech*	herb	*	*
24	*Hygrophila auriculata*	*Amekyla*	herb	**	**
25	*Justitia schimperana*	*Sensel*	shrub	**	*
26	*Lathyrus sativus*	*Guwaya*	crop	**	**
27	*Lycopersicon esculentum*	*Timatim*	crop	*	**
28	*Mangifera indica*	*Mango*	tree	*	
29	*Melea azedarach*	*Neem*	tree	*	
30	*Nigella sativa*	*Tkur Azmud*	Spice/crop	*	*
31	*Ocimum basilicum*	*Besobla*	Spice/crop	*	**
32	*Persea americana*	*Avocado*	tree	*	*
33	*Trachyspermum ammi*	*Nech Azmud*	Spice/crop	*	*
34	*Trifolium spp.*	*Maget*	herb	**	*
35	*Sorghum bicolor*	*Mashila*	crop	***	***
36	*Vernonia amygdalina*	*Grawa*	Shrub/tree	**	*
37	*Xanthium spinosum*	*Torserawit*	herb	**	*
38	*Xanthium strumarium*	*Yemogn fikir*	herb	*	**
39	*Zea mays*	*Bekolo*	crop	**	**
40	*Ziziphus mauritiana*	*Kurkura (Geva)*	shrub/tree	*	*

* stands for modest occurrence, ** medium density, *** high density; most crops are herbs

Pollen and nectar for honeybees become more available from September to November in upstream and from October to December in lower stream. In Fogera, pollen and nectar become more available from January to March because of flowers of chickpea in the lower stream and maize in the upstream. The frequency of honey harvests per year depends on rainfall, which determines the source of nectar, the vegetation. Good *belg* rainfall can give one more honey harvest, making a total of two harvests per year. Honey production seasons are October to December in upstream, which comes from the main rains, and when there is belg rain, honey is also harvested in June in both the upper and lower streams. In the lower stream, honey production time has shifted from November (main honey harvesting season) to late May and June due to flooding problems and pesticide application.

Honey is the only product and wax is not extracted. Some 4 to 10 kg honey is produced from the traditional hive, 15 to 20 kg from the top bar and 20 to 25 kg from the frame hives per harvest. Bee colony management and honey harvesting is done by men; women seldom inspect honeybees.

According to farmers, *Wanza* (*Cordia africana*), niger seed, grass pea, *Guizotia scabra*, and *Andropogon abyssinica* give good quality honey. Honey processing is unknown in the study areas. It is sold or consumed as medicament, beverage and diet. Honey is stored in pots, plastic buckets or gourds that are properly covered with lid, sealed air tight. Sale of bee colonies has become a source of income for farmers. Depending on strength, a colony can be sold for 200 to 400 birr per hive.

According to farmers, the dearth period runs from February to April in the upstream and from August to September and March to April in the lower stream. During these periods, some farmers practice supplementary feeding of flour and sugar solution in Dembia and Libo Kemkem woredas but not in Fogera. Farmers claim that bee colonies normally abscond (abandon their hive) at times of feed shortage particularly in March and April when the scarcity is severe. Colonies seldom abscond in September and October in Fogera.

Recently, honeybee colonies and their productivity have declined in the areas. Non-selective pesticide application, deforestation and overgrazing in the upper and lower stream and the destruction of honeybee floras by floods in the lower stream had negative impact on honeybees. Small ants, locally known as *chuchan*, bee-eating birds and wax moth are also serious problems of beekeeping, according to farmers.

5.4 Feed resources and management

The major feed resources of livestock in order of importance include crop residues, natural pasture, hay and crop aftermath in upstream and natural pasture, crop residues, crop aftermath and hay in lower stream. Nevertheless, in Libo Kemkem, salt, niger seed cake and urea treated straws are fed to animals. Improved forage crops are seldom cultivated and utilized. Napier grass, vetch, sesbania, pigeon pea and oat are rarely planted in the study areas.

In order of importance, tef straw, finger millet, grass pea, faba bean, barley, chickpea, rice and sorghum and maize stover are the major crop residues identified by farmers in the upstream areas. More or less the same range of crop residues occurs in the lower stream.

Communal or privately owned natural pastures may be found. In communal pastures, grazing period is not balanced with stock density. As a result, palatable species become overgrazed and unpalatable species such as *Hygrophila auriculata* (*Amekyla)* and *Xanthium strumarium* (*Yemogn fikir)* take over the pastureland. Weeds are also carried and disseminated everywhere by animals themselves. However, when feeds become scarce, animals eat these spiny invasive weeds. This indicates how severe the feed scarcity can be. Farmers gravely condemned these weeds for the following reasons: these weeds replace the grasses. They suppress the growth of grasses and the thorny weeds prevent animals trying to graze on struggling grasses. Farmers do not attempt to remove these weeds from the pastureland. Given the invasive nature of these weeds, farmers think that it is beyond their control. Communal pastures are also dwindling due to ever worsening shortage of crop fields. In effect, recently the quantity and quality and carrying capacity of these pastures have drastically declined in the study areas.

Farmers who own larger plot of land can allocate a piece of land for grazing. In so doing, they fence, weed and fertilize the grazing plots. The plots are strictly used to supplement oxen or lactating cows with green forage or they are used to make hay at the later stage of growth of plants.

The botanical composition of pastures locally known as *humya*, *serdo*, *gumarie sar*, *chew tamie*, *chilklika*, *gingra* and *asendabo* are found in both upper and lower streams of Dembia. *Serdo*, *kumie*, *gingra*, *maget*, *gajja* are some of the grass and legume species that make up pastures of the upper and lower streams of Libo Kemkem. Likewise, *asendabo*, *arimasso*, *yebrie sar*, *kumie*, *maget*, *gingra* and *gajja* are some of the grass species found in communal grazing in the upper and lower streams of Fogera.

The natural pasture can support the animals from June to December in upstream and June to July and November to March in lower streams with minimum supplementary requirement (Table 25). Cattle, small ruminants and equines spend much of their time on communal grazing land. Farmers claim that these communal grazing lands are currently used as a waiting place because there is nothing animals can graze. These days, grazing lands are being used for crop production. The future of grazing lands is slim. At crop harvest, animals are allowed to graze on crop aftermath. Stall feeding is not practiced at all. Tethering exists in all the areas; large ruminants are tethered at 3:00 or 4:00 o'clock local time. Presently, more land is being irrigated but improved forages are not cultivated at all, and this makes zero-grazing inconceivable.

In the past, farmers in Dembia used to trek their livestock to Quara in search of feed for their livestock especially during the flooding season; they no longer do this. Farmers mention two reasons: first, the inhabitants of Quara did not allow them, and secondly they are worried by the robbers in the area. As a last resort, the crop residues were the ones farmers relied on. Feed shortage in lower stream is not as serious as the upstreams because grasses and legumes can re-grow there. In the lower stream, pastures are close to the lake, i.e., Lake Tana, and the residual moisture is available for a long time, which facilitates the revival of pasture lands. Moreover, increased rice, maize, barley, etc., production on the residual moisture increased the crop residues. Farmers store crop residues to cope up with feed shortages during the critical period of February to June in upstream and August to October and April to May in lower stream. The residues are used during the dry spell in the upper stream and during the flooding seasons in the lower stream. They also buy additional crop residues and hay from farmers who don't possess livestock.

Table 25: Feed calendar as practiced by farmers of survey woredas

Feed resource	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Natural pasture												
Upstream						*	*	*	*	*	*	*
Lower stream	*	*	*			*	*				*	*
Crop residues												
Upstream	*	*	*	*	*	*	*				*	*
Lower stream	*	*	*	*						*	*	*
Aftermath												
Upstream	*	*									*	*
Lower stream	*	*	*	*						*	*	*
Hay												
Upstream	*	*	*	*	*					*	*	*
Lower stream	*	*	*	*	*						*	*
Improved forage												
Upstream						*	*	*	*	*	*	*
Lower stream	*	*				*	*	*	*	*	*	*

* Stands for presence in a given typology

Hay making is virtually not a common practice in the area. But some farmers attempt to make hay from private grazing land, crop field boundaries and protected areas. Hay making takes place from the end of September to the end of November in all the upper and lower streams of the survey areas. Depending on its availability, hay is supplemented in precedence to draught oxen, lactating cows and the others follow. Farmers never practice urea treatment to upgrade the nutritional quality of crop residues in both Megech and Ribb rivers irrigation command areas.

Forage development can be integrated and implemented in the project areas on a sustainable basis. For instance, planting forage crops such as Rhodes and Napier grasses on catchment areas can also serve as means of soil erosion control and source of forage. Planting *Sesbania sesban* and Napier grass on canal banks can give substantial forage yield without affecting the irrigation system.

5.5 Animal health and veterinary services

Animal health problems affect the economy of the farmers and the country at large. Animal diseases strongly hinder productive and reproductive performance of animals. The major causes of diseases are bacteria, viruses, protozoa, parasites, fungi, poisons, trauma, and poor nutrition. According to farmers, outbreaks of infectious diseases such as trypanosomoses, anthrax, blackleg, pasteurollosis, foot-and-mouth disease (FMD), sheep and goat pox, and the like, are common threats of animals. Both external and internal parasites are important. Skin diseases caused by mange mites, ticks, flies and lice are serious health problems of small ruminants.

Animal health problems in the study areas are further complicated by predisposing factors such as severe feed shortage, flood related problems, lack of clean drinking water and uncontrolled animal movements. Malnourished animals cannot resist disorders such as infectious and parasitic diseases.

Different animal diseases occur at different seasons in the upper and lower streams (Table 26). Therefore, seasonal outbreaks of infectious diseases differ in upper and lower streams. This may be because of differences in topography, weather and vector complex that favour micro-organisms to infect animals at different months of the year. Trypanosomoses and endoparasites such as *fasciolosis* occur all year round, while ectoparasites become more prevalent during the dry season.

The most important infectious diseases are those of bacterial and viral origin such as anthrax, blackleg, pasteurollosis, and FMD. Some diseases such as anthrax, pasteurollosis, trypanosomoses, streptothricosis, and coccidiosis affect different animal species. Common animal diseases in the study areas are indicated in Table 27.

Table 26: Seasonal occurrence of major diseases and parasites in the study areas

		Upstream	Lower stream
1	Anthrax	March – June	April - May
2	Blackleg	May – June	June and November
3	Trypanosomoses	Year round	September - December
4	Pasteurollosis	March - September	January - June
5	FMD	June and September	June - July
6	Streptothricosis	May – August	June, September and March
7	Ectoparasites	February – June	January - May
8	Endoparasites	Year round	Year round
9	Coccidiosis	Year round	Dry seasons
10	Babesioses	February – June	April - June
11	Diarrhoea	April – June	July - September
12	Bloating	August – October	October - November
13	Abortion	March – June	March - June
14	Sheep and goat pox	August - November	September - December
15	Orf (sore mouth)	Year round	Dry seasons
16	Peri-parturient rise (PPR)?	January and June	Not reported
17	Tetanus	September – June	Not reported
18	Pneumonia	March – July	January - May
19	African horse sickness	July – October	Year round
20	Newcastle disease	January – May	February - May
21	Fowl pox	October - December	November – February
22	Salmonella	June – September	June, November - December

Anthrax is a bacterial infectious disease that affects all livestock species. Often the only sign of anthrax in cattle is sudden death without any warning signs. Farmers recognize the disease by the symptoms of high fever, oedematous swellings of the throat, difficult breathing, bloating, and dark blood oozing out from nose and rectum of the dead animal.

Blackleg is also another bacterial infectious disease of cattle and it is more prevalent on younger animals that are 6 to 24 months old. Farmers claim that this disease occurrs at the beginning and at the end of the rainy season. Trypanosomoses is protozoan infectious disease that affects domestic animals. In the study areas it has been reported that this disease is mechanically transmitted by *Trypanosoma vivax* and the vectors are biting flies. Its seasonal occurrence differs in both upper and lower streams,

Table 27: List of common animal diseases in order of importance

No	Bovine	Shoats	Equines	Chicken
1	Anthrax	Pasteurollosis	Anthrax	Coccidiosis
2	Blackleg	Anthrax	Pneumonia	Newcastle disease
3	Trypanosomoses	Sheep and goat pox	Trypanosomoses	Fowl pox
4	Pasteurollosis	Endoparasites (fasciolosis)	Tetanus	Salmonella
5	FMD	Streptothricosis	African horse sickness	Ectoparasites
6	Streptothricosis	Trypanosomoses		Gumboro disease
7	Ectoparasites	Diarrhoea		
8	Endoparasites	Orf (sore mouth)		
9	Coccidiosis	Abortion		
10	Babesioses	Coccidiosis		
11	Diarrhoea	Peri-parturient rise (PPR)		
12	Bloating			
13	Abortion			

Pasteurollosis is a bacterial infection of cattle, sheep, and probably goats and is characterized by swelling of the throat and may be spread all over the head, down to the neck and forelegs. In small ruminants the disease is associated with pneumonia of the lungs and diarrhoea.

Foot-and-mouth disease (FMD) is extremely infectious viral disease affecting mostly cattle and cloven hoofed animals. Farmers reported that the damage from this disease is reduction in the production of affected animals.

Coccidiosis is another protozoan infection of the intestines of domestic animals caused by *Eimeria* and *Isospora* species. The organisms are host-specific and transmission of infection between different types of domestic animals does not occur. The disease is normally seen in young animals (calves, lambs and kids, and chicken) in the first few months of their life.

In the study areas traditional method of disease control is very limited or absent and modern veterinary services are rendered. Veterinary clinics treat different clinical cases and castrate animals. However, farmers reported that the service is not satisfactory due to lack of veterinarians and medicaments. Moreover, animals are not clinically examined due to lack of technicians and laboratory facilities.

According to the veterinarians of the WARDO, common livestock diseases are detected (Table 27) at the clinics based on symptoms and the course of the diseases. Most of them are not supported by scientific diagnosis because of poor coordination with Bahir Dar Regional Laboratory. No veterinarians (Doctor of Veterinary Medicine) are stationed in the study areas. Moreover, lack of transportation service, trained manpower, antibiotics and anthelmentics and laboratory facilities are very crucial problems of the study areas.

5.6 Animal disposal and marketing

According to farmers and experts, aggressive or old oxen and sterile cows are culled and slaughtered in October, December or before the start of the main fasting period. Young and infertile adult sheep are also slaughtered mainly for Easter and the New Year. A few rich farmers may also slaughter either sheep or goat for Christmas. Animals are expensive during this time. Farmers who have extra animals for sale could trek their animals to the proximate market and earn better income.

The cash obtained from the sale of live animals, honey and skins and hides falls under the discretion of the husbands. Demand for honey harvested in October is higher, because it is believed to have medicinal value and thus it is expensive. Most of the eggs and the butter produced are sold. Eggs and butter are expensive during holidays and the non-fasting season. Women use the cash gained from the sale of these products. However, each household rears only a few chicken, receives minimal income, despite the high price in the market. Hides and skins are also sold but are rarely kept for use in the house. Because most of the kebeles of the study area are far away from urban centres, the milk is either consumed in the house or it is processed into butter.

Recently, the livestock sub sector has become encouraging because the Ethio-Sudan border is opened, where animals are sold and farmers earn more income. Moreover, the opening of meat processing plants, such as Ashiraf, a Sudanese-owned plant, might create additional market for livestock herders in the area. The driving forces for accelerated animal production in the area are better access to markets, improving farmers' livelihood (as a result of use of irrigation), and growing demand for animal protein.

5.7 Labour in livestock activity

Division of labour between members of the household helps them to run different activities of the livestock sub sector. The herding of animals is the dominant labour input in livestock production. Young children from the age of six and above are engaged in herding. Mostly boys do the herding, though girls may also assist. Herding takes place about 9 hours a day in the upper as well as the lower streams. Women take care of young animals.

All family members can feed livestock in the village. Along with the herding of animals, herders water animals and cut grasses. Women and young girls clean the barn, process the milk, inspect bee colonies during swarming season, sell chicken, eggs and butter and collect manure. They may do these activities in turns or together.

Men and boys can milk cows, harvest the honey, make hay, construct the barn, sell the honey, sell large and small ruminants and trek sick animals to the clinics.

5.8 Constraints

During the current study, farmers were allowed to discuss freely and prioritize their animal production constrains. In the upstream, they listed the constraints in the following order: feed shortage, animal diseases and inadequate animal health services, low productive and reproductive performance of animals and death of honey bees due to insecticide poisoning. In the lower stream, everything remains the same except one of them, i.e., low reproductive and productive performance of animals, holds the last position.

5.8.1 Livestock feed shortage

In the study areas, livestock feed shortage is considered to be one of the most important constraints that hinder the livestock development. It was number one problem, also first priority according to farmers. Pasturelands are pushed to marginal and overgrazed areas, where unpalatable woody plants are growing. Recently, unpalatable thorny weeds have invaded pasturelands. This situation should be stopped by whatever means available. Moreover, the grazing land is being cultivated for crop production. Pasturelands in the lower streams remain covered by floods for at least four months per year and animals cannot graze for that long. As floods inundate the area, forage plants sink or become buried under silt. This situation denies animals of their feed and undermines their full potential performance.

5.8.2 Animal disease

Poor animal health is still a major constraint in the animal sub sector. Important contagious diseases such as anthrax, blackleg, trypanosomoses, pasteurollosis, FMD, and sheep and goat pox are the most serious health problems of livestock. Vaccines are available for most of these diseases, but there is no regular vaccination program. External and internal parasites, skin diseases caused by ticks, mange mites, etc. contribute for the poor performance and low productivity of animals. Unregulated livestock movement and poor veterinary service, i.e., lack of veterinarians and drugs, are common problems in the area.

5.8.3 Low productive and reproductive performance of animals

Animals serve as fixed assets for farmers and as security to guarantee self-replacement through natural breeding. Currently, animals are meant to support crop production and not as a full-fledged business by their own. Generally, the productive and reproductive potential of animals is low due to shortage of feeds, diseases and their poor genetic potential. Indicators for this poor performance include longer age of first calving, longer calving intervals, low milk yield, minimal number of eggs per clutch, low honey yield per hive, etc.

5.8.4 Honeybee health

Chemicals used for crop protection are the main pesticides that kill the bees and other beneficial insects that have indispensable role in pollination. Farmers and development agents are not aware of the role of honeybees in crop pollination and yield increment. Recently, the use of pesticide has increased dramatically. Chemicals and knapsacks are available in the local markets. Farmers use these technologies without consulting experts. There is little effort paid to use selective chemicals judiciously. In the survey areas unwise application of pesticides destroy of honeybee colonies which in turn lower the quantity and quality of honey. Proper use of selective insecticides can help minimize the death of honeybee colonies in the project area.

5.9 Fishery

This sub- section of the study addresses the fishery aspect of the irrigation development project in Megech and Ribb rivers.

Among the 12 basins in Ethiopia, the Abay/Blue Nile basin is the largest with a basin area of about 200 thousand km^2 and the Sub-basin Lake Tana area is 15 thousand km^2. The Lake Tana Watershed is bounded between latitude 10°58`-12°47`N and longitude 36°45`- 38°14`E. Lake Tana is the largest lake in Ethiopia and covers an area of over 3 thousand km^2. It has an average depth of 9 m and surface level of 17851 m asl. The Lake Tana basin is endowed with a huge volume of water, land, human resources and currently ongoing and planned development activities. Underpinned by the development of these endowments, the resources offer tremendous opportunity to enhance growth.

The sub-basin has abundant economic, environmental, and cultural assets which, if managed carefully, can provide the resource base to realize an opportunity for accelerated economic growth. Lake Tana is a valuable resource, but it is ecologically fragile. The Lake Tana sub-basin's significant water, land, livestock, forest, and fishery resources, rich cultural heritage and natural assets, well developed urban centers (relatively) and dense settlements, good roads, and reasonable air connectivity, has potential for growth in multiple sectors with strong multiplier effects. In so doing, commercially-oriented smallholder agriculture, agro-industry, tourism, fisheries, livestock and energy can serve as a stimulus to national economic growth and improved livelihoods for the residents in the sub-basin.

The Beles sub-basin, linked to the Tana sub-basin through the hydro-power inter sub-basin transfer tunnel (under construction) also has productive land that is under-utilized. Development of large-scale irrigated agriculture (through private sector development) and strong linkages between the two sub-basins could encourage agro-processing opportunities in the Tana area through large and consistent supply of agricultural inputs.

The Lake Tana watershed, sub-basins of Megech and Ribb contribute considerable water, land, livestock, fishery, and natural and cultural assets, which are significant social and economic benefits to the livelihoods of its people living in rural and suburban settlements/kebeles. It is reported that over 8 hundred legally registered fishers are engaged in fishing activities in the Megech and Ribb sub-basin area. The number does not include illegal fishers, who roam around the lake because fishing is open to every one even if the fishery legislation says otherwise.

In 2008/2009, 1.7 thousand ton fish is expected to be harvested in Megech and Ribb sub-basins. Lake Tana and the rivers that flow into it are the fishing grounds. Fishing activities provide income to traditional and commercial fishers and also cheap and high quality protein to the diet of the urban and local community.

The Nile Tilapia, African Cat fish, and 15 species of the *Labeobarbus* species that are endemic to Lake Tana dominate the watershed. The endemic *Labeobarbus* species migrate upstream for reproduction in Megech and Ribb rivers and their tributaries. These rivers are now being dammed for the irrigation projects. The ecology or the habitat of migrating fish should be preserved to sustain the fish resources and the fisheries activities.

Megech and Ribb sub-basins and associated flood plains/wetlands in Lake Tana Watershed provide a habitat to many birds and are part of an international flyway for bird migration. The area has high biodiversity and needs to be conserved. The rivers help to navigate Lake Tana, which is an important means of transporting people, goods and services to various towns and centers across and between the islands. The sub-basins also serve as a sink for the disposal of mostly untreated or partially treated waste waters from domestic, industrial and agricultural uses, urban runoff, and livestock grazing areas within the sub-basins.

The Ribb and Megech Sub-basins and its wetlands are home to several natural and cultural assets that are an important part of the Ethiopian identity and tourism. The Fasil building in Gondar in the sub-basin above Lake Tana is both a national icon and an important part of the Region's identity, as well as a popular tourist destination. The Lake Tana watershed with its 20 monasteries (from the 13th -17th Century A.D.) on the 37 islands in the Lake draws about 130 thousand visitors to the sub-basin annually (including 39 thousand international visitors).

According to the project plan of Ethiopian Irrigation and Drainage Project, a part of a larger development project that involves building multipurpose dams on 5 tributaries, i.e., Abay, Jemma, Gumara, Ribb and Megech (of Lake Tana), a big multipurpose dam will be built in South Gondar Zone on the Ribb and Megech rivers. The project will use the water from the Ribb and Megech dams to support irrigation development in Fogera, Libo Kemkem and Gondar Zuria Woredas located in the east of Lake Tana.

The proposed irrigation area is located in the plain in the middle Ribb valley on both sides of Addis Zemen-Woreta highway. Water released from the reservoir of Ribb Dam into the riverbed will be diverted to the irrigation sites by a weir built close to the irrigation sites. Close to 20 thousand ha of land is expected to be irrigated in the irrigation command area. The net irrigated area on both banks of the river is estimated to be 15 thousand ha (9 thousand on the right and 10 thousand on the left bank of the river). The project area covers 19 kebeles with a total area of 473 km^2.

Ribb River is one of the sites that fishing activity is linked to the Lake and the flooded (wetland) area of Fogera. This riverine fishery depends on the longitudinal exchange of fish, nutrients, sediments, organic matter and water in sufficient quantity and quality. The lateral connectivity of habitats to the main river channel is also essential for the fishing. Lowland rivers such as Ribb which are surrounded by floodplains are often contained by massive levee systems erected to protect cropland, settlements and other infrastructure against floods.

The dam and related structures development on the Ribb River isolates the floodplains from the river and the seasonal dynamics of the system is destroyed, with grave consequences for the fisheries. The *Taqua, Daga*, *Shesher* and *Wolala* natural ponds of Ribb River are typical examples that have been disconnected from Ribb River through time due to human activity and the diversion of natural water course. African catfish from Lake Tana breed in these ponds. To restore the natural water course and the natural ponds, dikes may be built to allow a partial flooding of the natural ponds and the former floodplains. In certain areas the river may also be allowed to inundate the entire floodplain artificially.

By allowing the fish to enter flooded areas to spawn and feed, the large surplus production of juvenile fishes, which is characteristic of healthy floodplains, ensures adequate recruitment of fish to restore fish populations. Isolated water bodies such as Shesher and Wolala natural ponds, channels, and pools in floodplains may be linked by installing or improving the culverts or by creating natural channels. These are good options because they rely on already existing habitats that only need reconnection.

The main river course of Ribb and its tributaries facilitate upstream migration and are important habitats for reproduction. The spawning migration of *Labeobarbus* species studied on the Ribb River indicates that the upstream migration is the very important mechanism for reproduction which sustains the survival of this species. Blocking this migration without considering the free fish passage/fish path way on the damming site and other irrigation structures severely threatens the survival of this endemic species and generally affects fish production in the lake system.

The catchment area of Megech River is 7 hundred km² and the river flows generally in a southerly direction to Lake Tana. The proposed sites of the irrigation scheme are located adjacent to the northern shores of Lake Tana. The area along each side of the river is proposed to be irrigated. The total irrigation command area is about 29 thousand ha with a net irrigated area of over 24 thousand ha. Sub-projects Seraba and Guramba lie to the west, located in Dembia woreda and sub-projects Robit and Jarjar lie to the east, located in Dembia and Gondar Zuria Woredas.

Fishing is also common in Megech River and the kebeles bordering Lake Tana, namely Aberja, Mangie, Gurandy, Debr Zuria, Gorgora, Seraba Dabilo, Tana Woina and Achera. Some 90% of the fish produced in Dembia is *Labeobarbus* species. Studies on previous market routes indicate that fish production in the northern part of Lake Tana and its rivers were significant, which were exported to Sudan. Prices were good, which in turn depended on season and the species of the fish (Table 27). Some 835 fishers are registered in the two sub-basins, and more than 60% of them are in Dembia woreda, indicating how important fishing is for the economy of the local community.

The spawning migration of the *Labeobarbus* species in Megech River is not adequately studied yet. As stated above, the significant fish production of *Labeobarbus* species in Dembia indicates that this river not only gives good yield of L*abeobarbus* but also sustains the reproduction of this species. Before constructing the dam on Megech River, the upstream spawning migration of *Labeobarbus* species should first be adequately studied and mitigation measures put in place as soon as possible. The dam and the irrigation structures on Megech River should include structures that provide the fish a pass or a fish ladder appropriate to the migrating species behavior. These structures enable the fish to migrate and spawn upstream of the main river course and to the tributaries that are very important for the fish reproduction. The same issue was discussed in Ribb River in this report. The fishery experts in the Megech and Ribb sub-basins express their concern that the open access fishing and the lack of proper Lake resource management plan may further deteriorate the resources unless corrective measures are put in place on time.

5.9.1 Fisheries resources perspective and future planned development opportunities in Tana basin

Irrigation development projects in Ribb and Megech Rivers are not the only development projects currently being established in Tana basin. In the Tana basin, several other public investments are underway. A big diversion tunnel is being excavated along the western shores of Lake Tana to be connected to the Beles basin and to generate hydropower (460 MW installed capacity). This project will essentially divert most of the current outflow. There are several other private investments, primarily in agriculture, agro-industry, hotels, tourism, and micro-enterprises that are underway around Lake Tana.

About 7 hundred ha of land is allocated for export-oriented floriculture on the shores of Lake Tana. This is anticipated to repeat the success of floriculture around Addis Ababa. Large tracts of land (45 thousand ha with 15 thousand ha for out growers) are planned to be allocated for sugarcane plantation, i.e., for sugar and ethanol production.

Table 28: Indicative prices (birr/kg) of fish products in the dry and in the rainy season at different places in North Gondar and in the Sudanese border

Place	Product	Barbus/Beso		Tilapia		Catfish	
		DS	RS	DS	RS	DS	RS
Delghi	WF	1	1	1	1	0.6	0.6
Dengel Ber	WF	1	1	1	1	0.5	0.5
Essey Ber	WF	1	1	1	1	0.5	0.5
Chuahit	WF	1.5	1	1.5	1	-	-
Gorgora	WF	1	0.75	1	0.75	0.5	-
Enfraz	WF	1.5	1.5	1.5	1.5	-	-
Gondar	WF	3	2.25	3	2.25	-	-
GFPME	FF	4.95	4.95	8.85	8.85	4.2	4.2
Humera	SD	18	8	18	8	21	8
Metema	SD	18	8	18	8	22	18
Abderafi	SD	21	19	21	19	22	18

Source: Lake Fishery Project, 1996. WF stands for whole fish, FF for fillet fish, SD for sun dried, GFPME for Gondar Fish Processing and Marketing Enterprise, DS for dry season and RS for rainy season.

These investments may stimulate growth and development in the region. Yet, efforts are fragmented and actors have no clear vision for an integrated development and management of these resources in a sustainable condition.

Currently, the water and natural resources of Lake Tana basin are being severely degraded. Severe erosion in the upstream is the most critical and persistent problem, with an estimated soil loss of 100 t/ha/year (Fig. 5.). The natural course of the stated rivers is filled with silt, the nearby agricultural land is flooded, sediment gets deposited in downstream and near inflowing river mouths. All these hinder the normal connectivity of the rivers and the lake. This also causes lake level fluctuation, loss of habitat and biodiversity and turbidity impacting on fisheries, and navigation.

The weather condition of Lake Tana basin, particularly around the lake, is affected by frequent flooding, especially in the Ribb and Megech sub-basin areas. Flood in 2006 inundated more than 15 thousand ha of land and displaced 10 thousand people. During the drought season of 2003, more hydropower generation was needed. At that time, more water was used, which exacerbated the drop in the level of the lake. The drought reduced the level of the lake, which is naturally shallow, by 2 m. The area of the lake was eventually reduced by 35 km^2. The result was significant impact on navigation for three months during the dry season. That hindered tourism and the transportation of goods and services affecting the livelihoods of associated communities. Increasing signs of stress on the trophic state of the shallow lake are evident, which can be expressed as local algal blooms that can induce mass fish destruction if no corrective action is taken immediately.

Open access fishing without enforcement of the legislation, conversion of the shoreline of the lake or the wetland to built-up areas (or settlements, or urban development with heavy recreational investments), expansion of recession agriculture, quarrying in the lake shore and in the rivers are some observed impacts that require due attention urgently in the planned development activities.

The Lake Tana basin has 1600 sq km of fluvial wetlands that provide natural filter against sediments and pollutants and habitats for fish spawning, birds, wildlife and plants. Increasing loads of sediment deposits and the conversion of wetlands into other purposes that serve as bio-filters imposes a grave danger to the lake ecosystem. The Wetlands serve as refuge, feeding, and growing site for fish, and biodiversity maintaining source in the system. Without the wetlands, the natural buffering capacity of the lake to deal with various stresses is jeopardized.

Generally, priority should be given to the most important challenges for the sustainability of the planned development activities in the Ribb and Megech sub-basins irrigation projects. Tackle issues such as the inadequate information and experience of water use management on Lake Tana hydrology. For instance, the lake elevation cited in many documents as 1785 m asl is the lowest and critical dry season elevation as stated previously. The fragile ecology of Lake Tana and the connected wetlands, with concerns of water quality and inadequate knowledge of the biodiversity issues, land degradation and erosion in the upper catchments and sedimentation in the lower flood plains that threatens the wetland and the lake level and lack of an institutional setting and experience in integrated water resources management all need critical attention.

6. SOIL AND WATER MANAGEMENT

6.1 Soil fertility management

The Fogera and Dembia plains are rich agricultural areas. Vertisols and Fluvisols dominate much of the area. The Fogera woreda consists of about 65% black, 12% red, 20% brown and 3% gray soil (WARDO, unpub. data). According to farmers, soils in Dembia and Fogera plains can be classified in to two major groups: *walka* and *dashena* types.

1. *Walka* soil: These are black (vertisols) and brown soils that dominate much of the plains of Dembia. Farmers grow sorghum, tef and chickpea on these soils. Although these soils are fertile, they easily swell when wet because of the clay minerals they contain. The clay makes them difficult to work, when they are very wet or very dry. These soils are characterized by poor internal drainage, which causes waterlogging and seasonal flooding.

2. *Dashena* soils: These soils are alluvial deposits (fluvisols) in the riverine system and dominate much of the area close to the lake. These soils are regarded as the most fertile soils of the area. Major crops grown on them include millet, maize, pepper, barley and rice.

The soil chemical and physical property of Woreta testing site, Fogera woreda, is shown in Table 28 (Yihenew, 2002). The cation exchangeable capacity of the soil was 39.7 $cmol_c$/kg and its pH value was 5.8, which is acidic. The total nitrogen content of the soil was relatively medium (0.14%), while the organic content of the soil is low because of low organic matter applied to the soil and complete removal of the biomass from the field after harvest. The soil type is clay and the consistency is sticky to sticky/plastic and the structure is sub angular blocky and prismatic. Crops to be grown in this field need to be chosen carefully. Farming operations should be the type that can improve soil aeration. The status of the soil moisture also needs to be carefully gauged, which is a critical parameter in tillage (Yihenew, 2002).

Table 28: Soil physical and chemical properties of Woreta Testing Site (Adet Research Center, Amhara Regional Agricultural Research Institute)

Soil depth (cm)	pH	Total N (%)	Organic carbon (%)	C/N ratio	CEC of soil	Available P (ppm)	Particle size (%)			Textural class
							Sand	Silt	Clay	
0-20	5.80	0.14	2.90	21	39.7	6.11	8	25	67	Clay
20-40	5.68	0.15	2.90	19	39.4	5.60	7	26	67	Clay

Source: Yihenew, 2002; soil type is Vertisol

The farming system in Dembia and Fogera plain is mixed crop-livestock. However, nutrient flow between the two systems is predominantly one sided, with feeding of crop residues to livestock but little or no dung is returned to the soil. Generally, soil fertility is declining in the plain (lower stream) as well as in the upstream areas of the command area. Loss of soil fertility is manifested through the use of dung and crop residues for fuels and animal feeds and the low use of chemical fertilizers.

Soil fertility is rather very poor in the highlands (upstream) of the study woredas. The causes for the low fertility are removal of crop residues for animal feed and house construction, removal of animal dung for fuel, intensive grazing, continuous cultivation, absence of fallowing and soil erosion, etc. Each year, soil depth continues to diminish in the upstream resulting in lower yield in the upstream and increase in the lower stream. Reduced soil depth reduces moisture-holding capacity of the soil, which in turn causes high runoff in the upstream areas that carry sand and gravel to the plain and the lake.

The Woreda Agricultural Offices are trying to convince farmers to use chemical fertilizers and compost. In 2007/8 cropping season, Dembia Woreda Agricultural Office distributed more than 5.5 thousand quintals of chemical fertilizer including organic fertilizer (Orga) and the farmers are now used to prepare and using compost.

Declining soil fertility is a problem also in Libo Kemkem woreda, especially in the highlands. Fertility is declining even in the flood plains because of sand sedimentation. Within a radius of more than 100 m from Ribb River, sandy soil is deposited. When water gets scarce, crops cultivated close to rivers immediately show signs of wilting, due to the low water holding capacity of the sandy soil. In the highlands, soil erosion is the major cause for the decline in soil fertility. In the upland of Libo Kemkem, farmers use chemical fertilizers and compost for the production of most crops, except for niger seed and sorghum.

In the plains of Dembia and Fogera, where chemical fertilizer is not used, alternatives to amend and replenish soil fertility include compost, green manuring plants, azolla and bio-fertilizers. These alternatives should be introduced and evaluated.

6.2 Soil conservation and sedimentation

In Lake Tana basin, soils are degraded largely because of water erosion and the extreme exploitation of soils, i.e., loss of soil fertility, in crop fields. Landscapes extremely prone to soil erosion, i.e., the steep slopes or mountains in the south, east, and north of the basin are cultivated. At present, about 27% of the rugged topographies (>15% slopes) were found to be threatened by severe soil erosion

(>60 t/ha/year; plot level prediction). On the other hand, soil loss rates were found to fall in the range of 15-25 t/ha/year, depending on differences in biophysical and management related factors of the individual catchments. Steep slopes cultivated for crop production or used for grazing had significantly lower available phosphorus, total nitrogen, and soil organic matter contents (Birru, 2007).

In the highlands of Dembia, i.e., the *dega* zone, severe soil erosion has created gullies, which dissect grazing areas and crop fields. Active deforestation, overgrazing, heavy and intense rainfall and steep slopes accelerate the speed of runoff. However, much of Dembia area is plain and the climate is subtemperate, or *woina dega.* Soil erosion is minimal in the plain, although the runoff created in the Dega area brings floods, sand and gravel to be deposited in the plain. Recently, undesirable soils of sandy texture are deposited around Megech. The risk of infertile soil deposit is certain.

Continuous changes in land use, land fragmentation, intensive use of the land and deforestation encourage massive soil erosion rates in Lake Tana basin (Fig. 5). The four natural factors that affect the rate of soil erosion in the basin include topographic gradients/ slopes, vegetation cover, rainfall intensity and soil type/nature (erodibility and corrodibility). Taking these variables/ factors into account plus the profound impact caused by man, over 7 categories of soil erosion rates were identified within the basin (Taddesse, 2006). Their spatial distributions of each class are indicated in Fig. 5.

The banks of rivers are not protected and hence river bank erosion is common. Megech River frequently changes its course and erodes the surrounding cultivated areas and forms a new river course. The lower parts of Dembia plain are dissected by river systems. This indicates the need to protect the river bank.

Gully erosion is common even in the plains. Because vertisols crack in the dry season, accumulated runoff from uphill enters the crack and widens it, ready to form gullies. Overgrazing and livestock trampling also create gullies in the grazing land. To control gully erosion, diverting the runoff entering the gully by constructing cutoff drains and check dams are recommended.

Megech River erodes a huge amount of soil from the highlands of Gondar and deposits it in Lake Tana and the plains of Dembia. Interviewed farmers claim that annually one hectare of new land forms at the entrance of Megech to Lake Tana by depositing sediment on the shores of the lake. Elder farmers estimated that about 15 ha of new land formed since 1998. The new land is given to landless youth farmers by the rural kebele administration. This indicates that Lake Tana is shrinking from time to time. The wetland surrounding the lake is being converted to crop fields. Watershed management activities should be given priority to minimize sediment deposition in Lake Tana.

In terms of soil erosion, the most visible evidence in the Ribb catchment is gully formation and sheet erosion with exposure of rock and stones on previously cultivated steep upper slopes. Gullies often appear to be associated with areas of communal grazing. Given the relatively high rainfall, the safe disposal of excess runoff in the rainy season is the main priority with in-field drainage furrows down the slope regularly as observed in the tef fields causing rill erosion. According to the information from farmers, gully erosion is more severe in the red soils of the bottom of hilly areas. *Gabion* and *sand bag* check dams are constructed to control gully erosion. The agricultural offices of the woredas have plans to establish one model watershed management project in each kebele. In addition, three model watershed management projects are implemented by GTZ and have become a model to the woreda.

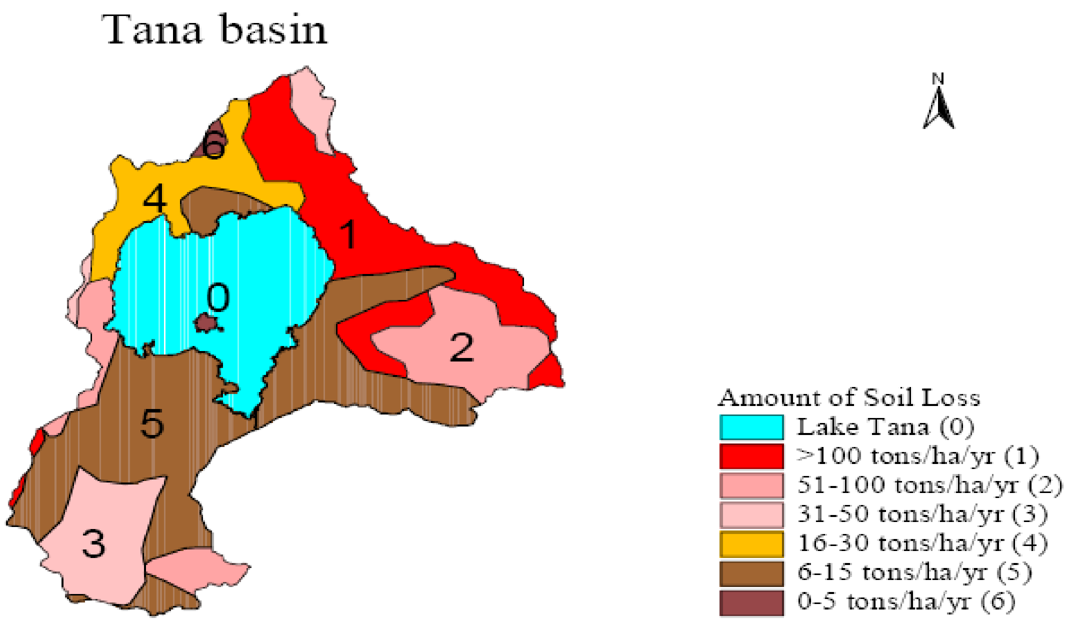


Fig. 5: Spatial distribution of the rate of soil erosion loss within Lake Tana basin (Taddesse, 2006).

As a general guideline, the following land management measures can be applied on Lake Tana basin to reduce erosion and runoff

i) On slopes <5% (Dembia and Fogera plains), agronomic measures may be applied. These may include: contour cultivation, strip cropping, multiple cropping and agroforestry practices.

ii) On slopes from 5 to 15% (slightly above the plains), agronomic measures should be supported by biological measures including planting of grass strips along the contour and use of hedgerows of leguminous woody species, to the same effect as the grass strips.

iii) On slopes >15% (upstream catchments), agronomic and biological measures should be supported by physical measures. This should generally be contour bunds, check dams for gully control, bench terraces, cut-off drains and protected waterways. Slopes above 45% should not be cultivated; generally they should be kept under permanent vegetation. However, this is unrealistic in Ethiopia, where a significant stretch of the cultivated land is steeper than this.

6.3 Agricultural water management m

6.3.1 Surface water resource management

In addition to Lake Tana, rivers such as Ribb, Gumara, Megech, Gilgel Abbay, Abagenen, Dilma, Koga and Jema are all found in the Lake Tana basin. These rivers are known for their huge potential for irrigated agriculture. However, it is still underutilized. The rural household survey report pointed out that about 21% of the households in the watershed are engaged in small-scale irrigation activities, their main water source being rivers (Endeshaw, 2006). About 95% of the irrigated land in Dembia woreda depends on rivers. Springs are also the next major sources of water, which cover 3.2% of the irrigated land. In Dembia, irrigation using shallow wells is negligible, just less than 1%

of the irrigated land. Area of irrigated land and their source of irrigation water in Dembia are shown in Table 29.

Table 29: Area of irrigated land and source of irrigation in Dembia Woreda (WARDO, unpub. data)

Irrigation sources	Irrigated land (ha)	Contribution (%)
River diversion	3027.0	86.1
Motor pump from rivers	327.1	9.3
Spring development	126.0	3.6
Shallow wells (can and pedal pump)	33.9	1.0
Total	3514.0	100.0

In Dembia, eight rivers are used for irrigation. The main rivers are Megech, Dirma and Gumara. The rivers flow generally in a southerly direction towards Lake Tana. There is no modern irrigation structure functional in Dembia woreda. The exception was a small diversion weir constructed earlier but never became functional yet. According to the farmers and woreda experts, most of the construction works of this weir was completed. However, the earthen irrigation canals became gullies themselves. The project was discontinued. Vertisols crack in the dry season and this might have caused gully formation on the irrigation canal. Lining with concrete and redesigning of the irrigation canal is required to make the irrigation scheme operational. Appropriate river bank protection work also needs to be done around the weir area.

Huge surface water resources are available in Libo Kemkem woreda. Some 94 rivers and 95 springs are recorded. Some of the rivers used for irrigation are Ribb, Kerareya, Shegne, Cheberena, Kechine wonze and Gedeye. Most farmers who have access to these water bodies cultivate their land using irrigation. One diversion weir (Kirerai) which has the capacity to irrigate 50 ha was constructed by ORDA. Also Co-SAERAR constructed a weir on river Shegne which can irrigate 42 ha, but it is not functioning very well. The problem is that the body of this weir degraded and the retaining wall collapsed. Almost all irrigation activities are traditional; river diversion and small pump irrigation from rivers and springs are widely practiced by farmers. The contribution of each source of water and its production in Libo Kemkem woreda is shown in Table 30.

Table 30: Area of irrigated land and production (WARDO, unpub. data)

	River Diversion	Motor pump	Shallow well	Pond	Water harvesting
Irrigated land (ha)	3775.9	1755.9	154.5	1.5	15.75
Production (q)	383024	165785	12548	141	1487

Similar to Libo Kemkem, Fogera woreda has also abundant and productive soil and water resources. Some 77 rivers and more than 100 springs flow throughout the woreda. Some of the rivers which are used for irrigation are Ribb, Alemayehu, Mareza, Mizawa, and Dibekena. However, modern irrigation is insignificant. The area irrigated by modern irrigation schemes does not exceed 254 ha (Table 31). A number of shallow wells and four ponds are constructed by farmers. Some 326 small motor pumps and 515 pedal pumps are used to lift water from the source to the irrigated land (WARDO, unpub. data).

Table 31: Modern irrigation schemes and potentials of Fogera woreda (source: WARDO)

Name of modern irrigation scheme	Type of scheme	Year of construction	Constructed by	Potential land that can be irrigated (ha)
Chane	Diversion weir	1997	Co-SAERAR	82.5
Temeqet Bahere	Spring diversion	1996	Co-SAERAR	55.5
Lomi Dure	Spring development	1993	ORDA	70
Goanta	Diversion weir	1999	AWWCE*	46
Total				254

* AWWCE stands for Amhara Water Works Construction Enterprise; total hectarage is 254

6.3.2. Ground water resource management

The ground water potential of Lake Tana basin was not studied very well. Looking at the large expanse of flooded plains surrounding Lake Tana in the rainy season, at first sight it seems that the ground water is close to the surface. The reality, however, is different. According to interviewed farmers who use hand dug wells, the ground water is found on average at a depth of 4 to 6 m in November and 8 to 12 m in April and May in alluvial deposits of Dembia and Fogera plains. The depth may even go up to 18 m in the vertisol areas. When farmers dig wells in the lower plains of Dembia, the soil horizon they witnessed is the following. The upper 2 m depth is *Dashena* or alluvial soil (red soil), the next 3 m is black soil and the last stratum of about 2 m is sandy/gravel substratum, where they get the water.

In the Dembia and Fogera plain, the use of hand dug wells is very minimal, i.e., shallow wells contribute for less than 1% of the irrigatation. Also farmers have problems with wells; the walls of wells frequently collapse (land slide) due to the nature of the soil and in the rainy season they are flooded and become filled up with sediment and disappear. Therefore, farmers must dig wells every year anew, which is a laborious and time consuming activity. The extension service must assist farmers to protect the wells from flooding and land slides.

6.3.3 Irrigation water management

Irrigation water management practices in the study area are traditional and are based on farmers local knowledge. Whenever water is available, the farmers irrigate their fields more than necessary. Most of the farmers irrigate their fields by flooding. Flood irrigation wastes much of the water. However, a few farmers irrigate row vegetable crops along furrows. Farmers never get expert advice about when, how, and how much water to irrigate. In the traditionally diverted rivers and springs, farmers allocate water on rotation. Water user associations (water fathers) prepare irrigation schedules. However, the schedule does not consider the type of crops irrigated and the size of the fields. It only considers the number of members. Farmers' irrigation method and intervals are shown in Table 32.

Table 32: Irrigation water management practices of farmers according to interviewed farmers

Crop Type	Irrigation interval (days)			Irrigation methods
	Dembia	Libo Kemkem	Fogera	
Shallot	7; no irrigation water supplied starting from 2 weeks before harvesting.	15	7	Border strip/furrow
Garlic	7	7	7	Border strip/furrow
Onion	-	15	7	Border strip/furrow
Tomato	21	15	7	Furrow
Cabbage	7	15	15	Flooding
Hot pepper	21	15	15	Furrow
Potato	14; no irrigation water supplied starting from 1 month before harvesting.	21	15	Furrow
Carrot	14; no irrigation water supplied starting from 3 weeks before harvesting.	15	15	Flooding
Beet root	14; no irrigation water supplied starting from 3 weeks before harvesting.	15	-	Flooding
Lentil	At planting and vegetative stages	-	-	Flooding
Chickpea	At planting and vegetative stages	At planting only	5 days before planting only	Flooding
Finger millet	At planting and panicle initiation	-	-	Flooding
Barley	At planting and 2 weeks after planting	At 1 month after planting, at panicle initiation and at grain filling stage	At emergence and at grain filling stage	Flooding
Grass pea	-	-	5 days before planting only	Flooding
Fenugreek	-	15	-	Flooding
Wheat and emmer wheat	-	At 1 month after planting, at panicle initiation and at grain filling	At emergence and at grain filling stage	Flooding
Maize	-	-	At planting and as needed	Flooding
Tef	-	-	7	Flooding

In the plains of Fogera and Dembia, two cycles of irrigated production are practiced per annum. The first one runs from October to January and after harvesting the first irrigation crop, the second crops are planted in February and harvested in May. Farmers close to the lake cultivate potato and maize as the lake recedes, so-called recession agriculture. As the flood continues receding in November, the farmers follow and continue cultivating crops. Women fully participate in irrigation activities, especially seedling transplanting. They do much of the planting activities.

In 2007/08, 3514 ha of land was irrigated using traditional river diversion and small pump irrigation (Dembia Woreda Agricultural Office, unpub. data). The total production under irrigation in the specified year was close to 275 thousand quintals. Area of irrigated land and production of crops in Dembia for two years (2005/6 and 2006/7) is shown in Table 33. Shallow wells and springs are also used for irrigation. Irrigation culture is generally a recent activity in the woreda. Farmers close to Megech River started irrigation agriculture only four to five years ago. Nevertheless, they all have now very well understood the importance of irrigation. The Woreda Agricultural Office has also planned to irrigate 6 thousand ha in 2008/09. The main problem of farmers was the lack of pump maintenance around the area.

Table 33: Area and production of crops by irrigation in Dembia (WARDO, unpub. data)

Crop Type	2005/6		2006/7	
	Area (ha)	Production (q)	Area (ha)	Production (q)
Cereals	331	2,784	272	2,918
Pulses	1,016	11,244	820	14,553
Vegetables and root crops	1,244	197,267	1,685	195,610
Fruits	19	13	12	308
Total	2,610	211,308	2,789	213,389

In 2006/7, 5705 ha of land was irrigated in Libo Kemkem. The area of land under irrigation is increasing. Some 170 water harvesting structures were constructed for irrigation. Farmers also buy motor pumps individually or in groups to irrigate their fields. More than 368 small motor pumps are operating in the woreda.

Irrigation is widely practiced in Fogera woreda compared to Dembia and Libo Kemkem. In 2006/7, 10,221 ha of land was irrigated and the area of irrigated land increased to 12,014 ha in 2007/8, with flood recession cultivation not included. In Fogera woreda, area of irrigated land including flood recession cultivation and production is shown in Table 34

6.3.4 Conflict over the use of water

In Libo Kemkem, WARDO experts believe that recently water has become a major source of conflict. Farmers in downstream run short of irrigation water because farmers in the upstream use it. Experts advice farmers to plant less water demanding crops. Since onions demand frequent watering, experts advice farmers to not grow them until water shortages are no longer a problem. Motor pump users are also advised to pump water directly from undiverted rivers.

Table 34: Area of irrigated land and production by crop type of Fogera woreda (WARDO, unpub. data)

Crop Type	2006/7		2007/8	
	Irrigated land*(ha)	Production (q)	Irrigated land*(ha)	Production (q)
Cereals	3,319	57,583	3,088	49,170
Pulses	4,926	49,515	7,047	72,800
Oil	47	236	17	96
Spices	46	462	97	959
Vegetables/ root crops	4,726	789,616	4,565	801,497
Fruits, chat and hops	58	32,079	101	27,401
Total	13,121	929,491	14,915	951,923

*N.B. The figures include areas of flood recession agriculture. Annually about 2,900 ha of land is cultivated as the flood recedes.

In the plains of Fogera, the number of farmers using irrigation is increasing from year to year. As a result conflict always rages between upstream and downstream irrigation water users. Farmers in the downstream use residual moisture most of the time but they need additional source of water from December on. Framers in the upstream don't have the opportunity to use residual moisture. That means more priority must be given to them. The two communities are planning to establish a joint committee that can fairly allocate the irrigation water.

6.3.5 Flooding problem

Megech and Ribb Rivers flood much of the plains in the study areas. In 1998, Megech River changed its course and created a new course over the lower reaches of Lake Tana, flooding the small rural town called Robit and the villages around it. Parts of the new Megech river course do not have a well defined channel. It flows in many different routes in the Dembia plain. This aggravates the flooding problem.

Following the severe flooding experienced in 2006, flood protection dikes were constructed on both sides of the river. Areas without dikes are still affected by the flood. In the southern part of Dembia, nine rural kebeles, with a total of about 69 thousand people, are affected by flooding. The kebeles include *Tana Woina abo, Debre zuria, Arebeya diba, Achera, Guramba bata chaniqua, Guramba Michael, Seraba dabilo* and partly *Sufanqira gubaya* and *Selje chilo gebeba*. However, farmers tend to value more the fertility advantage obtained from the river in the form of alluvial deposit than the damage caused by the sporadic floods. The Dembia and Fogera plains benefit from the fertile soils deposited due to flooding. Therefore, it is possible to conclude that farmers have adjusted themselves to live with floods instead of controlling them.

Flooding during the rainy seasons forms extensive wetlands and adds more sediment to the lake. Ribb has inadequate flooding capacity in the lower reaches due to mild bed slope and undersized cross-sections. It inundates the upstream and downstream of the road between Woreta and Addis Zemen. Similar to Megech, Ribb River does not have a well defined course past the highway on the direction of the lake. The river altered its old course into several paths in Fogera plain in 2001 (Yirga, 2007).

Four rural kebeles from Libo Kemkem woreda (*Teza amba*, *Genda Woine, Bamebiko* and *Sheena Tsion*) and six from Fogera woreda (*Kokit, Nabega, Shaga, Kidest Hana, Wogetera* and *Shina*) are close to the lake and suffer from periodic flooding. Here too, flood control dikes along Ribb can reduce the flooding problem. However, there is still controversy among farmers about flooding and sedimentation. Some complain about the construction of the dike and try to demolish it so that they will get the fertile sediments deposited in their farm lands. Others claim that recent sediments are no more fertile as they are more of sand than soil, so they don't want sedimentation. Similar debate is also raging over the construction of the dam. The dam will eliminate sedimentation, which some farmers consider a reward.

6.3.6 Land drainage and waterlogging

Most crops are sensitive to waterlogging. The plains of Dembia and Fogera are the most affected by waterlogging. When farmers cultivate wheat, finger millet and maize, farmers traditionally drain the water by constructing graded channels, or water ways, at 3 to 5 m intervals. The woreda agricultural offices also demonstrate Broad Bed Maker (BBM), which is an animal drown implement to make beds for crops and furrows to drain the land. However, the adoption of BBM is very minimal. Because the topography is flat and the soil is heavy clay, it is difficult for farmers to make proper broad bed and furrow. In Dembia woreda, the total crop area that needs drainage is 6,774 ha. Some 2,500 ha is covered by seasonal water, which is difficult to drain. According to the woreda agricultural office, some 6544 ha was drained in 2008.

6.4 Constraints of soil and water management

Farmers in Dembia area mentioned the most pressing problems in their area. In descending order, the major problems in soil and water management include flooding, soil fertility decline, waterlogging, shortage of irrigation water, and limited availability of pumps and lack of pump maintenance services. In addition to these, in Libo Kemkem farmers mentioned erratic rainfall, soil erosion and lack of potable water are their problems. Farmers' ranking of constraints of soil and water management in decreasing order in the study area is shown in Table 35.

Other constraints raised by woreda experts in Fogera are sliding of wells, cracking, sedimentation and high seepage of canals, and gully erosion around irrigation structures. According to farmers the major problems related to soil and water management are shortage of irrigation water, lack of irrigation canal, lack of credit facility for purchasing of irrigation pumps, lack of pump maintenance, land degradation in the upper catchment and waterlogging in the lower plains. Soil moisture and rainfall availability are adequate for crop production both in Fogera and Dembia woreda. However, early cessation of rainfall is only mentioned in the upper part of Libo Kemkem, when there isn't rainfall in September, they face drought problem.

Table 35: Constraints of soil and water management as perceived by the interviewed farmers (rank in decreasing order)

Dembia		Libo Kemkem		Fogera	
Upper	Lower	Upper	Lower	Upper	Lower
Soil erosion	Flooding	Declining soil fertility	Flooding	Shortage of irrigation water and modern facilities	Flooding
Declining soil fertility	Declining soil fertility	Erratic rainfall	Shortage of irrigation water and modern facilities	Decline of soil fertility	Waterlogging (permanent water ponding)
Shortage of irrigation water and modern facilities	Waterlogging	High cost of chemical fertilizer	Erratic rainfall	Soil erosion	Shortage of irrigation water and modern facilities
Erratic rainfall	Lack of water pump maintenance	Soil erosion	High cost of chemical fertilizer	Lack of water pump maintenance	Lack of water pump maintenance
		Shortage of irrigation water and facilities	Declining soil fertility		

7. FORESTRY AND AGROFORESTRY

7.1 Forest resource base

Information on forest resources of *Ribb* and *Megech* river catchments is scanty. No systematic information is available on the past and present extent, growth rate, species composition and diversity, etc. of forest resources. Whatever is available is inconsistent. According to the reports from WARDO, the forest and woodland resources of these catchment areas can be categorized into four major types of vegetation. These include natural forests, plantation forests, farm forests and shrubs and bushlands. The total area covered by forest and woodland resources is about 8,416 ha in Dembia, 4,391 ha in Libo Kemkem and 2,780 ha in Fogera. Out of this, natural forests cover some 1,525 ha in Dembia, 1,931 ha in Libo Kemkem and 557 ha in Fogera. The rest is covered by plantation forest, bushlands and shrub land resources.

7.1.1 Natural forests

This type of vegetation comprises remnants of disturbed natural forests that are mainly found along catchment areas and less accessible steep slopes. Analysis of the available forest resources in the three woredas within the study areas indicates that the area of natural forests in these woredas ranges between 5 hundred and 2 thousand ha. Visual assessment and information on the forest resources in the study area indicates the forest status to be 15% undisturbed and 85% degraded and disturbed. Formal surveys need to be done to validate this claim. The indigenous tree species constituted the natural forest resources of the catchment area. *Sapium ellipticum, Acacia albida, Acacia seyal,* *Acacia tortilis, Albiza gummifera, Allophylus abyssinica, Calpurina aurea, Capparis tomentosa, Carissa edulis, Cordia africana, Croton macrostachysus, Dodonaea anguistifolia, Entada abyssinica, Erythrina abyssinica, Ficus sycomorus, Ficus vasta, Grewa villosa, Juniperus procera, Millettia ferrugunea, Mimusops kummel, Phytolacca dodecandra, Podocarpus falcatus, Prunus africana and Ximenia americana* are some of the indigenous tree species.

7.1.2 Plantations forests

The available information on the plantation forests of the Rib and Megech river catchments is fragmented and unreliable. The estimates are often based on the number of seedlings delivered from nurseries and planting densities in each woreda. Information on areas actually planted and survival rates of species planted does not exist. However, according to the information from each WARDO, plantation forests range from 1 thousand to 2.3 thousand ha with the following categories: state forests, conservation, community and private plantations.

The plantation forests include the trees planted by government or individual farmers in different tree growing niches for different purposes. *Eucalyptus camaldulensis* is the dominant tree species that has been planted as a plantation tree in the Rib and Megech river catchment area. Individual farmers prefer to plant the indigenous tree species, *Cordia africana*, as plantation tree. Other species such as *Acacia bussei, Acacia indica, Acacia melanoxxylon, Acacia saligna, Arundo donax, Azadirchta indica, Cajanus cajan, Coffea arabica, Ficus thoninngii, Justicia schimperiana, Leucaena leucocephala, Rhamnus prinoides, Schinus molle, Sesbania sesban and Spathoda nilotica* are also found in forest plantations. Species in plantation forests vary according to purposes they are intended to serve.

7.1.3 Bushlands and shrublands

In the study woredas, bushlands are largely restricted to grazing lands and degraded hill sides. According to the respective WARDO, the total area covered with bush and shrub species in the three woreda's ranges between 2 thousand to 7 thousand ha. Species such as *Pterolobium stellatum, Acacia albida, Acacial bussei, Acacia indica, Acacia seyal, Acacia tortilis, Allophylus abyssinica, Calpurina aurea, Capparis tomentosa, Cordia africana, Dodonaea anguistifolia, Entada abyssinica, Mimusops kummel, Phytolacca dodecaandra, Rhus vulgaris, Syzygium guineense and Ximenia americana* are grown as components of the bushland and shrubland species in the catchment area.

7.1.4 Farm forestry

Farmers plant or deliberately leave trees in their fields in pursuit of income generation, risk management, household food security and optimum use of available land, labour and capital. In Rib and Megech catchment area, there is no clear information on the number or coverage of tree species that are included in the farm forestry. However, according to the information from WARDO of each woreda, it is assumed that farmers should leave about 30 to 40 different trees per ha for various purposes. Farmers plant or deliberately leave different tree (agroforests) species on crop fields. *Cordia africana*, *Crotone macrostachys*, and *Acacia* species are the dominant farm forestry tree species in the catchment area.

Other species such as *Acacia albida, Acacia seyal, Acacia tortilis, Capparis tomentosa, Dodonaea anguistifolia, Entada abyssinica, Ficus vasta, Grewa villosa,* and *Eucalyptus camaldulensis* are also found in the farm forestry tree species of the area.

7.2 Tree planting practices

7.2.1 Tree seed source

Trees grown in the vicinity are used as a source of seed for planting, although the quality and quantity of seed produced is substandard. Traditionally, farmers collect the seed from the tree they want to raise in the satellite nursery of their backyard. The mother trees that serve as a tree seed source are not permanent and the selection of trees follows the traditional way. The seeds collected from the mother trees are dried well and sown. Farmers never practice pre- seed treatment and other germination tests. Government nurseries use seeds from the local grown trees and the national tree seed center. Seeds are treated before sowing in these nureseries.

7.2.2 Nursery establishment and management

About 13 nurseries are found in the three woredas, all of which are government owned. Except in Fogera, the community is not involved in permanent nursery establishment (Table 36). Local people commonly establish temporary nurseries to raise exotic seedlings. The largest number of nurseries is found in Fogera.

Table 36: Number of permanent forest nurseries in each woreda

Woreda	Owner		Area
	Government	Community	
Dembia	3	Not Known	>2 ha
Libo Kemkem	7	Not Known	>1 ha
Fogera	3	21	>0.5 ha

These nurseries raise potted and bare root seedlings of both exotic and indigenous tree species. *Eucalyptus camaldulensis* is the most preferred exotic tree species, while *Acacia* species, *Cordia africana,* and *Croton macrostachys* are among the indigenous tree species raised in greater quantity. The common nursery activities and their time schedule are shown in Table 37. This schedule is the same in all woredas.

Table 37: Nursery calendar for different activities

Activities	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Land preparation			X	X								
Seed collection	X	X	X	X	X	X	X	X	X			
Seedling raising					X	X	X					
Transplanting							X	X				
Seedling distribution										X		
Planting											X	X

Note: In the nursery, most tree species fall within the above calendar.

Nursery managers sell different types of seedlings, whose prices vary with species, to users. One birr can buy any one of the following species: 25 *Eucalyptus camaldulensis,* 10 *Cordia africana,* 25

Gravelia robusta, 10 *Mangifera indica,* 25 *Azadirachta indica,* 10 *Cupresses lustanica,* 20 *Acacia species* seeddlings.

Farmers sell bare root seedlings. The main tree species farmers raise and sell is *Eucalyptus camaldulensis*. One hundred bare seedlings are sold for one birr. The number can increase according to the availability of seedlings in the market from the governmental nurseries. *Cordia africana* is the second most important tree species that is raised and sold by farmers in the study area. It is also supplied in bare form and 10 seedlings are sold for one birr. The government nurseries sell seedlings according to the price indicated above. Fodder tree seedlingas are distributed freely to the farmers.

7.2.3 Tree growing, management and limitations

Farmers commonly raise and plant tree seedlings in the catchments area. The preferred tree species are fast growing and economically important tree species such as *Eucalyptus camaldulensis*. Farmers do not neglect other tree species. Some indigenous tree species are commonly seen in farmers' fields and around the homestead. However, the poor growth performance of indigenous tree species discourages farmers. The most important tree management activities include side pruning, lopping, hoeing, weeding, manuring, and fencing. Thinning, that is reducing the stocking number as the tree grows in size, was not mentioned as a management activity by the farmers.

Farmers mentioned low seedling survival and unavailability of alternative seedlings as obstacles for tree growing. It can be concluded that although seedling supply is there, the quality and diversity is poor. Moreover, the shortage of land constrained the tree growing in the catchment areas.

7. 2.4 Impact of gender, tenure and beliefs on tree planting

Farmers are allowed to plant trees in their holdings. Men plant and take care of trees, while women are less involved because they are engaged in household activities such as fetching water, taking care of children, etc. The local people do not cut trees growing in places of worship such as churches and mosques. The cultural taboo does not allow farmers to cut trees especially the indigenous ones around the churches.

7.3 Agroforestry practices and tree growing niches

Agroforestry is a collective name for a range of land use practices in which trees or shrubs are grown in association with herbaceous plants (crops or pastures), in a spatial arrangement or a time sequence, and in which there are both ecological and economic interactions between the tree and non-tree components of the system. The economic interaction is the production of fuel wood or fruit for cash or income. The ecological interaction is the biogeochemical cycle in the system.

Some agroforestry practices exixt in Ribb and Megech river catchments. It involves the arrangement of components (trees, crops, pastures, and livestock) in space and time. Trees in homesteads, scattered trees in farm lands, woodlots trees and trees on gullies are the dominant practices. These practices are also identified as the main tree growing niches in the catchments. In terms of the availability of tree species in each practice, homesteads are found to be the most important tree growing niches followed by trees scattered inside the farm in the catchment area (Table 38). Homesteads are under strong and secured ownership feeling of the household owner. Besides, they are near settlements and are always under the direct supervision of members of the household. As a result, they will be managed and watched easily. On the other hand, the low number of species in road sides, gullies and woodlot plantations suggest that these areas are not utilized well as tree growing niches in the Rib and Megech river catchments. This may be due to the uncertainty of who will take the benefit from road side and gully plantations, as they are communal in nature. Each practice is discussed as follows. A list of tree species planted around homesteads is presented in Table 38.

7.3.1 Trees in homesteads

Homestead trees are found in the form of live fence, woodlot and intercropped with crops. *Euphorbia tirucalli, Opuntia ficus-indica, Euphorbia abyssinica, Arundo donax and Eucalyptus camaldulensis* are the dominant plants in the living fence practice. Farmers appreciate these trees because they propagate easily. *Eucalyptus camaldulensis* is a common tree in the woodlots. Trees like *Acacia seyal* and *Croton macrostachys* are intercropped with crops. *Rhamnus prinoides* is also found in homestead plantations.

7.3.2 Scattered trees on farm lands

Trees are deliberately left in crop fields, the most common in the area being *Cordia africana, Croton macrostachys, and Acacia*. These species are mostly found on sorghum and tef fields. Farmers pollard *Croton macrostachys* and *Acacia* species when sorghum is grown beneath these trees to prevent birds that build nests and also to prevent shading effects.

7.3.3 Trees in woodlots

Woodlots could be described as monocultures of *Eucalypts camaldulensis,* deliberately established to produce wood as a cash crop and for home use. Farm woodlots are commonly cultivated as part of the farm. Farmers establish and manage woodlots their own way, not based on recommendations from WARDO experts. They are advised to establish their woodlots at a lower density. They simply ignore the advice and establish high tree density woodlots. They do this to compesate for seedling mortality.

7.3.4 Trees on gullies

Trees are gown in gullies for soil and water conservation. The aim is to rehabilitate degraded pieces of land by growing a few exotic trees. The most common are *Sesbania sesban*, *Acacia melanoxylon*, *Leucaena leucocephala*, and *Erythrina abyssinica*.

7.3.5 Trees on roadsides

Roadside plantation is not common but it is observed in some places where ornamental trees are planted. *Casurina* species, *Schinus molle*, *Jacaranda* and *Spathodea nilotica* are some of the trees grown along the road.

7.4 Agroforestry packages

The Bureau of Agriculture and Rural Development has prepared different agroforestry packages, which consist of alley cropping, woodlots, farmland plantation, boundary plantation, roadside plantation and homestead plantation. Woodlot, farmland, boundary and roadside plantations are practiced in each woreda. The remaining agroforestry packages are not disseminated widely.

7.5 Timber and non- timber forest products

Trees are a fundamental element of life. They play a vital role in our lives. They provide us with some of the foods and fruits we eat, medicines we use that are extracted from leaves and barks of trees, etc. Other products and services people get from trees include fuelwood, charcoal, feed, shade, fence, farm implements, and construction materials and they also serve as means of conservation, according to farmers in the catchment areas (Table 39).

Farmers use wood for cooking and heating especially *Eucalyptus camaldulensis, Acacia species, Albiza gummifera, and Terminalia brownie*. Farmers appreciate these species because they are commonly available and they burn slowly releasing a lot of heat energy. Acacia species and Eucalyptus species are chosen for charcoal making

The duration of stay on fire and demand in the market are tree selection criteria in charcoal making. Live fences are used as sources of fuelwood, shade for humans and livestock, feed for livestock and windbreak for the compound. *Eucalyptus camaldulensis, Gravelia robusta, Ficus thonningi, Euphorbia* species and *Arundo donax* are used as live fence. Trees for live fence are chosen based such criteria as thorniness, availability and phenology, etc.

Trees provide shade both for human beings and livestock. Farmers prefer trees with larger crown and those which can provide dense shade year round. Trees chosen for human and livestock shade are *Cordia africana, Croton macrostachys, Ficus* species *and Acacia* species. Farmers make traditional farm implements from trees. The indigenous species are the most preferred tree species for making farm implements. However, currently farmers shift towards eucalyptus for making farm implements because it is available. A complete list of trees and shrubs found in Rib and Megech river catchment is given in Table 40.

7.6 Problem analysis

7.6.1 Forest land degradation and loss of biodiversity

The *Ribb and Megech* river catchment has been subjected to prolonged use for agriculture without conserving natural resources. The vegetation cover is cleared including forests throughout the catchment. Much of the upstream area must have been covered with forests in the distant past. Patches of natural forests remainig around places of worship are indicators of this fact. Forest trees have been subjected to repeated manmade and natural disasters. Thus forests have decreased both in size (deforestation) and quality (degradation) from time to time.

Table 38: Major trees and shrubs and their niches in the river catchments of Rib and Megech

Dembia	Libo Kemkem	Fogera
	Homestead niche	
Eucalyptus camaldulensis, Cordia africana, Ficus thoninngii, Ficus sycomorus, Olea europaea, Coffea arabica, Phoenix reclinata, Euphorbia abyssinica, Euphorbia triucalli, Opuntia ficus indica, Mangifera indica and Rhamnus prinoides	*Eucalyptus camaldulensis, Cordia africana, Ficus thoninngii, Euphorbia triucalli, Cupressus lusitanica, Mangifera indica, Sesbania sesban, Carica papaya*	*Eucalyptus camaldulensis, Cordia africana,, Sesbania sesban Carissa edulis*, qega, *Euphorbia triucalli, Justicia schimperiana,* koshim, *Justicia schimperiana, Chamaecytisus palmensis, Phoenix reclinata*
	Farmland niche	
Acacia albida, Acacia bussei, acacia seyal Cordia africana, Albiza gummifera, Entada abyssinica and Eucalypyus camaldulensis	*Acacia albida, Acacia bussei, Acacia seyal, Acacia tortilis, Entada abyssinica, Eucalypyus camaldulensis*	*Eucalyptus camaldulensis, Cordia africana, Croton macrostachyus, Acacia saligna, Acacia decurrens, Albiza gummifera, Millettia ferrugunea, Erythrina abyssinica, Schinus molle*
	Woodlot niche	
Eucalyptus camaldulensis	*Eucalyptus camaldulensis*	*Eucalyptus, Acacia melanoxylon, Grevillia robusta*
	Gully niche	
Euphorbia abyssinica, Euphorbia triucalli, Sesbania sesban, *Eucalypyus camaldulensis*	*Sesbania sesban, Eucalyptus camaldulensis*	*Euphorbia abyssinica, Euphorbia triucalli, Sesbania sesban, Eucalypyus camaldulensis, Leucaena leucocephala, Erythrina abyssinica, Acacia melanoxylon*
	Roadside niche	
Casuarina equistifolia, Schinus molle, Jacaranda	*Gravellia robusta Casuarina*, *Schinus molle*, *Spathodea nilotica*	*Spathoda nilotica, Schinus molle,* Sheewshewe, *Azadirachta indica, Acacia saligna, Cupressus lusitanica*

Deforestation causes loss of biodiversity and eventually environmental degradation. Uncontrolled removal of forests and demographic pressure are the major causes of forest resource degradation. The loss of biodiversity through deforestation has undoubtedly caused many social and economic problems and the need for food, fodder, energy, biomass, and wood continues unabated.

Farmers also mentioned that some species had been utilized for different purposes in the not too distant past. However, currently these tree species are no longer around. Agricultural land expansion and increased demand for forest products such as fuelwood and charcoal are the main causes for the loss of these tree species in the catchment area. Farmers recognise the impact of loss of biodiversity in their vicinity.

Table 39: Indigenous trees species and their main uses as indicated by farmers in the Ribb and Megech river catchments

No	Species	Local Name	FW	CH	FD	SH	FC	FI	HC	CON
1	*Acacia albida*	Girar	X	X	X					
2	*Acacia seyal*	Debele (nech gerar)	X	X						
3	*Acacia tortilis*	Yabesha gerar	X	X						
4	*Albiza gummifera*	Sesa	X	X						
5	*Allophylus abyssinica*	Enbise	X						X	
6	*Capparis tomentosa*	Gemero	X				X			
7	*Cordia africana*	Wanza	X	X	X	X	X	X	X	X
8	*Croton macrostachyus*	Mesana (Bisana)	X	X	X			X		X
9	*Entada abyssinica*	Kontir	X	X		X	X			
10	*Erythrina abyssinica*	Korch	X			X	X			X
11	*Euphorbia abyssinica*	Kulkual	X				X			
12	*Ficus sycomorus*	Bamba	X		X	X				X
13	*Ficus toninngii*	Cheba	X		X		X			X
14	*Ficus vasta*	Warka	X		X	X				
15	*Juniperus procera*	Yabesha tid	X	X			X	X	X	X
16	*Millettia ferruginea*	Birbira	X			X				
17	*Olea europaea*	Woira	X	X				X	X	
18	*Phoenix reclinata*	Seleln	X							
19	*Podocarpus falcatus*	Zigba	X	X		X		X	X	
20	*Prunus africana*	Tiqur Enchet	X	X		X			X	
21	*Spathoda nilotica*	Yechqa nebelbal	X			X	X			X
22	*Syzygium guineense*	Dokma	X	X	X				X	
23	*Terminalia brownie*	Abalo	X	X					X	X

Note: - FW-Fuelwood, CH-Charcoal, FD- Feed, SH- Shelter, FC-Fence, FI- Farm implement, HC-House construction, and CON- Conservation

7.6.2 Land degradation and soil erosion

Clearing of forest cover also causes very severe soil erosion. This is more serious in the upstream, where gullies form in crop fields and grazing areas. Farmers also mentioned that the major causes of soil erosion include lack of farmers' devotion to protect the land from erosion and unavailability of adequate conservation practices. There is no motivation on the part of the farmers and they do nothing to restore such large tracts of degraded areas. Plantation activities to rehabilitate these degraded areas or as an investment approach is very limited.

7.6.3 Monospecific plantation

Fast growing exotic tree species (mainly *Eucalyptus* species) dominate plantation forestry over indigenous species in the catchment area. Their fast growth and high demand makes fast growing trees to be able to occupy tree growing niches and abandoned lands, where native species apparently fail. They even extend the new forest boundary by establishing themselves in areas previously not under forest cover like swampy areas and on badly degraded sites, where it is extremely difficult to establish native species. The effort by governmental and non-governmental organizations, following the millennium celebrations, to promote indigenous trees is rather limited and was not successful.

7.6.4 Shortage of forage trees

Scarcity of animal feed is common in the catchment area because grazing lands are converted to agricultural lands. Fodder trees are not easily available and the technology is not well adopted by farmers. This has direct impact on the production and productivity of livestock in the area.

7.6.5 Flooding and waterlogging threaten tree planting

Flood and waterlogging are common problems in the catchment area, especially in the lower stream. Floods and waterlogging affect the farming system in general. Survival of seedlings is low in conditions of excess and stagnant water in the plains. Therefore, alternative species that can survive under these conditions need to be planted. Species that are environmentally friendly if planted in the river bank and as buffer plantations around the lake to help keep the natural resource and agriculture sustainable over the long term are mandatory. Table 40 shows a list of trees and shrub species found in the Ribb and Megech river catchment area.

Table 40: List of trees and shrub species found in the Ribb and Megech river catchment area

Species name	Common name	Life form
Acia albida	Girar	Tree
Acacia bussei	Girar	Tree
Acacia decurrens	Decurrens	Tree
Acacia indica	Indica	Tree
Acacia melanoxylon	Omedela	Tree
Acacia saligna	Saligna	Tree
Acacia seyal	Debele	Tree
Acacia seyal	Qey gerar	Tree
Acacia tortilis	Yabesha gerar	Tree
Albiza gummifera	Sesa	Tree
Allophylus abyssinica	Enbise	Tree
Arundo donax	Shembeko	Grass
Azadirachta indica	Neem	Tree
Cajanus cajan	Yergeb ater	Shrub
Calpurina aurea	Zeqeta	Shrub/small tree
Capparis tomentosa	Gemero	Shrub
Carissa edulis	Agam	Shrub
Casuarina equisetifolia	Arzelibanos	Tree
Casuarina equisetifolia	Shewshewie	Tree
Coffea arabica	Buna	Tree
Cordia africana	Wanza	Tree
Croton macrostachyus	Mesana	Tree
Cupressus lusitanica	Yeferenje tid	Tree
Dodonaea anguistifolia	Kitkita	Shrub
Dovyalis abyssinica	Koshim	Shrub

Entada abyssinica	Kontir	Tree
Erythrina abyssinica	Korch	Tree
Eucalyptus camaldulensis	Key bahire zaf	Tree
Euphorbia abyssinica	Kulkual	Tree
Euphorbia tirucalli	Kinchib	Shrub
Ficus sycomorus	Bamba	Tree
Ficus toninngii	Cheba	Tree
Ficus vasta	Warka	Tree
Grevillia robusta	Gravelia	Tree
Grewa villosa	Lenquata	Shrub
Jacaranda mimosifolia	Yegoradie zaf	tree
Juniperus procera	Yabesha tid	Tree
Justicia schimperiana	Semiza	Shrub
Leucaena leucocephala	Lukina	Shrub/small tree
Mangifera indica	Mango	Tree
Millettia ferruginea	Birbira	Tree
Mimusops kummel	Eshehe	Small tree
Moringa oleifera	Sheferaw	Tree
Olea europaea	Weira	Tree
Opuntia ficus-indica	Beles	Shrub
Phoenix reclinata	Seleln	Tree
Phytolacca dodecandra	Endod	Shrub
Podocarpus falcatus	Zigba	Tree
Prunus africana	Tiqur Enchet	Tree
Psidium guajava	Zeituna	Tree
Rhamnus prinoides	Gesho	Shrub
Rhus vulgaris	Qmmo	Shrub
Rosa abyssinica	kega	Shrub
Schinus molle	Qundoberbere	Tree
Sesbania sesban	Sesebania	Small tree
Spathoda nilotica	Yechqa nebelbal	Tree
Syzygium guineense	Dokma	Tree
Terminalia brownie	Abalo	Shrub
Ximenia Americana	Enkoy	Small tree
	Fafanya	
	Gemeteto	
Pterolobium stellatum	Kentefa	Climber
	Chibeleqa	
	Wenbela	
	Shenshena	
Sapium ellipticum	Arbojie	Tree

8. FARM POWER AND FARM IMPLEMENTS

Working animals traditionally constitute an integral part of the farming system in both river Megech and river Rib irrigation project areas. They are used as a major source of power to conduct agricultural work operations and transport of goods, which reduce the work load of workers. Animals also convert crop residues and other biomass into valuable products such as manure, meat and hide. The major working animals used in both irrigation project areas are cattle and donkeys. A few mules and horses are also available in the upstream areas of Rib River, where they are used only for human transport. Oxen harnessed in pairs are mainly used for land preparation, sowing and threshing. In some areas, cows are also harnessed with oxen for carrying out these operations. The number of oxen is usually greater than the number of donkeys in all surveyed areas as the function of donkeys is only limited to transporting goods. Donkey power is not diversely utilized as oxen power in these areas. The major use of donkeys in both irrigation project areas is for transporting of goods by means of packing. In the upstream areas of Megech River, donkeys are also used for trampling fields before sowing small cereals like *tef* and finger millet.

Management of working animals is greatly influenced by the importance of their role in the work operations. Oxen usually receive better attention than donkeys in terms of feeding and health care. After field work in the wet season, oxen are additionally fed with weeds and they are kept alone to graze in the natural pasture near villages. During the dry season, oxen are additionally fed to crop residues, while donkeys in all areas are only allowed to natural grazing whether they are at rest or after work. Farmers require additional work and labour investment to collect, transport and store straw (sorghum, *tef,* finger millet, rice, wheat and barley) for animals. Available fodder resources are apparently exploited with too much labour, but the amount of fodder available is very small that compels farmers to keep only a few working animals. In all areas, secondary sources indicate that the number of farmers who do not own oxen at all or those who own one ox is much greater than those who own a pair or more working oxen. Not only the working animals are few in number but they are also in poor condition. This contributes for the shortage of power and low performance in the field. Furthermore, the recently opened livestock market with Sudan increased the price of cattle in general and oxen in particular. Fattening and dairy cattle are more profitable than using animals for draft power. Because of greater profits, fodder resources are used for fattening and dairy cattle instead of draft power. As a result, small farmers find it difficult to rear, buy and even hire draft animals.

8.1 Work operations and farm implements

8.1.1 Field preparation

There is no tradition of fallowing in the lower stream areas of the irrigation projects as the soil is relatively fertile due to alluvial bed formation and abundant moisture when compared with the upstream areas. The land use intensity in these areas is very high as farmers can grow two to three times a year using rainfed, irrigation and residual moisture. Crop residues are primarily meant for cattle feed. Maize stalk residues are uprooted usually by children for fuel wood before any field work operations. Though some farmers in the upstream areas are practicing short fallowing, any biomass residue in this area also serves to feed cattle. Land preparation is relatively easy in most of the catcment because of the plain topography. Damage of farm implements is uncommon. Roots, rocks and organic residues rarely create obstacles during field operations.

8.1.2 Soil preparation

The most important rainfed crops grown vary from one area to another. The commonly cultivated crops in both survey areas include: sorghum, tef, chickpea, finger millet, maize, pepper, barely, tef, rice and spices. In the upstream areas of Megech river, sorghum is dominant crop followed by tef and chickpea whereas in the lower stream area, finger millet and maize are more important. Apart from rainfed crops, irrigated crops like garlic, shallot, potato, chickpea, pepper, spices and barely are widely grown in the area. In upstream areas of the Rib river, crops like tef, chickpea and finger millet are dominant. In the lower stream areas of Rib river, rice is widely cultivated as a major crop.

Soil preparation in both areas begins one to two months before planting using the traditional plough. In all upstream areas soil preparation for rainfed crops starts with the onset of the first rains. In the lower stream areas soil moisture is good and the first ploughing is done immediately after crop harvest. It is carried out using a pair of oxen with the traditional beam and plough (*maresha*). The *maresha* consists of a long wooden drawbar which is attached to the yoke of team of oxen and wooden handle with steel plough share. The wooden part of *maresha* is made by farmers themselves and the steel plough share is manufactured by local artisans.

Maresha is utilized in both types of soils and even in vertisols, which severely expand when wet and shrink when dry due to high clay content. Maresha does not turn the soil and in most cases leaves some un-worked patches. Several tillage operations in criss-cross fashion are done before the land is ready for planting crops. The number of passes varies with crop type. The maximum for tef in both areas ranges from three to five. There are also instances where the maximum number of ploughings can be as many as 10 for irrigated pepper, where two passes within a day is possible. The weight and size of maresha used in the dry season is different from the one used during the wet season. The dry season maresha is larger and heavier than the wet season maresha. In both areas, a very light maresha, lighter than the ones described above, is used to cover seeds after sowing.

8.1.3 Sowing

The seeding procedure varies with crop and soil type. The most common types of sowing employed in these areas are hand broadcasting, row planting, drilling and transplanting. For crops like tef and finger millet the seed bed is usually trampled with cattle in the upstream areas of Rib river and using donkeys in the upstream areas of Megech river. In lower stream areas, seed bed trampling is not common. The seeds are broadcast by hand immediately after trampling. Barley, sorghum, beans and chickpea are broadcast by hand and covered with light weight maresha to protect seeds from birds. Crops like maize, sorghum and pepper are manually row planted in flat fields with recommended spacing between rows and plants. Potato seeds are drilled manually where seeds are placed at regular intervals as the maresha opens the furrow. After placing the seeds the furrow is covered with the maresha with a team of oxen. Shallot and tomatoes are widely transplanted. Irrigated crops are mostly planted on flat field with flood irrigation, which is not suitable for subsequent weed control and this system is subject to high loss of irrigation water. In both areas, row planting and seed drilling consume more workload than broadcasting method.

In upstream areas where water logging is a problem, rainfed tef and wheat are planted using broad bed and furrow system which is traditionally prepared using maresha. Recently, the extension service has supplied the BBM, which is mounted on the maresha, to be used to make broad beds and furrows in water logged crop fields, mostly wheat. Similarly, in Rib river area, the implement is used for finger millet and soya bean. Broad beds and furrows are made after broad casting of seeds by hand. The seeds grow on the raised broad bed and the excess water is drained along the furrow.

BBM is made of sheet steel having a thickness of 2.5 mm which is bent to a certain angle and provided with wings made of deformed iron for seed covering. After hand broadcasting the raised bed and furrow is prepared using BBM where seed covering is simultaneously done by the wings attached to the BBM. For this implement to be used successfully, knowing the right soil moisture is mandatory. However, that is practically very difficult to achieve. There is also a problem of back bending while working resulting in a loss of the original shape and eventually in non-uniform broad bed and furrow. This is usually caused by faulty manufacturing of the BBM using thin sheets of steel. The sowing operation is generally spread over two months for both rainfed and irrigation farming in all surveyed areas but it does not represent a work peak in all areas.

8.1.4 Weeding

Weed control is chiefly conducted manually using hand tools in all surveyed areas. In Megech river areas, sickle is the universal hand tool used for weeding for both rainfed and irrigated crops. In Rib river area, hand hoe, locally known as *chiro* and sickle are used for weeding. *Chiro* is a metallic spear inserted on a bent wooden frame; it has one to three fingers and it is made by local artisans. Thinning using maresha, a process locally known as *shilshalo* for finger millet and maize, is practiced in these areas. It is an operation used to break the upper soil, to remove emerging weeds and to thin the emerging seedlings. The use of herbicides is increasing in all areas.

The number of weedings varies with crops. In Rib river area, pepper is the most frequently weeded crop, which can be as many as seven times. This is the peak working season. Farmers in all surveyed areas normally weed some crops quite late in the season. This is due to the fact that weeds are widely used for cattle as green fodder.

8.1.5 Harvesting

Harvesting operation employs different methods like manual harvesting with sickle, hand picking, and manual pulling up and with the help of maresha. Survey areas did not vary in types of implements used for harvesting. Cereals are exclusively harvested manually using sickle. Crops like chickpea, shallot and garlic are manually pulled out by hand whereas other crops like tomato and pepper are harvested by hand picking alone. Potato tuber is harvested using maresha with a team of oxen.

Sorghum is harvested by bending over and cutting the top most part of the stalk using sickle. The sorghum stalk is left in the field for some time and it is later harvested with sickle near the bottom and stacked, and later fed to cattle or used for thatched roofing. . Shattering, bird damage and pest attack are serious problems of some crops. Harvesting is the most labour intensive activity. It should be done on time before damage is inflicted by any of these agents. After harvesting the bulk is left in the field for a few days to dry in the sun and it is stacked for a couple of weeks in the field too until it naturally loses its moisture.

8.1.6 Threshing and hulling

Threshing of crops is mostly done using oxen, manually using stick and hand shelling (maize). Threshing using oxen on a threshing field is the most common practice. Prior to threshing a circular threshing plot is prepared near to the bulk grain stack area. The threshing plot is levelled, sprayed with some water and lightly compacted using cattle. In some areas, after compacting it is smeared with cow dung mixed with water.

During threshing a manageable layer of bulk crop is uniformly spread over the threshing ground. About 4-8 oxen are driven over the ground in a circular fashion until there is a clear separation between the head grain and straw. Then the straw is taken out from the threshing plot using fingered and bent stick (usually two fingers) known as *menshi* and another manageable layer of the harvested crop is spread over and the cycle of threshing continues until the stack is completed. Finally the chaff is separated from the grain by hand blowing using the natural wind.

Threshing methods, like harvesting methods, do not vary from place to place. This method of threshing has been used since time immemorial, with significant loss of grain in quantity and quality due to cattle dung and urine during threshing. Other observable losses in this method include spillage and shattering out of the threshing ground, loss by wind during blowing, loss due to unusual rain, loss due to theft and loss due to rodents and other pests.

In the Megech river area, during the threshing of the local variety of sorghum known as *isha*, the threshed grain is mixed with ash on the threshing field, rubbed uniformly by hand and covered with straw and left to stay there for about two days. Then, the grain is separated from the ash by hand blowing and will become ready for consumption or storage. This additional activity increases market value of the crop and farmers also believe that it helps to remove stinky powder which might be the source of bitterness from the outer part of the grain.

Maize is shelled by hand in both areas. Rice is threshed like other crops by using oxen or manually by using hitting stick. The panicle is hit with the stick to remove the grain from the bulk. This method of rice threshing is used when the rice stalk is used for thatched roof covering.

Before consumption, the non-edible rough outer cover of the rice seed should be removed in a process known as hulling. Rice producing farmers in Megech river areas use manual methods of hulling such as hand mortar and hand pounding. Currently there is no rice hulling service either at farm level or in towns. Intead, farmers use traditional methods which are labour intensive and subject to significant loss. In Rib river areas, rice hulling facilities are available in towns like Addis Zemen, Yifag and Woreta. These hullers are mostly single stage type with low head rice recovery usually below 60% which is lower than when compared with multistage rice mills having a head rice recovery of up to 68%. This is to say that the total estimated loss of rice in hulling operation alone accounts more than 8% in the surveyed area.

8.1.7 Storage

The major storage structures used in both areas are simple indoor mud structures which are locally built. The most widely used indoor storage structure in all areas is g*ota,* which is locally built by women from well kneaded clay soil and straw and placed on raised bed. In River Rib areas, other indoor storage structures such as *gigir* and *kimba* are widely used in addition to *gota*. Girgir is made of wood and plastered with mud and *kimba* is made from reeds and also plastered with mud. These household storage structures are used for storing cereals as well as pulses. Before storing in these structures, pesticides are applied to crops like sorghum, barely, wheat and maize as storage pest infestation is a common problem. For shorter periods of storage fibre jute sacks are also used as a means of storage and handling.

Seeds of horticultural crops are stored on raised bed for some time. However, there is no method of storing these perishable crops for consumptive use to extend their shelf life in any of the surveyed areas. This has forced farmers to supply the produce immediately after harvesting to the already saturated market giving low return to the farmers due to low price. In remote areas with poor access road, a total product loss is common as these crops could not timely reach the market place.

8.1.8 Rural transport

This covers operations which take place largely at the farm and household level which are outside the urban peripheries. Transport in all areas is a year round activity moderately uniform throughout the year. Major household and farm level transport activities in the surveyed area include: firewood collection, fetching water, crop harvesting, grinding mill, crop production and trips to the market place.

The mode of transport in all lower stream areas is generally traditional. Head loading and packing with a donkey which takes place off-road, usually on foot are most widely employed transport methods. Only dry season road is available to the lower stream areas of river Megech, which is primarily used for trucks transporting sand. Some traders from bigger towns like Gondar often come to this area during the dry season and transport marketable produce using modern transport means. This has little impact on the daily transport needs of most people in the area. Once the rainy season starts, it is difficult not only for trucks but also for packed donkeys to walk on it due to the clayey nature of the soil.

Transport methods in upstream areas of river Rib is a combination of traditional, intermediate and modern methods where the traditional mode is more widely used. As the main asphalt road crosses these areas, transport to market and transport to grinding mills can be done using modern means of transport. Three wheeled vehicles known as Bajaj are increasingly becoming a common means of transport of goods and people. There is a clear interface between traditional transport methods and modern transport methods in these areas. Appropriate technologies such as animal drawn carts are seldom used in these areas on narrow farm roads.

8.1.9 Water lifting

Irrigation is increasingly practiced in both the upstream and lower stream areas. The major sources of water are rivers and ground water. Farmers along the *Megech* River cultivate irrigated cash crops as well as field crops using the river water. The river is provided with soil dike to prevent flooding during the rainy season. Because of the dikes, the tradional method of irrigation is at stake now, since farmers cannot divert the river water to irrigate their crops. This along with labour peaks has made a shift from traditional river diversion to the use of mechanical water lifting devices for conveying irrigation water to the farm field. Previously, a few economically well-to-do farmers had experiences of using engine driven centrifugal pumps in these areas. Since 2005, pressure pumps or pedal operated steel made pumps were supplied to farmers in these areas through the extension service on loan basis. Most of these pumps did not work and they are stored in a deplorable condition at the Woreda Agricultural and Rural Development Office. Some functioning pumps are not reliable enough and spare parts are not available. Malfunctioning and unreliability emanate from faulty manufacturing. These pumps hardly work properly in other countries.

Currently farmers are supplied with diesel engine operated centrifugal water pumps on loan basis in which a down payment of Birr 1,500 is made in advance through the extension service and the remaining will be paid in three years. Farmers who can afford can directly purchase these pumps. Loans are given to groups of farmers, a typical group comprising three people. These pumps are supplied to farmers with kit which consists of wrenches, spare parts like gaskets and filters and operating manual written in English. The pumps are provided to farmers with very short and often hasty training sessions on how to operate and manage the pump by staff in the Agricultural and Rural Development Office which by no means is enough to operate and manage these pumps.

The major problem associated with the use of these pumps is that the pump casing which is made of aluminium cast breaks down while in operation. This part has no spare to change the broken one and bring the pump back in operation. The reason for this failure might be associated with the quality of cast which needs further investigation. Aother notable problem is the frequent air entrap in the fuel system creating difficulties in starting the engine in which it can be managed through proper training. High fuel price is also a problem associated with the use of centrifugal pumps.

9. PERCEPTION OF FARMERS TOWARDS THE UPCOMING IRRIGATION PROJECTS

Any project intervention should address local peoples' perspectives and attitudes for the project implementation to be sustainable. With this regard, the beneficiary farmers' perception towards the new projects was assessed in detail. Pertinent issues including farmers' perception for the construction of the dam, upstream and down stream conflicts, possibility of irrigated land redistribution and compensation, reaction of farmers where canals cross their fields and water pricing were thoroughly discussed with farmers.

Perceptions of the farmers about the construction of the dam greatly varied with individuals and localities. Farmers enumerated both the positive and negative implications of the irrigation projects.

In Dembia, according to farmers, the construction of the dam helps to alleviate the problem of flooding, it helps to put more land under cultivation by avoiding floods that submerge fields that could be cultivated, it gives an opportunity to use the limited water resources more economically, and it gives an opportunity for multiple croppings within a year, while some farmers fear that it may lead to land redistribution and shortage of water for livestock.

In Libo Kemkem, majority of the farmers did not have positive attitudes about the irrigation projects. They listed the possible negative consequences that range from eliminating alluvial soils near the lake, the need for bridges to cross the big canals, limited access to water for livestock and impact on sand quarry. Many landless youth and poor farmers are engaged in sand mining.

In Fogera, the farmers' perception towards the construction of the dam was rather limited. However, they stated that flooding will be reduced, while negative consequences include decline in alluvial soil deposits and worsening weed infestation.

Farmers in all woredas expect that conflicts can rage between beneficiary farmers of the upstream and the down stream of the irrigation project area unless a fair allocation of water is put in place.

Most farmers in the two woredas had negative attitude towards the possible redistribution of irrigated land. Interviewed farmers in Libo Kemkem and Fogera woredas unanimously rejected the idea of redistributing land at any level, while those in Dembia suggested that they need compensation for whatever they lose as a consequence of redistribution. However, given the fact that all land in Ethiopia belongs to the government, and there are many farmers who don't possess irrigated land, there is room for possible land redistribution.

Farmers in the three woredas suggested that compensation must be made when large canals cross their crop fields and they accepted the idea of fair water pricing.

Farmers in Dembia suggested that the impact of the dam on Lake Tana would bring siltation down but the level of the lake may fall. Details of farmers' perception are given in Table 41.

10. SYSTEM TREND ANALYSIS

Trend analyses were conducted in the three woredas independently and the summary is given in Table 42. As it can be seen in the table, the trend analysis, by and large, tends to vary with domains that were identified, i.e., upstream and lower stream.

Some pertinent factors were presented to the farmers for their judgement regarding the trend that has happened in the past and the reasons they think are involved.

Soil erosion. Farmers revealed that soil erosion was one of the factors that had an increasing trend in the upstream due to continuous cultivation, over grazing, cultivation of steep slopes and deforestation. Soil erosion was not serious problem in the lower stream domain since runoff is low in plain topography.

Soil fertility. Farmers pointed out that **s**oil fertility is declining fast in the upstream caused by severe soil erosion, continuous cultivation, and removal of crop residue and manure.

In contrast, in the lower stream domain, soil fertility improved considerably due to the deposition of alluvial soils, the near absence of soil erosion (since the landscape is flat) and because it has been cultivated only recently. For a long time in the past, the lower stream was rather dominated by wetland ecosystem, in which farmers basically specialized as pastoralists. It was hardly cultivated for a long time in the past and therefore it was good in soil fertility status.

Vegetation cover. The natural forest was reported to have declined significantly in all the study areas due to the expansion of cropland, timber production for the increasingly urban population, for fuel wood consumption, and for construction. On the other hand, the exotic eucalyptus trees were rapidly increasing in area coverage in much of the lower and upstream areas.

Table 41: Farmer perception towards the irrigation project

Issues	Dembia	Libo Kemkem	Fogera
Farmer perception for dam construction	• advantage o flood reduction o more land for cultivation o saves water o multiple cropping opportunity • disadvantage o fear of land redistribution o shortage of water for livestock	• disadvantage o no more alluvial soil available near the lake o sand mining will be affected o big canals require bridge o limited access to water for livestock	• advantage o flooding reduced • disadvantage o decreasing alluvial soil deposition o more weed infestation
Upstream vs down stream conflict within the irrigated area	• fair allocation of water expected	• fear of biased allocation of water upstream	• concerned about water allocation
Irrigated land redistribution	• no problem if given substitution	• strong objection for redistribution	• redistribution not accepted
Reaction of farmers when canals cross their fields	• larger canals require compensation	• larger canals require compensation	• larger canals require compensation
Water pricing	• fair pricing accepted	• fair pricing accepted	• fair pricing accepted
Impact of dam construction on Lake Tana	• advantages o prevents silting • disadvantages o lake level falls	-	-

Flooding. Floods are uncommon in the upstream unlike the lower one. Incidence of flooding has increased in the lower stream caused primarily by flat landscape, the natural diversion of rivers from their natural courses due to sedimentation and certainly minimal upper watershed treatment.

Rainfall. Over the last several decades, there has been a steady decline in the amount of rainfall, while the distribution was also erratic and uneven. This was caused by the ubiquitous climate change, particularly the effect of climate change on rainfall. The effect of climate change on rainfall was explained in the form of late onset, early cessation, low amount, and unpredictability. Natural resource depletion also contributed to the problems associated with rainfall.

Crop production. Farmers were of the opinion that crop production had a decreasing trend in the upstream. This was partly due to the poor performance of the landraces, declining soil fertility, ever increasing pest and disease attack (in type and scale) and erratic and uneven rainfall distribution. On the other hand, crop production had an increasing trend in the lower stream due to factors such as shift from livestock dominant system to crop (basically rice), extensive deposition of alluvial soils, abundant moisture, better input and credit supply, extensive opportunity to practice multiple cropping and vigorous extension services.

Livestock production. According to farmers, livestock production was dwindling in both the upper and lower stream of the study area due mainly to shortage of animal feeds, the impact of animal diseases, and a shift from livestock dominant system to crops. Particularly, in the lower stream area, the well-known Fogera cattle breed has constantly cross-bred with undesirable genotypes leading to inferior genotypes that have now populated the area.

Grazing land. Farmers revealed that the grazing land area coverage has steadily diminished because of the encroachment of cropland to the wetland area, severe weed infestation, and poor rangeland management practices,. In the lower stream, in addition to the factors listed above, submergence of the grazing land due to seasonal flooding had contributed a great deal to the decline in the grazing land.

Crop pests and diseases. According to farmers, pest and disease incidence has been on the increase in both the upper and lower stream domains. Factors that contributed a part to this situation include the creation of a favourable environment, i.e., favourable weather and suitable host plants, lack of improved management practices, and fragmented control measures. Particularly, in the lower stream, pest and disease occurrence has been aggravated by floods and generally by abundant moisture, which create favourable breeding grounds for pests and diseases.

Table 42: System trend analysis in the study areas

Variables	• **Upper**		• **Lower**	
	Trend	• Reasons	Trend	• Reasons
Soil erosion	Increasing	• Continuous cultivation • Over grazing • Cultivation of steep slopes • Deforestation	No significant change	• Low runoff velocity due to plain topography
Tree plantation	Increasing	Expansion of eucalyptus	Increasing	• Expansion of eucalyptus
Natural forest	Declining	• Cropland expansion • Timber production • Fuel wood • Construction	Declining	• Cropland expansion • Timber production • Fuel wood • Construction •

Soil fertility	Decreasing	• Continuous cultivation • Soil erosion • Removal of crop residue and manure	Increasing	• Alluvial deposits • Minimal erosion • Recent exploitation
Flooding	-		Increasing	• Flat landscape • Rivers divert from their natural courses due to deposition of sediments • Minimal upper watershed treatment
Rainfall amount and pattern	Decreasing	• Climate change (late onset, early cessation, low amount)	Decreasing	• Climate change (late onset, early cessation, low amount, unpredictable) • Natural resource depletion
Crop production	Decreasing	• Poor performance of land races • Poor soil fertility • Pests and diseases • Erratic and uneven rainfall distribution	Increasing	• A shift from livestock dominant system to crop (rice) • Alluvial soil deposition • High moisture availability • Input and credit supply (improved technologies) • Multiple cropping • Extension services
Livestock production	Decreasing	• Shortage of animal feeds • Animal diseases • A shift from livestock dominant system to crop	Decreasing	• Shortage of animal feeds • Animal diseases • Crossing with undesirable genotypes (Fogera cattle breed) • A shift from livestock dominant system to crop
Honey bee	Decreasing	• Pesticides • Deforestation	Decreasing	• Pesticides kill bees • Deforestation • Submergence of honey bee flora by flooding
Fish	Decreasing	• Poor fishery	Decreasing	• Poor fishery

production		management • Water level fluctuation		management • Water level fluctuation • Watershed degradation
Irrigation practices	Increasing	• Awareness • Credit facility • increased need for cash • Shortage of farm land	Increasing	• Awareness • Credit facility • Increased need for cash • Shortage of farm land
Household food self-sufficiency	Increasing	• Introduction of improved technologies • Better access to extension services • Use of irrigation	Increasing	• Introduction of improved technologies • Better access to extension services • Increased use of irrigation • Introduction of rice
Crop diversity	Increasing	• Use of irrigation • Multiple cropping • Extension services	Increasing	• Multiple cropping • Introduction of rice • Use of irrigation • Alluvial soil • Recession farming • Extension services
Grazing land	Decreasing	• Expansion of crop land • Weed invasion • Improper rangeland management	Decreasing	• Expansion of crop land • Submergence of grazing land due to flooding • Weed invasion due to flooding • Improper rangeland management
Crop pests/ diseases/ weeds	Increasing	• Favourable environment (weather, host plants) • Lack of improved management practices • Lack of communally coordinated control measures	Increasing	• Aggravated by flooding • Lack of improved management practices • Lack of communally coordinated control measures

11. PRODUCATION CONSTRAINTS

Farmers were asked to prioritize their production constraints during the group discussions. Generally farmers identified and prioritized two major groups of constraints: agricultural and non-agricultural problems, i.e., lack of well established infrastructure and services. Lack of modest infrastructure and general services around the community certainly constrains the performance of agricultural production and productivity directly or indirectly. These include road access, health services, clean water supply, electric power supply and bridges crossing rivers were mentioned as some of the major infrastructural and service problems. However, we capitalize on agricultural constraints, which are within the scope of the current study and the upcoming project.

Farmers in the three woredas prioritized their respective constraints differently. Priorities also seemed to vary with the target domains. Flooding appeared to be the most important constraint in the lower stream area of the respective woredas. In the lower stream of Fogera, apart from flooding, the blockage of pond outlets was a serious problem, which was also connected with the flood itself. Farmers wanted to have a canal that would drain surplus water from those ponds so that the ponds won't expand and submerge their farmlands nearby. In contrast, in the upstream of Libo Kemkem and Fogera woredas, farmers gave first priority to declining soil fertility and lack of sufficient irrigation water, respectively.

In Dembia, next to flooding the following constraints come in order of importance: animal diseases, pests and diseases, lack of improved seeds and shrinking grazing land. In Libo Kemkem, in the upstream, out of a list of 10 constraints, farmers gave high priority to declining soil fertility, rainfall variability and pests. In the lower stream, the highest rank was given to flooding, pests and access to market. In Fogera, three different recommendation domains were identified but later they were grouped into two major domains, thereby the middle and lower streams had approximately similar characteristics. In the upstream, lack of adequate irrigation water, lack of upland rice varieties and poor soil fertility were the three major constraints. In the lower stream, flooding, lack of animal feeds, pests and animal diseases were the most important constraints.

Generally, it can be concluded that in the upstream, priority constraints varied with locality that range from poor soil fertility to lack of adequate irrigation water, while in the lower stream flooding and pests were the major bottlenecks. Details of constraints are shown in Table 43 and Fig. 6.

Table 43: Production constraints in the study areas

	Dembia	Libo		Fogera		
		Upper	Lower	Upper	Middle	Lower
Rank	**Infrastructure and services**					
1	Road access (market, health)	Clean water supply	Clean water supply	Bridge	Human health (clean water, malaria, drugs)	Human health
2	Health (malaria, lack of drugs and		Roads	Human health	Roads	Roads

	practitioners)					
3	Education (secondary school)			Electricity	Electricity	Electricity
4	Electricity			Clean water		
5	Clean water supply					
6	Improved stove					
	Agricultural constraints					
1	Flooding	Declining soil fertility	Flooding	Irrigation water	Flooding	Flooding and blockage of pond outlets
2	Animal diseases (veterinarians and drugs)	Rainfall variability (poor distribution)	Pests/ diseases /weeds	Lack of upland variety	Animal feeds (submergence of grazing land)	Animal feeds
3	Pests/diseases/ weeds	Pests/ diseases/ weeds	Market	Poor soil fertility	Crop pests/ diseases/ weeds)	Animal health
4	Lack of improved seeds	Increasing fertilizer cost	Animal health services	Animal feeds	Upland rice	Crop pests/ diseases/ weeds)
5	Declining of grazing land	Soil erosion	Lack of irrigation facilities (scarcity of water and management problem)	Side effects of pesticides on bees	Animal health	Upland rice
6	Low soil fertility	Lack of irrigation facilities (scarcity of water and management problem)	Rainfall variability (poor distribution)	Soil erosion	Irrigation water supply	Side effects of pesticides on bees
7	Water-logging	Animal feeds and grazing land	Animal feeds and grazing land	Market (long distance and interference by middle men)	Water pump maintenance	Water pump maintenance

8	Water pump maintenance	Animal health services	Lack of improved varieties/ seeds	Water pump maintenance	Side effects of pesticides on bees
9	-	Market			Market (information)
10	-	Lack of improved varieties/ seeds			

Villages covered in the field study include Debir Zuria, Tana Woina, Achera, Aba Libanos, Seraba, Jarjar in lower stream and Birkute, Estifanos, Agita, Angot, Burra in upper stream in Dembia;
Shina, Tsion, Bambiko, Genda Wuha, Teza Amba, Kab in lower lower stream and Diba in upper stream of Libo Kemkem; Kokit in lower and Nabega in lower stream of Fogera were included in this report
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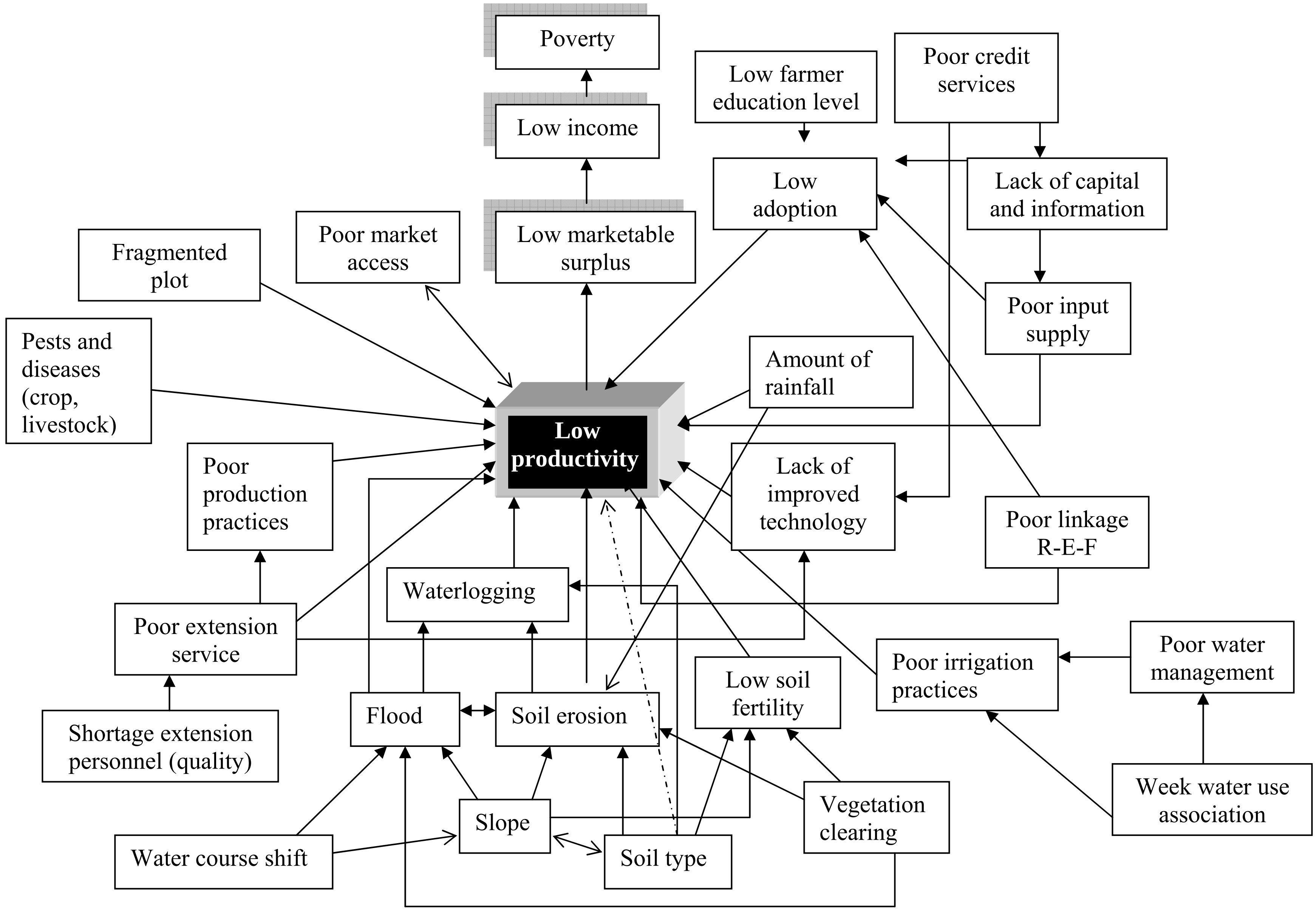

Fig. 6: Cause-effect relationships of factors hindering agricultural production systems in the study area

12. OPPRTUNITIES AND THREATS

12.1 Opportunities

Future potentials as a result of large scale introduction of irrigation agriculture

- Enabling policy environment and growth corridor with high government attention
- Available personnel
- Available technologies
- Available labor
- Established culture in irrigation and motivation
- Relatively good market outlets (transport, air and road)
- Favorable environment (topography, soil, cultivated land, climate, water, suitable for irrigation)
- Suitable for mechanization
- Suitable for diversification
- Organic farming
- Fogera cattle breed available
- Human diseases such as malaria and others that follow accumulated water

12.2 Threats

- Sedimentation (dam, river course, canals)
- Low soil fertility
- Pollution
- Ecosystem disruption
- Loss of biodiversity
- Falling water level of the lake and the ground water
- Declining area of grazing land and water for livestock
- Pest and disease aggravated
- Soil salinity

13. INTERVENTIONS

(1) Policy Intervention

- Irrigated land re-distribution, resettlement and water pricing are anticipated
- Design policy environment to establish water use associations (WUAs)
- Develop proper livestock movement control and quarantine systems
- Enact laws related to the application of chemicals against pests that affect bees and other beneficial insects (proper use of selective insecticides and establish an effective system of pesticide, use to minimize death of honeybee colonies).
- Enforce land use proclamation No. 456/2005 that has been put in place in 2005 as per its implementing regulation No. 51/2007.

- Enforce effectively existing laws and regulations on fisheries, pollution control, environment, land use, water use and forestry
- Develop operating rules for water resource sharing
- Design strategies to strengthen multisectoral cooperation and integration among stakeholders for water resource management
- Design strategies that recognize the impact of development activites on the livelihood of inhabitants and also impact on environmental health
- Establish and implement Lake Tana hydrology monitoring program and design a transparent reporting system
- Create platform for ensuring sustainable benefits to Lake Tana basin resource users and stakeholders

(2) Development Intervention

- Demonstrate and disseminate different improved crop, livestock, natural resource and agricultural mechanization technologies
- Create high public awareness to bring a positive attitude towards on upcoming irrigation and dam construction
- Introduce alternative economic crops in the farming system
- Improve road network, marketing and credit facilities
- Strengthen and organize cooperatives and unions
- Build the capacity of farmers, extension personnel and cooperative committee members
- Link production with marketing and introduce value adding schemes like small scale processing plants
- Oversow natural pastures with herbaceous legumes and browse species
- Develop high yielding improved grasses, herbaceous and tree legumes that complement the nutritional requirement of livestock
- Introduce pasture management techniques such as pasture enclosure, stock exclusion, regulating stocking rate and pasture rotation, etc
- Introduce proper storage mechanism of crop residues, treatments and their utilization.
- Utilize properly (avoid wastage) and conserve excess forage obtained in summer in the form of hay and silage to be used in the dry season
- Introduce silage technologies
- Provide seeds of the promising forage crops that could serve as feed and soil erosion control
- Eradicate the most noxious weeds like *Hygrophila auriculata (Amekyla)* and *Xanthium strumarium (Yemognfikir)* that have infested and affected the productivity of communal grazing land
- Establish and strengthen veterinary services.
- Introduce and disseminate improved breeds of livestock (cattle, sheep and poultry)
- Provide AI service and/or establish bull stations
- Introduce and evaluate semi-intensive livestock production systems under smallholder farmers' conditions.
- Introduce appropriate design of hay-box brooder for chickens, particularly at their younger age, to minimize chicks' mortality.

- Provide improved beehives with all their accessories as full package to enhance honey and other hive products.
- Introduce and conserve suitable multipurpose trees and other honeybee flora
- Train farmers about the different strategies of growing and utilizing indigenous and improved forage crops, breeding, animal diseases control and treatment, proper management of livestock and improved beekeeping.
- Create public awareness in integrated lake basin and environmental management
- Strengthen Fisheries Research Centre, support research on aquaculture and hatchery unit establishment
- Develop Lake Tana management plan
- Create consensus platform for Lake Tana integrated development scheme
- Delineate Lake Tana areas considering the previous boundaries accessed from the last 40-50 years satellite Image particularly land use and land cover focus
- Upgrade traditional irrigation schemes to modern irrigation and drainage development
- Create public awareness for different stakeholders about land degradation
- Give technical backup to the traditional water use associations
- Undertake and promote integrated watershed management
- Scale up and scale out organic soil fertility management technologies
- Construct dikes, where rivers flood agricultural and settlement areas
- Construct livestock watering troughs and bridges
- Close and manage hills in the upper part of the catchments (for both ecological and economical reasons)
- Plant trees in the degraded catchments by taking into consideration of the species-site relationships
- Conduct environmental auditing to monitor and evaluate the impact of closing and planting
- Domesticate indigenous fruit trees and introduce new fruit trees both in the upper and lower part of the catchments
- Establish tree fodder bank at household level to alleviate the feed shortage in the lower and upper part of the catchments

Research Intervention

Socio-Economics

- Investigate value chain of major horticultural crops, rice and fish
- Study crop enterprise choice of major crops in irrigation
- Study the socio-economics of improved agricultural water management technologies
- Study the impact of climate change and its adaptation options
- Study the adoption of farm implements
- Assess and evaluate the traditional water use associations
- Organize farmers research and extension groups (FREGs)

Field crops

- Replace the low yielding and long maturing sorghum varieties by early maturing and high yielding crop varieties to fit for double cropping system
- Determine the rate and time of fertilizer application for major crops
- Determine appropriate crop rotation especially for rice production in the up stream areas
- Identify intercropping systems that fit into the system; select crop types and varities with appropriate seed rates and planting times
- Conduct crop variety adaptation trials to select high yielding and disease resistant ones preferably at the farmers' fields
- Promote rice and finger millet planting by seedling transplanting method

Horticultural Crop

- Adapt improved varieties suitable for each typology and location. Some of the improved varieties of major vegetable crops worth testing include: tomato (Melka salsa, Melka sholla), Onion (Melkam), Garlic (Tsedey, which is tolerant to root rot), shallot (Huruta, an early maturing and diseases tolerant variety), hot pepper (Mareko Fana and Bako local, Paprikas in the off-seasons), potatoes (Tolcha, Guasa, Zengena), banana (Giant Cavendish, Poyo, Williams and Butazua), papaya (solo, a gynodiecious variety), avocado (Hass and Fuerte), mango (Kent, Kett, Tommy Attkins), sweet orange (Washington Navel, Pine apple, Jaffa, Hamlin, Olinda), lime (Bearss, Mexican).
- Adapt varieties developed for irrigated cultivation
- Develop varieties tolerant/ resistant to waterlogging conditions.
- Develop and/or test root-stocks tolerant to waterlogging and associated diseases. For instance, for citrus Trifoliate Orange and Sour orange which have resistant reactions and Carizzo and Troyer Citrange that are tolerant to Phytophtora could be considered. On the other hand, growing Rough lemon may need to be avoided because it is susceptible to waterlogging and requires light sandy soil, which is uncommon in the target area. Generally, in the low lying high water table areas the research needs to focus on citrus species, mango and banana than fruits like avocado and papaya.
- Develop pest and disease tolerant/ resistant varieties
- Develop varieties of varying maturity periods
- Introduce and adapt new and or less known high value crops: snap bean, sugar cane, sweet corn, etc.
- Conduct research on genetic and agronomic improvement of spices, condiments and medicinal plants
- Investigate the feasibility of growing horticultural crops in plastic tunnels. This technology helps to grow these crops in the rainy season and thereby extend the period of production and double the number of harvests.
- Determine the effect of staggered planting times
- Determine the effect of high-budding technique for disease management
- Determine optimal mixed cropping systems, i.e., regimes of intercropping (preferably vegetables, legumes and short stature fruits as papaya should be included) and major nutrient needs, compatibilities, etc.

- Determine the effect of fruit tree planting on raised mounds compared with flat plots
- Investigate the feasibility of organic production of horticultural crops
- Establish efficient nutrition management systems for different soil types and typologies. Determine nutrient needs of horticultural crops focusing on type of nutrient(s), rate and time of application
- Standardize seed production techniques of horticultural crops
- Conduct research on harvesting techniques, curing, pre-cooling, value adding, sorting, grading and transportation, etc. This is important because, despite the favorable climate that can make high quality production possible, product quality remains very low. This would ultimately influence market prices against the interest of farmers. Farmers cannot maximize their income.
- Develop / test appropriate storage structures such as zero-energy cool chamber
- Investigate pre-harvest management techniques such as the control of irrigation (withhold) to improve shelf-life.

Crop protection

- Cutworm biology and ecology study. How do they overwinter the rainy season? How do they survive the deep water level that submerges the rice plants? Can they be managed by activities like flooding after the rice harvest so that the larvae will be drowned and die? Can deep ploughing contribute to the reduction of cutworms? Can plastic sheeting help to heat the moist soil and thus kill the larvae? Can soil sterilization (methyl bromide) be adopted for cutworms?
- Recently, hot pepper has suffered a huge blow due to root rot disease whose causative agent is largely unknown. This disease needs a thorough investigation by the right institution and expertise. Also look for relevant information from other research centres in the country and abroad.
- Red tefworm management study. This insect pest may be controlled by some cultural control techniques such as crop rotation. Given the fact that red tefworm feeds on grasses, non-host crops (crop rotation) may be chosen and grown in a wider scale for a few years. This will deprive the pest of its host and will push it to a minor status. Simultaneously, wild hosts should be identified and destroyed. With wild hosts around, the pest will maintain its presence on them and wage its attack any time the appropriate host is grown. The effect on red tefworm of ploughing as well as flooding immediately after crop harvest should be investigated.
- Head blast both on finger millet and rice needs to be investigated. Little is known about it because nothing has been done until now. The research in India is far ahead and resistant varieties are available there, which we can exploit by making contact with them. Focus on both its epidemiology and management.
- Grasshopper management. Detailed long term weather data should be collected and modelled to determine the relationship between weather variables and hoppers and hence predict ahead of time the probability of outbreaks.
- Wilt root/rot on chickpea. Scaling up/out activities of more tolerant chickpea varieties such as Marye should be advanced. Seed bed management techniques can also help deprive the pathogen of the moisture required for development.

- Different *aphid* species on pulses, barley, potatoes, mustard and sorghum, maize (varietal resistance, habitat management, biological control)
- Pest management research strategy ought to focus on non-chemical control methods, i.e., integrated pest management, as applicable (physical, cultural, biological, varietal resistance, etc).
- Evaluate the impact of pollinators (especially honey bees and other flower feeding organisms) on crop production.
- Detailed studies of major pests (insect biology, ecology and population dynamics)
- Loss assessment study caused by major pests
- Research on IPM components mainly biological, cultural and varietal resistance mechanisms
- Type, distribution and status of storage insect pests and associated storage structures

Livestock

- Experiments on the natural pastures
- Screen and adapt forage crops
- Determine the effect of different feeds on animals (forage species and urea treated straws)
- Agronomic studies of major grass and legume forage crops
- Evaluate the impact of silage on dairy cows
- Study the epidemeology and extent of economic losses of different animal diseases
- Study the interaction among management, disease and agro-ecology in livestock health
- Design effective methods for disease monitoring, forecasting and control
- Conserve and protect Fogera cattle breed from mixing up
- Improve the local livestock breeds
- Introduce and evaluate the reproductive and productive performance of different improved livestock breeds
- Conduct fattening experiments using different feed resources
- Conduct experiments on locally available feed resources for poultry
- Assess and evaluate the traditional beekeeping practices
- Assess and evaluate locally available feed resources for honeybees and design feeding strategies for supplementing during dearth period.
- Identify and evaluate suitable pollen and nectar rich honeybee floras that could adapt and perform better under water logging conditions

Fisheries

- Establish and implement a lake-wide fisheries monitoring program
- Develop and implement a Fisheries Management Plan
- Carry out a comprehensive 5-year fisheries stock assessment
- Conduct fish farming systems research and recruit potential fish species for aquaculture
- Investigate the health of the lake - limnology- in detail
- Assess waste load in detail
- Establish and implement lake water quality monitoring program

- Develop and implement water pollution control and management plan
- Conduct wetland inventory and evaluation
- Design and implement wetland management plan
- Determine the carrying capacity of the Lake Tana watershed
- Assess environmental impact to develop appropriate mitigation measures (e.g., environmental flows, fish ladders, etc.)

Forestry

- Select trees to diversify species
- Determine the diversity, phenology, propagation technique, characteristics and the socio economic importance of farmland tree species
- Assess and evaluate bio-drainage technology for reclaiming water logging areas
- Evaluate the biomass transfer potential of adaptable tree and shrub species for soil fertility improvement and its comparative advantage compared with inorganic fertilizers.
- Determine the adaptability of tree species for alley and double cropping in the upper catchments

Soil and water conservation

- Study on irrigation schedule and requirements of irrigated crops
- Design techniques to determine water requirement of crops for farmers
- Determine optimum irrigation water use and efficient water allocation systems
- Assess and evaluate different alternative irrigation methods
- Develop models for the hydrology and water balance analysis of Lake Tana basin.
- Develop systems to analyze soil moisture dynamics and rainfall variability in relation to supplementary irrigation of crops grown in residual moisture
- Assess and evaluate simple and low cost methods to control seepage and loss of water caused by evaporation.
- Devise engineering standards for the construction of irrigation infrastructure in Vertisol areas.
- Assess and evaluate different land drainage techniques and estimate drainage coefficient for each crop
- Estimate runoff coefficients for different land use/cover
- Estimate crop coefficient (Kc) especially for indigenous crops
- Evaluate and map soil fertility status of Lake Tana basin
- Determine chemical fertilizers rates for irrigated crops
- Evaluate and select the best soil and water conservation methods in upper catchments
- Assess and evaluate compost, green manuring, plant and bio-fertilizers for lower catchment areas where chemical fertilizers have adverse effects

Mechnaization

- Mechanical powered soil preparation and weeding. It is important and timely to devise other sources of power which can be within the reach of farmers. Among others, walking tractors (power tillers) could be options, if not better, to fill the gap. These technologies must be evaluated under the prevailing circumstances and attachments need to be further developed to mechanize subsequent work operations in the farming system.

- Rice mechanization- The production of quality rice should start from its onset and some of the workloads have to be reduced through mechanization. Therefore, soil preparation, sowing, threshing, processing and the management methods of byproducts have to be further studied and addressed through appropriate mechanization interventions.

- Cattle feed processing and handling- Grazing land is steadily shrinking because of expansions in crop production. This will force farmers to shift from free grazing to stall feeding of animals. Stall feeding comes with additional tasks such as harvesting, collecting, transporting and storing of the available animal fodder. This work needs to be mechanized both to reduce workload and to prevent loss that occurs in the course of the process.

- Mechanical threshing methods using existing water pump engines-The current method of traditional threshing of cereals and pulses is highly labour intensive and time consuming. Loss of grain is also significant. Human and animal power is used in traditional threshing. On the other hand, the use of water pumps for irrigation has increased recently in the area. The engines of these pumps can be used for threshing if appropriate threshing units are studied and developed.

- Work on broadbed and furrow makers for horticultural crops on vertisols-The predominant soil type in the surveyed area is Vertisols and planting is usually carried out on flat fields except for limited crops such as wheat and *tef*. Irrigated crops are planted on flat fields and the common irrigation technique is flood irrigation. In flood irrigation, weeds are a serious problem and water loss is high. Instead, bed and furrow planting methods need to be introduced to fully exploit Vertisols and maximize production. The accompanying implements, animal drawn or mechanically powered, should be investigated.

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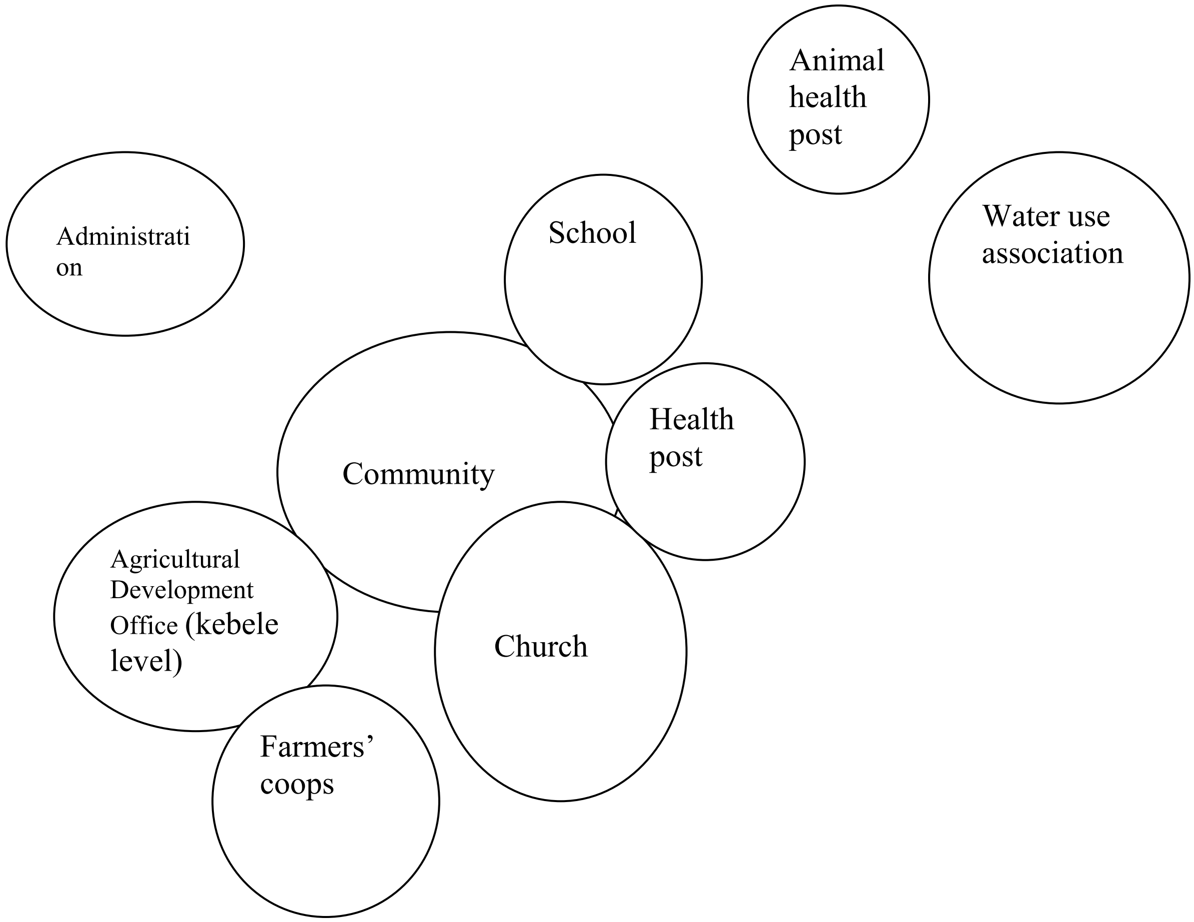
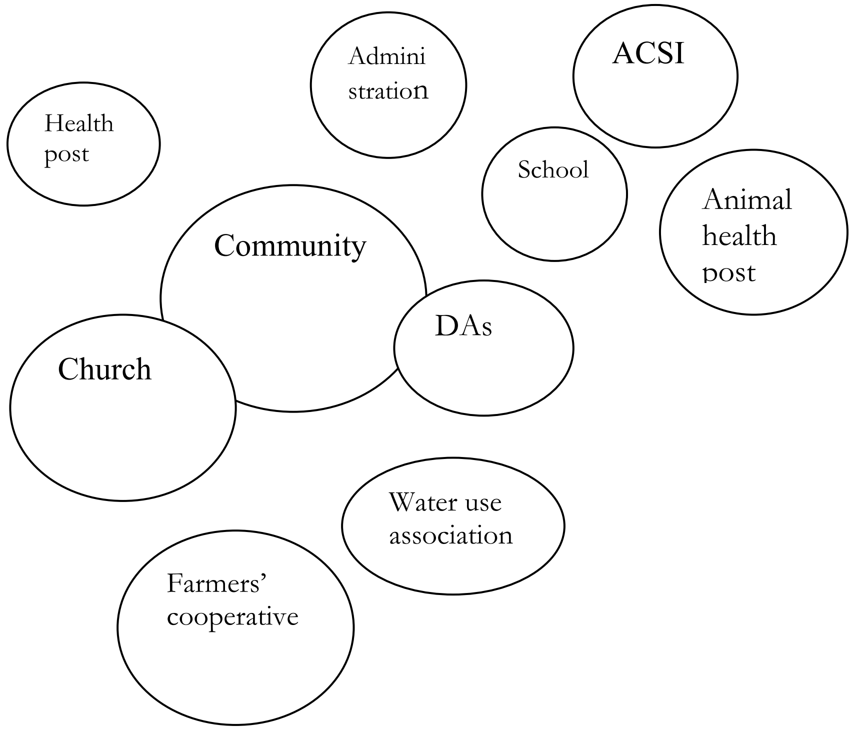
Appendices

Appendix 1. Venn diagram prepared by Dembia farmers



Appendix 2.Venn diagram prepared by Libokekem farmers



Appendix 3.Venn diagram drawn by Fogera farmer