The Invertebrates of Lake Tana Sub-basin

Emiru Seyoum
Department of Biology
Addis Ababa University
PO Box 33244 (Private Bag) Addis Ababa Ethiopia

5. Introduction

The invertebrates provide the highest number of individuals and species, biomass and production in wetland ecosystems. Invertebrates are the most successful and prolific animals on the planet. They have been around for over 400 million years and dominate the animal kingdom in terms of numbers of species and numbers of individuals (Figure 5.1)

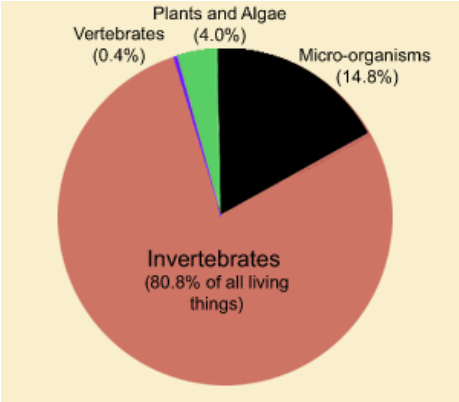

Figure 5.1 Percentage proportion of invertebrates to other living organisms globally (Hanson & Swanson, 1989).

The number of invertebrate species is staggering and new species are constantly being discovered. To date, scientists have only documented 1.7 million invertebrate species, but they estimate numbers could range from 5 to 30 million. At this rate, it will take scientists over a thousand years to identify all invertebrate species. Unfortunately, species numbers are declining faster than their existence can recorded.

Within invertebrates, insects dominate freshwater aquatic systems where their species numbers, biomass and productivity are the highest. Aquatic macro-invertebrates, including insects, crustaceans, molluscs and worms, inhabit lakes, wetlands and oceans. Their abundance and diversity have been used as indicators of ecosystem health and of local biodiversity. Macro-invertebrates are categorized as being pollution-sensitive as well as pollution-tolerant.

Water flow, food, habitat and water quality are the primary determinants of macro-invertebrate abundance and diversity. Any activity which alters these factors affects the normal functioning of an invertebrate ecosystem. Food sources include phytoplankton, biofilms and terrestrial organic material that enter the water from the

riparian vegetation. Major predation occurs from other macro-invertebrates and fish. The key habitats for macro-invertebrates are the benthic sediments, aquatic vegetation and woody debris. Salinity, temperature, dissolved oxygen, and turbidity have a significant impact on the survival and diversity of invertebrates in wetlands (Gullan & Cranston, 1994).

Sustainable development requires sustainable biodiversity and natural resource management strategies. This is because biodiversity is the basis for natural products (food, medicines, timber etc), while ecosystems underpin many natural resources and environmental services (clean water, healthy soils, pollination of crops, leisure and thereby employment, etc). Understanding the complex processes involved in biodiversity and conservation requires mechanisms and systems to evaluate the processes at all levels and time. Invertebrates play paramount roles in discovering, conserving and identifying native and alien species.

Invertebrates as indicators of ecosystem integrity

Many invertebrates are intrinsically linked to wetland conditions, completing their life cycles within the wetlands, and are thus exposed to site-specific conditions. Some depend on particular types of vegetation for reproduction. Invertebrates can be sampled with standard methods once during the year. Invertebrates can be identified in the laboratory using available taxonomic keys and the high number of taxa and individual counts permit the use of statistical ordination techniques that might be more difficult with just a few species.

Invertebrates have short life cycles and they integrate stresses to wetlands often within a 1-year time frame. They are major indicators of environmental stresses, particularly the following:

- sedimentation and increased turbidity - species richness is particularly likely to decline in semi-permanent and permanent wetlands, where sediments are most likely to cause anoxia. A reduced variety of invertebrates is a sign that turbidity and sedimentation conditions have been severe.
- nutrient loads and other contaminants - particular assemblages of invertebrate species are reported to be useful indicators of lake trophic status (Adamus, 1996) and might help in identifying wetlands that have received excessive nutrients. Invertebrates are also used to test for bioaccumulation of contaminants and analyze effects of pollutants in food webs.
- vegetation cover loss - The composition of invertebrate populations is associated with plant succession. Invertebrate associations with plants are influenced by the leaf shape, structure and surface area of aquatic vegetation. An increase in ratio of algae-consuming species (certain mayflies) to detrivorous species (certain worms, amphipods) and in the ratio of open-water forms (water strider, midges) to vegetation dwelling forms (snails, some mayflies) is expected if a wetland has been exposed to herbicides, grazing, fire, flooding, other vegetation removal processes and alterations to the landscape (including introduction of exotic species). The ratio of predatory to herbivorous-detrivorous invertebrates might be used to indicate changes in vegetation cover conditions (Murkin *et al.,* 1991).

- history of wetland condition - decay-resistant invertebrate remains provide a means for establishing reference to historical conditions in wetlands and other ecosystems
- input of storm water or wastewater runoff - Invertebrates are used for a large variety of experimental approaches in toxicological and laboratory-based research as well as whole-effluent bioassay or *in-situ* assessments.

5.2 Objectives

The objectives of this study were to:

- collect, identify and document invertebrate fauna in and around Lake Tana sub-basin
- describe the economic and ecological roles of the invertebrates around the LTSB
- document environmental health indicators and recommend management options for improved management of the ecosystem.

5.3 Methods

(i) Literature review

Literature reviews were undertaken, which helped to determine the sampling sites within the sub-basin. Previous systematic studies on the diversity, abundance and spatial characteristics of macro-invertebrates are few and limited, compared with studies on other organisms such as plants, birds, fish and mammals. This study therefore will serve as a baseline and form a link between invertebrates and other biodiversity of the LTSB.

(ii) Stakeholder consultations

Relevant institutions and individuals were contacted during the study and their responses to informal questions were used to gather information on the economic and ecologic role of invertebrates in the sub-basin.

(iii) Sampling sites

Sampling sites were selected based on: the magnitude of vulnerability to and effect of human disturbance ie, urban-affected, agricultural-affected and a reference or control site; and the representative aquatic, riparian, wetland and terrestrial macro-invertebrates.

Sampling site categories

a) Urban affected (aquatic and riparian)

The city of Bahir Dar on the southern shoreline of Lake Tana was included as a distinct sampling site as human interference occurs here with the result that the area is affected by potential pollutants (such as leakages/emissions from nearby factories, poor water drainage systems, unwise use of water for washing clothes and other domestic uses). In general, the city lacks a proper drainage system. During the survey the run-off from different sources during the rainy season, including from garbage dump-sites, were sampled.

b) Agricultural-affected (wetland and terrestrial)
Representative sampling sites for this area included: a) agricultural fields in Fogera Plains wetland in the east; b) upland agricultural (terrestrial) fields; c) terrestrial farming and grazing sites along the Woreta-Woldia road east of Lake Tana.

The Fogera wetland has experienced increased rice cultivation and farmers are using modern agricultural inputs such as fertilizers, hybrid varieties of rice and pesticides. During and shortly after the rainy season, water from Fogera wetland drains into the lake bringing with it some of the agricultural inputs (fertilizers and pesticides), with obvious detrimental effects on the invertebrate fauna of the sub-basin. The upland catchment areas outside the Fogera Wetland (east of the main road from Addis Ababa to Gondar) are typical of an agriculturally-affected terrestrial area where mixed farming (animal and crop husbandry) has been practiced for centuries.

c) Control sites (aquatic and riparian, wetlands and terrestrial)
Several relatively unaffected control sites were sampled as comparisons with the results obtained from the sampling categories (a) and (b) above These included sites near Tana Hotel, in the Delghi wetland and at Taragedam natural forest, ie aquatic, riparian, wetland and terrestrial sampling sites respectively.

The locations of all sampling sites are shown in Figure 5.2.

Figure 5.2 Invertebrate sampling sites in and around Lake Tana

Tana Hotel, the largest hotel in the city, was selected as a control site because of the relatively short time it has been in operation (about 20 years) and its location outside the city center. It was assumed that the level of organic pollution at this site might be

less than that (photo 5.1) at the other aquatic sampling sites (Ghion Hotel and Felege Hiwot hospital).

Photo 5.1 Aquatic and riparian sampling site near Tana hotel

Ghion Hotel (photo 5.2) was selected as an urban-affected sampling site on the assumption that the unlimited release of effluents from the hotel, coupled with effluents from the poor municipal drainage might have an effect on the quality of the lake water. Ghion Hotel has been in operation for over 50 years and is located 20 meters from the lake shore. It is situated very close to the city center and hence subject to all sorts of potential contaminants.

Photo 5.2 Ghion Hotel aquatic and riparian sampling site

Photo 5.3 Aquatic and riparian sampling site at Felegehiwot hospital

Felegehiwot hospital has been in place for more than 30 years and the waste disposal system is appalling (photo 5.3). Invertebrate collection in this urban-affected aquatic and riparian sampling the site was carried out at the entry point of all sorts of effluents in to the lake. The hospital is 20 meters away from the lake and a variety of untreated laboratory, latrine, ward and kitchen wastes are disposed of and channeled into the lake.

Dek Island is densely populated and has been used for crop and animal husbandry (agricultural-affected). The only means of transport is by boat and there is strong reliance on crops, animals and animal products, petty trading, sale of fuel wood and fishing. At the end of the long rainy season, fires are set to get rid of rodents, snakes and scorpions and this has probably contributed to the loss of invertebrate diversity and density. Photo 5.4 shows the sampling site on Dek Island.

Photo 5.4 Dek Island aquatic and riparian sampling site

Delghi wetland in the west of Lake Tana was sampled for wetland invertebrates (photo 5.5). The site is well protected as it is fenced and the wetland is owned by an adjacent primary school. The school uses the wetland as a source of income through sales of grasses (hay) at the end of the long rainy season. Adjacent to the western part of the site is an orchard, which is also protected from human and animal interference with guards on 24 hour shifts. The wetland was chosen as a control site based on the assumption that it was less disturbed compared to other wetland sites in and around the lake.

Photo 5.5 Delghi riparian sampling site

Gerima monastery is 10km from Bahir Dar in the south of the Lake and includes a large wetland (photo 5.6). It is a relatively well conserved agricultural-affected site,

used by the monks, and their livestock, who live in the vicinity. The regional government has proposed this site as a Biosphere Reserve (Dejen, pers comm).

Photo 5.6 Gerima monastery wetland sampling site

Fogera wetland plain is an agricultura-affected wetland and comprises is unprotected, open grazing land adjacent to the main road from Addis Ababa to Gonder. The sampling sites and the surrounding area are dominated by rain-fed rice production (photo 5.7). In terms of coverage, it is among the largest wetlands ecosystems, if not the largest, in the country. However, the area is over-grazed and cultivated and human pressures have exceeded its carrying capacity. Consequently, most of the area has been changed from permanent wetlands to non-permanent/temporary wetlands that last for only 2-3 months after the long rainy season of June-August. The predominantly black soil is then used by farmers to grow different crops.

Photo 5.7 Fogera wetland sampling site

Taragedam natural protected forest (photo 5.8) was chosen as a control site for comparison with other terrestrial sampling sites. The natural protected forest at Taragedam is north east of Lake Tana and has been protected from animals and human disturbance for many years. The area is recognized as a conservation site by the government, the monks in the adjacent monastery and the community at large.

Photo 5.8 Taragedam control terrestrial sampling site

Woreta-Woldia road, east of Lake Tana, was chosen as an agricultural-affected (terrestrial) sampling site (photo 5.9). The area is a typical depleted highland ecosystem as a result of overgrazing, intensive cultivation and settlement. The combined effects are manifested as eroded and bare soils and large gullies.

Photo 5.9 Woreta-Woldia terrestrial sampling site

Gorgora (Wawa) agricultural-affected terrestrial mixed farming areas, north of Lake Tana, are used by inhabitants for mixed subsistence farming i.e farming and animal husbandry. The site where invertebrate samples were collected (photo 5.10) lies beneath high mountain plateaus and is to the east of the main road from Gondar to

Gorgora. Compared to the other terrestrial sampling sites at Woreta-Woldia and Kunzila, this site seems less disturbed as *Hyperrenia* and other grass species were found growing relatively well. This is probably due to the deposition of eroded soils from the surrounding higher altitudes which contribute to the nutritional requirements of vegetation in and around the sampling site.

Photo 5.10 Gorgora terrestrial sampling site

Kunzila in the west of the Lake is an agricultural-affected terrestrial farming and grazing site (photo 5.11). Some portion of the area is currently used as a camping site for a road construction company. The site is highly affected by soil erosion and is turning into gullies and bare land.

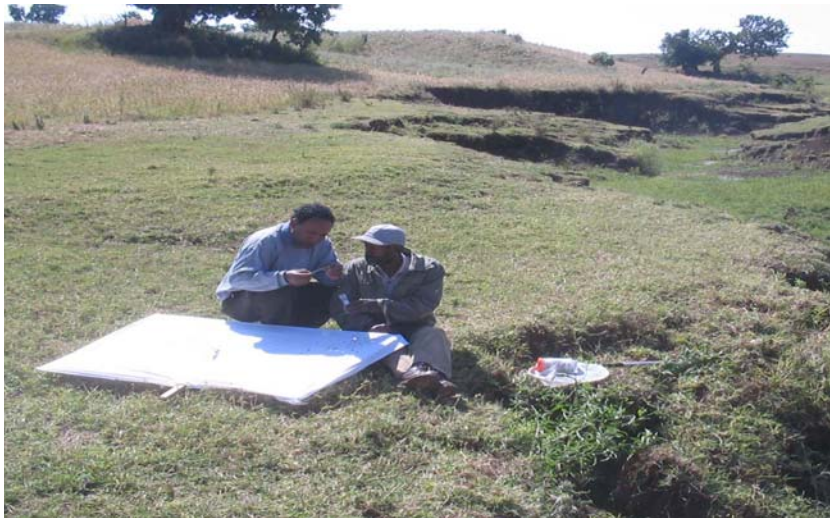

Photo 5.11 Kunzila terrestrial sampling site

(iv) Sampling

Materials used in the present study included; butterfly nets, beating cloths, aquatic (deep) nets, aspirators, vials, killing jars, spreading boards, collection boxes, pins (different sizes), GPS, digital camera, paper boxes and styro-foam. 70% chloroform and ethyl acetate were used as killing agents. Each of the three sampling sites were subdivided into two sampling locations; each sampling location was further divided into two sampling spots. The sampling spots included 4 'zones':

(i) deep into the lake (about 5 m from the edge) and at the edge of the lake with emergent vegetation (sampling using aquatic 67 µm throw net);

(ii) riparian vegetation near the shore (using beating cloths);

(iii) under stones and wood (insects were collected near the shore using aspirators); and

(iv) casual flying insects (collected with sweep nets if encountered near the shore).

Collection from the riparian sites was made by sweeping three times using butterfly nets and beating cloths. Soil-dwelling insects were also collected by sorting. Invertebrates collected from the four sampling spots were pooled for each sampling site

The invertebrates collected were preserved in 70% chloroform and ethyl acetate, or in the case of insects collected from soils in 70% ethanol.

The small invertebrates collected were sorted into different vials (photo 5.12), while large invertebrates were pinned onto pinning boxes (photo 5.13). Once collected and sorted, the invertebrates were brought to the laboratory and identified to family level using available taxonomic keys, texts and reference specimens. All identified invertebrates have been preserved and transferred to the Zoological Natural History Museum, Addis Ababa University, as voucher specimens.

Photos 5.12 and 5.13 Representatives of preserved small invertebrates in vials and representative sample of pinned large invertebrates in a collection box

(v) Matrix analysis of results

The following two matrices can best describe the status of each sampling site:

(i) Shannon-Weaver Index (H= -ΣPi ln Pi)

Pi = Proportion of each taxon in a sample

This index is used to assess the species diversity and richness of invertebrates in each sampling site and to compare invertebrate diversity between sites

(ii) Hilsenhoff's Family level Biotic Index = (H-FBI= ΣXi Ti/N)

Xi = Number of individuals of each taxon (eg Chiromidae)
Ti = Tolerance value of the respective taxon
N = Total number of invertebrates in the sampling site (Reference).

This index was used only for invertebrates collected from aquatic sampling sites (to indicate water quality and degree of organic pollution).

5.4 Results

The total number of orders, families and individual invertebrate specimens found at the various sampling sites are given in Table 5.1.

Table 5.1 Summary of invertebrate abundance by habitat in the LTSB

Habitat	Order	Family	Numbers collected
Aquatic	18	31	241
Urban-affected	*8*	*16*	*69*
Agricultural-affected	*6*	*9*	*118*
Control	*4*	*6*	*54*
Riparian	27	85	354
Urban-affected	*11*	*42*	*220*
Agricultural-affected	*6*	*9*	*22*
Control	*10*	*34*	*112*
Wetland	31	92	1129
Urban-affected	*10*	*24*	*204*
Agricultural-affected	*8*	*20*	*594*
Control	*13*	*48*	*331*
Terrestrial	24	99	545
Agricultural-affected	*11*	*55*	*322*
Control	*13*	*44*	*223*

The largest taxa of families was collected from the terrestrial habitat (a total of 99), with 55 taxa from the agriculture-impacted and 44 taxa collected from the control (see tables 5.10 and 5.11 for details). The wetlands had the highest number of invertebrate orders (a total of 31) with more families recorded from the control sites (48). Agricultural-affected sites in the aquatic, riparian and wetland habitats showed fewer orders and families than the urban-affected areas in the same habitat.

The Shannon-Weaver diversity index values and the Hilsenhoff index (for data collected in aquatic habitats only) are summarized in Table 5.2.

Table 5.2 Diversity and pollution values for invertebrates in the LTSB

Habitat	Impact	Shannon-Weaver diversity index	Hilsenhoff index of organic pollution
Aquatic	Urban	2.0	6.7
	Agricultural	1.3	4.97
	Control	1.3	5.6
Riparian	Urban	2.39	-
	Agricultural	1.5	-
	Control	1.9	-
Wetland	Urban	1.9	-
	Agricultural	1.4	-
	Control	2.7	-
Terrestrial	Agricultural	2.79	-
	Control	3.1	-

The control sites had lower diversity values for the aquatic and riparian habitats, probably because the index does not discriminate at species level, but rather at family

level and more generalist invertebrate families could be recorded from impacted sites. Anthropogenic effects such as pollution, water quality deterioration, eutrophication and water level changes in the aquatic habitat could mobilize new taxa into such impacted sites. More studies are required to investigate the taxonomy to species level to explain the paradox that despite having a higher Hilsenhoff index for the urban-impacted site the species diversity there is more than that in the control.

High diversity values were calculated for the control sites in both wetland and terrestrial habitats. However, given the small difference in the Shannon-Weaver index values between the control sites and the impacted sites could indicate that the selected control sites have already experienced some form of anthropogenic input, as observed at Teragedam and Zeghe forest. This will require additional studies to verify this assumption.

The detailed data on the diversity and abundance of invertebrates collected from the sampling sites are given in Tables 5.3 to 5.13.

Table 5.3 Diversity and abundance of invertebrates collected from urban affected aquatic habitats near Ghion Hotel and Feleghiwot Hospital

Order	Family	Number
Odonata	Coenagrionidae	6
Diptera	Ptychopteridae	2
	Chiromidae	1
	Scathophagidae	1
	Culucidae	1
Hemiptera	Notonectidae	6
	Belostomatidae	8
	Gerridae	13
	Naucoridae	4
Coleoptera	Halipidae	2
	Chrysomelidae	1
	Staphylinidae	1
Molusca	Lymnaeidae	1
Aranae	Oonopidae	2
Copepoda	Diaptomidae	14
Ephemeroptera	Baetidae	6
8	**16**	**69**

Ghion Hotel :
Location 1 - 11°35.904N ; 37°23.131E ; altitude 1,794 m asl
Location 2 - 11°36.258N ; 37°23.668E ; altitude 1,798 m asl
Feleghiwot Hospital:
Location 1 - 11°36.621N ; 37°22.208E ; altitude 1,784 m asl
Location 2 - 11°36.570N ; 37°22.266E ; altitude 1,802 m asl

Shannon-Weaver Diversity Index:
Location 1: 2.2062
Location 2: 1.95
Site Diversity: 2.01

Helsinhoff Index:
Location 1: 4.85
Location 2: 4.95
Site Index: 4.9 (good)

Table 5.4 Diversity and abundance of invertebrates collected from agriculture-affected aquatic habitat on Dek Island

Order	Family	Number
Hemiptera	Notonectidae	86
	Gerridae	9
	Naucoridae	2
Odonata	Coenagrionidae	6
Ephemeroptera	Baetidae	9
	Trichoritidae	1
Coleoptera	Dysticidae	1
Homoptera	Delphacidae	1
Diptera	Chironomidae	3
6	9	118

GPS Coordinates:
Location 1 - 11°53.147 N ; 37°15.263E ; altitude 1,790 m asl
Location 2 - 11°53.212N ; 37°15.369E ; altitude 1,793 m asl

Shannon-Weaver diversity index:
Location 1: 0.91
Location 2: 1.169
Site diversity: 1.3

Helsinhoff Index
Location 1: 4.97
Location 2: 5.27
Site index: 5.12 (good)

Table 5.5 Diversity and abundance of invertebrates from the control aquatic site near Tana Hotel.

Order	Family	Number
Odonata	Coenagrionidae	4
Hemiptera	Notonectidae	19
	Gerridae	19
	Naucoridae	3
Ephemeroptera	Baetidae	8
Araneae	Caponiidae	1
4	6	54

GPS Coordinates:
Location 1 - 11°36.447N ; 37°23.623E ; altitude 1,794 m asl
Location 2 - 11°36.562N ; 37°23.607E ; altitude 1,782 m asl

Shannon-Weaver diversity index:
Location 1: 1.2
Location 2: 1.36
Site diversity: 1.3

Hilsenhoff Index:
Location 1: 6.0
Location 2: 5.22
Site index: 5.6

Table 5.6 Diversity and abundance of invertebrates collected from urban affected riparian habitats (Ghion Hotel and Feleghiwot Hospital).

Order	Family	Number
Orthopteraa	Acrididae	9
	Tettigoniidae	1
Trichoptera	Rhyacophilidae	2
Coleoptera	Chrysomelidae	7

	Coccinellidae	2
	Curculionidae	2
	Carabaeidae	3
	Bostrichidae	3
Hemiptera	Pentatomidae	1
	Pyrrhocoridae	1
	Miridae	7
	Lygaeidae	5
	Reduviidae	1
	Tingidae	3
	Cixiidae	4
	Berytidae	1
Hymenoptera	Formicidae	43
	Apidae	1
	Sphecidae	1
	Vaspidae	1
	Halicitidae	1
Thysanoptera	Phlaeothripidae	10
Araneae	Zodariidae	17
	Selenopidae	2
	Oonopidae	7
	Segestridae	10
	Tetragnatidae	1
	Syrphidae	7
Diptera	Chironomidae	12
	Scathophagidae	29
	Muscidae	4
	Tephritiae	1
	Culicidae	2
	Dolichopodidae	1
	Otitidae	1
	Callophoridae	1
	Coenagrionidae	6
Odonata	Libellulidae	1
	Noctuidae	1
Lepidoptera	Nymphalidae	2
	Cicadellidae	2
Homoptera	Aphididae	4
11	42	220

GPS Coordinates:
Near Ghion Hotel:
Location 1 - 11°35.904N ; 37°23.131E ; altitude 1,794m asl
Location 2 - 11°36.258N ; 37°23.668E ; altitude 1,798m asl

Near Feleghiwot Hospital:
Location 1 - 11°36.621N ; 37°22.208E ; altitude 1,784m asl
Location 2 - 11°36.570N ; 37°22.266E ; altitude 1,802m asl

Shannon-Weaver diversity index:
Location 1: 2.265
Location 2: 2.52
Site diversity: 2.39

Table 5.7 Diversity and abundance of invertebrates collected from agriculture-affected riparian habitat on Dek Island

Hymenoptera	Formicidae	2
Diptera	Chironomidae	1
Coleoptera	Curculionidae	1
	Carabaeidae	1
Aranae	Zodaridae	3
	Mimetidae	2
	Oonopidae	2
Odonata	Libellulidae	1
Lepidoptera	Noctuidae	9
6	9	22

GPS Coordinates:
Location 1- 11°53.147N ; 37°15.263E ; altitude 1,790m asl
Location 2 - 11°53.212N ; 37°15.369E ; altitude 1,793m asl

Shannon-Weaver diversity index:
Location 1: 1.99
Location 2: 0.934
Site diversity: 1.463

Table 5.8 Diversity and abundance of invertebrates collected from the control riparian site near Tana Hotel

Order	Family	Number
Orthopteraa	Tettigonidae	7
	Acrididae	8
Ephemeroptera	Tricorythidae	4
Hemiptera	Anthocoridae	10
	Miridae	1
	Reduvudae	2
	Pentatomidae	1
Homoptera	Cicadellidae	12
Hymenoptera	Formicidae	1
	Vespidae	1
	Anthophoridae	1
Lepidoptera	Noctuidae	9
	Geometridae	2
	Pieridae	3
	Lycaenidae	1
	Paplionidae	1
	Arctidae	1
Diptera	Chironomidae	11
	Chloropidae	3
	Syrphidae	2
	Scathophagidae	1
	Muscidae	2
	Tephritiae	1
	Aeshinidae	1
Odonata	Libellulidae	1
	Coenagrionidae	2
Aranae	Segestridae	10
	Oonopidae	1
	Mimetidae	3
	Thomisidae	2
	Plectreuridae	2
	Zodariidae	5
Trichoptera	Leptoceridae	3
	Baetidae	4
10	34	**112**

Coordinates:
Location 1 - 11°36.447N ; 37°23.623E ; altitude 1,794m asl
Location 2 - 11°36.562N ; 37°23.607E ; altitude 1,782m asl

Shannon-Weaver diversity index:
Location 1: 2.782
Location 2: 2.52
Site diversity: 2.65

Table 5.9 Diversity and abundance of invertebrates collected from urban-affected wetland at Gerima monastery

Order	Family	Number
Orthoptera	Acrididae	4
	Tettigoniidae	2
Diptera	Culicidae	5
	Syrphidae	4
	Otitidae	2
	Callophoridae	4
	Chloropidae	11
	Chironomidae	32
	Muscidae	7
	Tipulidae	1
	Scathophagidae	4
	Dixidae	8
Homoptera	Cicadellidae	100
	Delphacidae	1
Hemiptera	Miridae	2
Lepidoptera	Noctuidae	1
	Nyphalidae	1
Coleoptera	Coccinellidae	1
Hymenoptera	Vespidae	1
Ephemeroptera	Baetidae	1
Odonata	Coenagrionidae	1

Araneae	Zodariidae	3
	Oxyopidae	3
	Araneidae	5
10	24	204

Coordinates:
Location 1 - 11°36.890N ; 37°22.073E ; altitude 1,797m asl
Location 2 - 11°36.870N ; 37°42.078E ; altitude 1,780m asl

Shannon-Weaver Diversity Index
Location 1: 2.015
Location 2: 1.799
Site diversity: 1.907

Table 5.10 Diversity and abundance of invertebrates collected from agriculture-affected wetland at Fogera

Order	Family	Number
Orthoptera	Acrididae	1
	Tettigoniidae	1
Diptera	Diopsidae	12
	Ephydridae	116
	Scathophagidae	20
	Tephritidae	2
	Chloropidae	22
	Chironomidae	5
	Tipulidae	1
	Syrphidae	1
	Muscidae	15
Homoptera	Cicadellidae	388
	(Typlocybinae sub-fam)	2
Coleoptera	Coccinellidae	1
	Staphylinidae	1
Odonata	Coenagrionidae	1
Hemiptera	Coreidae	1
Lepidopter	Pieridae	1
	Arctiidae	1

Araneae	Zodaridae	2
8	**20**	**594**

Coordinates:
Location 1 - 11°50.662N ; 37°38.341E ; altitude 1,799m asl
Location 2 - 11°56.160N ; 37°42.477E ; altitude 1,790m asl

Shannon-Weaver Diversity Index
Location 1: 0..936
Location 2: 1.916
Site diversity: 1.42

Table 5.11 Diversity and abundance of invertebrates collected from wetland control site at Delgi

Order	Family	Number
Orthoptera	Acrididae	9
Diptera	Empididae	1
	Tachnidae	4
	Callophoridae	1
	Chloropidae	15
	Diopsidae	4
	Muscidae	25
	Tipulidae	1
	Dixidae	4
	Scathophagidae	7
	Dryomyzidae	16
	Culicidae	3
	Chironomidae	12
Homoptera	Cicadellidae	99
	Cercopidae	1
	Delphacidae	1
Hemiptera	Miridae	4
	Reduvidae	4
	Coreidae	5
	Aradidae	1
	Gryllidae	3
Odonata	Coenagrionidae	10

	Libellulidae	4
Hymenoptera	Braconidae	2
	Apidae	2
	Trigonalidae	2
	Vespidae	4
	Bradynobaenidae	3
	Formicidae	2
	Chalcididae	1
	Anthophoridae	8
Coleoptera	Carabaeidae	2
	Coccinellidae	4
	Chrysomelidae	4
	Anthicidae	1
	Staphylinidae	2
	Curculionidae	17
Araneae	Zodaridae	4
	Oxyopidae	1
	Araneidae	16
	Lycosidae	4
	Plectreuridae	3
Lepidoptera	Arctiidae	1
	Pieridae	1
Ephemeroptera	Baetidae	1
Thysanoptera	Thripidae	1
Acari	Salticidae	1
Scorpiones	Tetragnathidae	10
13	48	331

Coordinates:
Location 1 - 12°11.596N ; 37°03.359E ; altitude 1,789m asl
Location 2 - 12°11.750N ; 37°03.395E ; altitude 1,789m asl

Shannon-Weaver Diversity Index
Location 1: 2.319
Location 2: 3.066
Site diversity: 2.69

Table 5.12 Diversity and abundance of invertebrates collected from agricultural-impacted terrestrial sites at Gorgora, Kunzila and Woreta

Order	Family	Number
Orthoptera	Acrididae	20
	Gyrillidae	1
	Tettigonidae	1
Diptera	Chloropidae	45
	Chironomidae	5
	Muscidae	25
	Tachnidae	9
	Syphridae	10
	Tipulidae	8
	Tephritidae	2
	Callophoridae	2
	Scathophagidae	10
	Empididae	1
	Culicidae	5
	Dixidae	3
Hemiptera	Cercopidae	1
	Miridae	14
	Reduviidae	15
	Pentatomidae	3
	Berytidae	1
	Pyrrhocoridae	8
	Scutelleridae	2
	Coreidae	1
	Aradidae	4
Homoptera	Cicadellidae	36
	Cercopidae	4
	Aphididae	1
	Fulgoridae	2
Colepotera	Curculionidae	1
	Chrysomelidae	1
	Scarabidae	1
	Coccinellidae	1
Lepidoptera	Zygaenidae	4

	Notodontidae	4
	Hesperidae	2
	Arctidae	3
	Pieridae	1
	Noctuidae	7
	Nymphalidae	2
	Lycaenidae	1
Hymenoptera	Sphaecidae	4
	Formicidae	2
	Apidae	5
Neuroptera	Myrmelonidae	3
Aranae	Plectreuridae	7
	Thomsidae	1
	Zodaridae	7
	Araenidae	5
	Salticidae	2
	Oxyopidae	7
	Oonopidae	2
	Mimitidae	1
Odonata	Coenagrionidae	6
	Libellulidae	1
Acari	Ixodidae	2
11	55	322

Coordinates:
Location 1: N 12°14.386; E 37°17.457 ; altitude: 1821m asl
Location 2: N12°15.028; E 37 °16.959 ; altitude: 1801m asl
Method of sampling: sweep net, beating and soil

Shannon-Weaver diversity index:
Location 1: 2.513
Location 2: 2.999
Site diversity: 2.79

Table 5.13 Diversity and abundance of invertebrates collected from terrestrial control site at Taragedam **monastery**

Order	**Family**	**Number**

Orthoptera	Acrididae	3
	Tettigonidae	1
	Gyrillidae	1
Diptera	Chloropidae	12
	Syrphidae	6
	Musscidae	17
	Tachnidae	10
	Callophoridae	11
	Diopsidae	14
	Scathophagidae	12
	Agromyzidae	2
	Empididae	3
Hemiptera	Pentatomidae	1
	Miridae	14
	Pyrrhocoridae	7
	Mesovellidae	1
Coleoptera	Curculionidae	5
	Carabaeidae	4
	Chrysomelidae	6
	Tenebrionidae	1
	Melooidea	3
Hymenoptera	Vespidae	1
	Formicidae	3
	Sphaecidae	5
Homoptera	Cicadellidae	1
	Cercopidae	6
	Aphididae	2
	Pseudocoxidae	3
Lepidoptera	Noctuidae	7
	Sphingidae	1
	Arctidae	6
	Geometridae	5
	Pieridae	9
	Lycaenidae	4
Psocoptera	Liposcelidae	1

Araneae	Plectreuridae	5
	Mimetidae	5
	Tetragnatidae	2
	Oonopidae	3
	Zodaridae	5
Blattoidea	Blatellidae	3
Isoptera	Termitidae	10
Dermaptera	Labiduridae	1
Diplopoda	Julida	1
13	44	223

Coordinates:
Location 1 - 12°08.866N ; 37°44.710E ; altitude 2,133m asl
Location 2 - 12°09.474N ; 37°44.048E ; altitude 2,146m asl

Shannon-Weaver Diversity Index
Location 1: 3.059
Location 2: 3.118
Site diversity: 3.10

On the basis of Hilsenhoff's Index and his previous works (1977, 1982 and 1987), there is some indication of aquatic organic pollution in urban sites. However, the diversity of invertebrates found across the various habitats indicate the health of the ecosystems in the LTSB.

The sites where invertebrate samples were taken are representative of habitats for different bird species, particularly waterfowl, which feed on invertebrates. The invertebrates' role in supporting the ecosystem should be encouraged through the restriction of pest-control through fires and other negative activities on biodiversity.

As far as the level of water quality and associated degree of organic pollution are concerned, the analysis results show that samples taken near Lake Tana (the reference site) and samples from Deke Island show good water quality implying that there is some organic pollution in both sites. The samples from near Felege Hiwot hospital have demonstrated that the average water quality is fair meaning that it is more polluted when compared with the results from the reference site (near Tana hotel).

The detail data on identified wetland invertebrates including GPS coordinates, Altitude, condition of sampling, and method of sampling are presented in Tables 5.3 below while the summary is presented in Table 5.4.

5.5 Discussion

The frequently encountered invertebrates in the aquatic sampling sites contribute to the sustainable food chain of the Lake Tana ecosystem. The invertebrates found display various feeding habits (ie herbivores, scavengers, detritivores, predators, vectors), often linked to the type of habitat where they were found (eg, plant hoppers *Nephotettix* sp were found in rice-growing areas, Ixodidae ticks were found in cattle-grazing areas). Some invertebrates are natural enemies of pests, thereby providing an environmentally-friendly biological control method against pest organisms.

The invertebrate population in the LTSB provides ecosystem benefits as well as investment opportunities for the local communities. However, public awareness is a limiting factor which compromises the conservation of invertebrates in the area. Some of the threats to invertebrates that were observed during the study include the following:

Low public awareness
Stakeholder consultations indicated that invertebrates are not considered to be as useful as fish, birds, mammals and plants. The values of invertebrates particularly, honey bees, has not previously been acknowledged by the local communities, who saw the resource as something that was exploited for export from the LTSB.

The effect of the poorly-managed municipal drainage and garbage collection system around Bahir Dar on invertebrate populations is not well understood. Although a real threat for biodiversity in and around the city, the results show that it is not necessarily having a negative impact on invertebrate diversity.

Changing wetland ecosystems
Among the wetlands studied, Fogera wetland has been altered from a permanent to a temporary (or seasonal) wetland, exemplifying the fast deteriorating habitat for wetland invertebrate diversity.

Pesticide use
The intensification of agriculture and the excessive and unwise use of pesticides may pose a risk to beneficial organisms such as bees and other invertebrates.

Recommendations
To mitigate against the above threats, public awareness campaigns and capacity-building efforts of relevant institutions mandated to protect the environment, and local municipalities, should be considered. In this regard, the regional Environmental Protection, Land Administration and Use Authority (EPLAUA) has commenced a program to strengthening staff capacity through training and experience-sharing with similar institutions, at both national and international levels. An Environmental Impact Assessment (EIA) department has been established with a mandate to ensure that new investments initiatives in the region have complied with EIA regulations prior to securing licenses from different government offices.

Attention should be given to the restoration of disturbed wetlands for they have the greatest potential in areas of marginal agricultural lands. Wetlands should be gazetted and protected. Previously disturbed wetlands should be restored.

The Association of Ethiopian Wetlands is an NGO working to promote the sustainable use of wetlands and is contributing to knowledge-sharing and advocacy for wetland management. In addition, further opportunities to mitigate against the threats include the Amhara Regional State Government Park Development and Protection Authority (PaDPA), which recognizes the importance of creating a Biodiversity Conservation Institute. The University of Bahir Dar, as the local learning hub, has several faculties where graduates could contribute to information gaps and manpower deficits.

Pesticide use should be eliminated on all refuge areas, regardless of proximity to urban sites where vector (eg mosquito) control is a concern. Water within the LTSB must be monitored for other pollutants and pesticides.

Phytosanitary controls need to be strengthened to curtail the introduction and spread of alien invasive species of invertebrates, in general and insects in particular.

Recommended Investment Opportunities

Honey and honey products (bees-wax, propolis) Ethiopia has a unique diversity of honey bee races and the products could be a major means of income generation and employment.

Sericulture (silk production): the LTSB habitats are suitable for cultivation of the host plants for silk moths.

Animal feed: Invertebrates make both direct (mass-reared for domestic animal food) and indirect (cross-pollination of feed plants such as clover and alfalfa) contributions as sources of animal feed owing to their nutritional value.

Insect attraction: insect collections in museums could attract visitors and can be a means for income generation and employment

Butterfly farms: insect farms, particularly butterfly farms, can be sources of income

Invertebrates as food: insects are rich in protein and their nutritional value makes them valuable as food supplements for human consumption.

In conclusion, this Chapter highlights the diversity of invertebrate species and their habitats in the LTSB. Conservation programs within the sub-basin should include invertebrates when monitoring ecosystem health. In areas where there is degradation, the wetland invertebrate communities can recover quickly (within weeks or months) from the direct effects of stressors due, in part, to their high dispersal abilities and reproductive capacities.

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Appendices 1(a-e).

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Representative samples of invertebrates collected, identified and preserved.

(a) A representative of rare insect collected (Neuroptera: Myrmeleontidae)

(b) Representative of wetland dominant insect (*Diopsis* sp. Diopsidae)

(c) Representative of wetland dominant insect (*Nephotetix* sp. Cicadellidae)

(d) Representative of wetland dominant insect (*Nephotetix* sp. Cicadellidae)

(e) Representatives of rare invertebrate (Scorpiones)

STATUS OF MAMMALS OF THE LAKE TANA BASIN, ETHIOPIA

Bakuneeta Chris
Department of Zoology, Makerere University
P.O.Box 7062, Kampala, Uganda

8. Introduction

Wildlife in Ethiopia, like in many other African countries, is still a public good. It should be seen as an economic resource as it can ably justify its existence if opportunities are made conducive. At present, its total economic value (TEV) is still unknown. The direct use values (eg. meat, tourism, hides, medicine, etc) and indirect use values (eg. ecosystem stability, watershed protection, species diversity, water quality, etc) are slowly being realized. Adding optional and existence values (such as the Walia ibex, which is endemic to Ethiopia) will enable wildlife to compete with domestic species.

Lake Tana is surrounded by floodplains (Fogera, Kunzila and Dembia) that used to be part of the lake before it was reduced to its present size due to anthropogenic factors such as siltation and climate change. There are 37 islands on the Lake housing monasteries and churches dating as far back as 400 BC. The cultural and religious centers comprise the main tourist attraction to the lake and its vicinity. From 1988 to 1996, an average of 27,189 visitors per year (domestic and foreign) visited the monasteries in and around Lake Tana and the Blue Nile.

8.1 Overview of mammalian species in the LTSB

Mammals in Ethiopia are among the most endangered wildlife. The most charismatic species include:

The Walia ibex (*Capra walie*)

The Walia ibex is Ethiopia's flagship species. It is restricted as well as endemic to the Simien Mountains National Park (Simien MNP) and is among the most critically endangered mammalian species in the world (EBSAP, 2004). Its population declined from around 1,000 individuals in the 1940s to no more than 350 in 1996 (Medhin, 1997) as shown in Table 8.1. The situation could be different since the gazettement of the National park.

Table 8.1 Population estimates for the Walia ibex inside and outside Simien MNP from 1994-1996 (Medhin, 1997; Nievergelt *et al*., 1998)

Year	1994	1995	1996
Inside the Park	186	172	180
Outside the Park	135	98	80

The Klipspringer population in the Simien MNP also decreased from 57 individuals in 1994 to 32 individuals in 1996 (Nievergelt, 1998). This calls for more protective measure on the side of the park management.

Photo 8.1: The Walia ibex

The Ethiopian Wolf (*Canis simensis*)

The Ethiopia wolf is the world's rarest canid with less than 500 adults remaining in the Ethiopian highlands, although remnant populations occur in Gondar, Wallo and north of Shoa (Tefera & Sillero-Zubiri, 2007). Approximately 80 adults inhabit the Simien MNP and less than 150 were known to occur in the Bale Mountains NP in 1995 (Sillero-Zubiri *et al*., 2000). The most serious threat to the species is its ability to interbreed with the domestic dog (Gotelli *et al*., 1994), which could result in transmission of contagious diseases such as rabies.

Photo 8.2 The Ethiopian Wolf (*Canis simensis*)

Among the strategies proposed by the IUCN Canid Specialist Group to conserve the remaining wolf population (Sillero-Zubiri & Macdonald, 1997) is the plan to start a captive breeding program of genetically pure wolves. This plan will help to safeguard wolf species from extinction in the wild. Available evidence suggests that domestic dogs are the reservoir for rabies in Ethiopia. Rabies is endemic in Ethiopia and the disease is both a public health and economic problem through livestock losses in the impoverished rural communities (Laurenson, 2004).

Gelada Baboon (*Theropithecus gelada*)
This was the only abundant species in Simien Mountains National Park. Over 400 individuals were counted in two troops.

With the exception of the Gelada Baboon, populations of most of the other endemic species are declining. More than 70 per cent of the country's land is used for agriculture and livestock production while less than 3% of the land is protected and available for wildlife. The target for most African countries is to set aside about 10% of their land surface for wildlife protection. Although increasing the land area for wildlife was not easy in the past, more land is now being allocated to wildlife management as the land becomes arid and unsuitable for agriculture.

8.3 Objectives

An inventory of the mammals found in Lake Tana sub-basin and their ecological importance and usefulness to the local communities was carried out. The specific objectives of the study were to:

a. Carry out an inventory of the mammal species in the Lake Tana sub-basin
b. Assess the institutional and legal framework for the management of mammals in the region
c. Analyse the links between international conventions and institutions to the management and conservation of mammals.

8.4 Methods

Data was collected using the following two methods:

i. a desktop review of the mammals of the Lake Tana sub-basin
ii. fieldwork in eco-sites representative of the sub-basin that distinguish mammals of the wetlands, the lake and the catchments.

8.4.1 Approach

The survey began with an in-depth literature search on available data at the national level. Data were obtained from direct interviews and through questionnaires with the local people at the sites visited. Data on in-situ conservation were obtained through direct observations or through focus group discussions. In-situ conservation data on protected area management were obtained from field visits to Simien Mountains National Park.

8.5 Results

A brief synopsis of the localities surveyed is provided below. The species encountered and the number of individuals observed at each of the survey sites are provided in Table 8.1.

Zeghe Forest
Originally a primary forest, Zeghe Forest has become secondary as a result of human activities that continue in this remnant forest patch. It has a population of vervet monkeys and other primates as shown in Table 8.1. People living in the forest, cultivating crops, were consulted to complete the data collection on mammals occurring in the forest.

Table 8.1 Mammalian species recorded in the Lake Tana sub-basin

Species	Zeghe	Teragedam	Kunzila	Delgi	Gorgora	Total
Vervet monkey (Amharic:**Tota**)	25	8	4	2	15	52
Bushpig (**Azama)**	2	0	0	0	1	3
Dik dik	1	0	0	0	2	3
M.Bushbuck (**Dukula**)	1	0	0	0	0	1
Bush Duiker (**Midakwa**)	0	1	0	1	0	2
African Civet	1	Extinct	0	1	1	2
■Porcupine (**Jarta**)	0	0	2	0	2	3
+Hyaena (**Jibu**)	1	0	1	1	1	4
+Leopard (**Nebbr**)	1	0	0	1	1	3
*Tree Hyrax	1	0	0	0	1	2
Rock Hyrax (**Eshkoko**)	0	1	0	0	2	3
Hippo (**Gumari**)	4	0	3	2	2	11
Olive Baboon	0	2	0	0	8	10
oBanded mongoose (**Anero**)	0	1	0	2	1	4
Marsh Mongoose	1	0	0	1	2	4
White-breasted. Hedgehog	0	1	0	0	3	4
Common Jackal	0	0	0	0	2	2
Black-and-white Colobus (**Guereza**)	1	0	2	0	3	6
Abyssinian Hare (**Tinchel**)	0	4	1	0	2	7
Honey badger (**Mwogeza**)	0	0	1	0	1	2
Oribi (**Midakwa)**	0	0	0	0	2	7
Bats	0	2	0	10	5	7
Crested porcupine (**Kenfiz**)	1					
Total 23	**40**	**20**	**14**	**21**	**57**	**142**

* The tree hyrax seen had been killed and was being taken to a traditional healer
+ Evident from the footmarks
○ Crushed by a vehicle along highway

■ Porcupine quills found

Goats and sheep were found grazing inside the forest. There was a general consensus among local residents interviewed that leopards reside in this forest patch. Hyena pugmarks were recorded. Zeghe forest is the main source of timber and fuel wood for Bahir Dar via Lake Tana, according to fishermen and local communities residing around the forest.

Various wildlife species have taken refuge in the forest patch Zeghe Forest (12 species were observed). It is one of the sites recommended for in-situ conservation development in the Lake Tana sub-basin. The forest limits is bordered by an extension of a papyrus-swamp wetland where monitor lizards (*Varanus niloticus*.) were seen.

Teragedam Woodland
This woodland is situated on an escarpment marking the end of Lake Tana catchment. Eight different species were observed. 8 vervet monkeys were observed crossing the road in the middle of the day (Table 8.1). The civet is said to be extinct in Teragedam woodland.

Kunzila
This area had one of the lowest populations of animals found during the survey and only 7 different species were observed. The vervet monkeys that were common elsewhere were not recorded in Kunzila rea. Among the species said to be extinct in the region was the aardvark (*Orycteropus afer*).

Delgi
Delgi town, located north of Lake Tana is a delapidated town and showed a low mammal population (8 different species observed). The town is mismanaged and organically polluted (there are no public toilets in the town), even in the surrounding *Eucalyptus* forest. The lack of public latrines has resulted in an extension of the town to the grassland-lake ecotone where the Lake is used for laundry, bathing and recreation.

Gorgora
Twenty different species were observed in this area, which had one of the higher populations of mammals (57 individual animals were counted). Although not seen, it was reported that the black-and-white colobus (*Colobus guereza*) and the vervet monkey (*Cercopithecus aethiops*) have taken refuge in the monasteries and churches in the region.

In addition to the above research sites, mammal species were also surveyed at Bahir Dar University, Gerima wetland and the Simien Mountain National Park. The different species observed and the number of individuals recorded are given in Table 8.2, which provides a good comparison with the populations of mammals that occur in protected and resilient ecosystems.

Table 8.2 Species and number of individuals observed at Bahir Dar University, Gerima wetland and Simien MNP

Species	Bahir Dar University	Gerima Wetland	Simien MNP	Total
Hippo	3	1	--	4
Wild cat	1	0	--	1
Anubis Baboon (**Djindjero**)	8	3	12	23
Vervet Monkey	18	9	5	32
Abyssinian Hare	1	0	--	1
Gelada Baboon (**Gelada**)	--	--	375	375
Bushbuck (**Dukula**)	--	--	5	5
Ethiopian Wolf (**Kai Kebero**)	--	--	2	2
Walia Ibex (**Walya**)	--	--	25	25
Klipspringer (**Sassa**)	--	--	15	15
Mole Rat (**Filfel**)	--	--	13	13
Total	31	13	452	496

Bahir Dar University

There is a large stretch of land on the campus of the University of Bahir Dar that borders a wetland where one hippopotamus was found grazing during the day. This wetland could serve as a sanctuary for the local hippo population, given its proximity to the University and potential interest to various faculties and other stakeholders for sustainable management.

Photo 8.3 The Blue Hippos on Lake Tana

Gerima Wetland
Although hippos were recorded in this habitat (Photo 8.3), it is unlikely that they will remain in the area as there is insufficient food to sustain them. A program should be be developed for their conservation and sustainable management.

The few remaining wild animals outside protected areas, such as the black-and-white colobus monkey (*Colobus guereza*) tend to occur on land owned either by churches and monasteries or occurring on private farms.

8.6 Discussion

In many African countries, conventional agriculture and animal husbandry are failing to meet the expectations and needs of the people who depend on them. Both practices are less ecologically sustainable. The overall economic development and the welfare of any nation and its people may benefit more from having environmentally-friendly multiple uses of its biological resources instead of setting aside a large piece of land for few land uses. The main threat to wildlife habitats and resources in Africa is not over-use but the conversion of land for agriculture and livestock.

Ethiopia has over 280 mammalian species and has the highest mammalian endemism on the African continent (31 species or 11.7%). There are six endemic mammalian genera of which four are monotypic (three rodents *Megadendromus*, *Muriculus*, *Nilopegamys* and one primate *Theropithecus*). The other two endemic genera are *Desmomys* and *Stenocephalemys* which are represented by two species each. Unfortunately, approximately 15% of the country's mammalian species are threatened and many more are vulnerable.

During the survey, 23 mammalian species were recorded in the Lake Tana sub-basin. Most of these species have taken refuge in the relict, marginal habitat patches of remnant wildlands (wetlands, forests and woodlands), which are shrinking in size thereby subjecting the extant mammalian population to increased vulnerability and the risk of becoming critically endangered.

The vervet monkey (*Cercopithecus aethiops*) was abundant in the remnant forest patches and wooded habitats in the Lake Tana sub-basin, whilst only the gelada baboon (*Theropithecus gelada*) was abundant in Simien MNP. Several species in the Simien MNP have the following IUCN's threat categories:

- the Walia ibex (*Capra walie*) is listed as Critically Endangered (Criteria C2b),
- the Ethiopian wolf (*Canis simensis*), the world's rarest Canidae, is Endangered (Criteria C2a),
- the klipspringer (*Oreotragus oreotragus*) is conservation dependent and of Least Concern and
- Meneliks Bushbuck (*Tragelaphus scriptus meneliki*) is listed as of Least Concern (www.iucnredlist.org/search)

The blue hippopotamus (*Hippopotamus amphibius*) historically occurred in large schools on Lake Tana but is now in need of immediate local conservation efforts

Ethiopia has ratified many multi-lateral environmental agreements and Conventions relating to biodiversity conservation (eg CITES in 1989; Convention on Biological Diversity in 1992; the Cartagena Protocol on Bio-safety in 2005; the International Plant Protection Convention in 1977). Ethiopia is a member of the World Heritage Convention and is a signatory to the Lusaka Agreement. Ethiopia is not yet a signatory to the Ramsar Convention.

8.6.1 Wildlife conservation challenges

The costs of conservation should be paid for either by the state (which may have more urgent priorities), local people (who are poor and are not willing to pay for it) or by national and/or international organizations. Without demonstrable economic benefits from wildlife at the local and national level, economists see conservation as a luxury they cannot afford (Adams, 2004).

Worldwide, wildlife is threatened mainly because it has not been able to justify its existence to humankind. When the economic value of wildlife to humankind is understood and appreciated, more land may be set aside and mankind will realize that the benefits that accrue from wildlife can compete favorably with those accruing from agricultural and livestock production.

In the Zambezi Valley (Zimbabwe), where the tsetse flies were eradicated and livestock displaced wildlife, Murindagomo (1997) concluded that wildlife could be more profitable than cattle at the household level if cattle subsidies were removed and appropriate institutions governing access to wildlife resources and benefits were introduced.

Wildlife conservation in Ethiopia is fairly new and started in 1965 with the formation of the Ethiopian Wildlife Conservation Organization (EWCO) whose mandate was to conserve and manage the country's wildlife in PAs. Up to the 1980s, EWCO was responsible for the management of 10 national parks, 4 wildlife sanctuaries, 11 wildlife reserves and 18 controlled hunting areas (Tadese *et al*., 1992; Hillman, 1993; Abdi *et al*., 2003). However, of the 10 national parks, only two (Awash and Simien Mountains National Parks) have been formally gazetted. The other eight are still waiting for government approval. The delay for their approval is partly linked to the insecurity that has persisted in the country for more than a decade, which has resulted in persistent weaknesses in park management and instability in park governance.

After the 1980s, EWCO has faced many challenges including the lack of a skilled human resource, political instability, human encroachment and the impacts of climate change on wildlife resources. Not involving the local communities in the wildlife management has led to local resentment of protected areas (Shibru, 1995).

8.6.2 Total Economic Value (TEV)

Wildlife can become a renewable resource when the concept of total economic value (TEV) is applied to justify its existence. TEV includes direct use values (eg. returns from meat, hides, tourism, medicine, etc) and indirect use values (eg. benefits from ecosystem stability, watershed protection, water quality, species diversity, etc).

TEV also includes non-use values such as option values and existence values, such as the fact that the Walia ibex and the Mountain Nyala are only found in Ethiopia. When

the full costs and benefits of all these values are known, the opportunity costs of wildlife resources in Ethiopia will be appreciated. Although attaching an economic value to an ecosystem good or service ignores the market forces, knowledge of this value will go a long way in reducing the extinction rate of the wildlife species.

8.6.3 Conservation Areas in the Amhara Region

Interviews held with wildlife managers in Bahir Dar and at the Simien MNP indicated that most of the Protected Areas have been heavily encroached by agriculturalists and pastoralists, including the gazetted Simien and Awash National Parks). A strategy is called for to address the problem of encroachment into protected sites.

Capacity building of wildlife managers in the Amhara Region is needed. For wildlife to attain a protected status similar to that of domestic flora and fauna in the country, highly trained wildlife managers are needed. Cost-benefit analyses should be undertaken to demonstrate to policy-makers and other stakeholders the potential gains that can accrue from investing in, and allocating more land to, wildlife.

(i) Simien Mountains National Park

The Simien Mountains National Park was established in 1966 and gazetted in 1969. In 1978, it became a World Heritage Site. The area was visited to assess the status of in-situ conservation since it is the potential gene pool for ex-situ conservation. The Park is under-staffed and under-financed for effective management. Encroachment is a problem. Over 30,000 people live inside the Park together with their cattle, goats, sheep, dogs and donkeys. Suitably trained staff are needed to publicize the park and advocate for the protection of its wildlife and resources. The Gelada baboon (*Theropithecus gelada*) is still abundant in the Park with normal troops of about 400 individuals. The other known species in the Park were rare, an indication that they might be threatened.

(ii) The Parks Development and Protection Authority

The Council of the Amhara Region initiated the development of the Parks Development and Protection Authority under the Ministry of Agriculture and Rural Development. This became operational in 2003. The Authority requires substantial support to realize its objectives for wildlife conservation and its potential for tourism. Although Amhara Region has one of the best tourist centers visited during the survey, tourism in the region is not well developed. The economic value of threatened and endangered species can be enhanced if tourists are able to visit and encounter those species.

(iii) Tourism potential

The tourism potential in Amhara Region is high but is currently biased towards cultural and religious tourism. Wildlife tourism could complement the existing tourism in places where churches and monasteries occur, given that many mammals occur there. Ethiopia's potential for adventure tourism in Africa is virtually untapped and this too could supplement and diversify the rural tourism industry.

Both in-situ and ex-situ conservation in the Amhara Region are poorly managed. The current status of the Simien MNP is a cause for concern due to the heavy encroachment that the Park is witnessing.

The current wildlife and tourism policies require amendment. Two Proclamations were assessed: The Development Conservation and Utilisation of Wildlife Proclamation No 541/2007; and the Amhara Regional State Parks and Development Protection Authority (96/2003). These policies need to be harmonized as they currently contain conflicting sections.

8.8 Conclusions

The future of mammalian conservation in the Lake Tana sub-basin should be extended beyond the Amhara regional State to all of Ethiopia. The lack of proprietorship needs to be addressed as natural resources for a long time have either belonged to the State or to nobody. The laws and regulations need to be enforced in order to protect these resources.

The future of Ethiopia's wildlife will depend on effective cooperation with, collaboration from and support of the people living alongside wildlife. As mammals survive outside Protected Areas, their fate will be determined by what happens to them in the rural landscape as well as in Protected Areas. The state is obliged to work with civil society, private sector and local communities as partners and together develop community resource management institutions and organizations as alternatives. This requires a paradigm shift which gives local communities a higher stake in conservation than they have had in the past. They should be at the centre of wildlife management and be involved in forging a way forward for its conservation and in addressing the severe resource degradation and poverty that they are experiencing. The potential for wildlife populations to improve could be improved when civil society and the private sector are fully involved in decision-making and a new 'breed' of highly trained conservationists are available who will ably demonstrate that there is much to gain from investing in wildlife conservation (Adams, 2004). This paradigm shift should be aligned with efforts to achieve the Millennium Development Goals.

A new system of wildlife management is needed to ensure the survival of Ethiopia's wildlife in PAs. Declines in populations can be mitigated through co-management practices not only in wildlife conservation and management but in natural resource management too. The Park Wardens interviewed expressed their enthusiasm and optimism for new management options that could effectively conserve wildlife.

Where habitat restoration for agriculture and livestock is not working as expected, attempts to restore and re-introduce wildlife populations may be possible since wildlife is better adapted to harsh environments than introduced food crops and livestock.

Attempts that ignore the local communities in wildlife management may not be successful as demonstrated by the failed efforts in the past where local communities were not involved in conservation practices (Turton, 1987). Local communities should, wherever possible, be involved in the pre-planning, operation and decommissioning of any initiative.

8.9 Recommendations

8.9.1 Creating a Ministry of Tourism, Wildlife, Culture and Antiquities (MTWCA)

The Department of Wildlife is currently housed within the Ministry of Agriculture, which could downplay the role of the wildlife department as there are regular conflicts between wildlife and agriculture (ie crop-raiding animals). A new Ministry of Tourism, Wildlife, Culture & Antiquities could target those sectors of the economy that bring in foreign currency (ie international tourists). In other countries where such cross-sectoral super-Ministries exist (for example, in Kenya and Uganda), they compete favorably with the agriculture sector in bringing in foreign currency. As the main income generating Ministry, it is likely that the various departments would benefit from an increased share of the national budget from Treasury.

Civet farming has been practiced in Ethiopia since the 17th century. The Districts of Sidamo, Shoa, Wollega, Keffa and Illubar, where civet farming is still being practiced, should be assisted to start a captive breeding program for civets. The proposed new Ministry should be charged with supervising humane captive breeding of civets. The private sector should be charged with marketing of civetone (African civet musk) products locally and internationally. It has been suggested that the proposed new Ministry would 'bury' civet farming (Edem & Wondmagegne, 2007).

8.9.2 Formation of Ethiopian Wildlife Authority (EWA)

The formation of a national wildlife authority is long overdue given that the Amhara Region created its State Protected Area Authority in 2003. Based on Amhara Region's example, Central Government should develop and create a competent authority responsible for all PAs and wildlife management.

The EWA's mandate should be to conserve, develop and sustainably manage wildlife inside and outside PAs in partnership with neighboring communities and other stakeholders. The advantages of such an Authority are that it would be semi-autonomous, implying that whilst financially supported by the government it can also solicit funding from outside Ethiopia. It is anticipated that the donor community will pool financial resources to support the EWA to operate with minimum difficulties, thereby assisting EWA to regain all the wild lands that have been encroached.

8.9.3 Amending wildlife policy and legislation

The analysis of the two proclamations (The Development Conservation and Utilisation of Wildlife Proclamation No 541/2007; and the Amhara Regional State Parks and Development Protection Authority No 96/2003) identified several sections where the two Proclamations are not in harmony. For example, the texts provide different definitions for the following:

a. National Park

In the Amhara Region Proclamation (ARP), the definition of a National Park separates wild birds from wild animals, whilst in the former National Proclamation (NP) there is no definition of a park. Instead, it uses a new term: "National Wildlife Conservation Park".

b. Wildlife

The ARP defines only wild animals where the NP defines wildlife as either vertebrates or invertebrates. The ARP considers plants as food or habitats for animals

whereas the NP defines wildlife as '*any wild plant or wild animal indigenous to Ethiopia including migratory species*'

c. Hunting

The ARP defines hunting as the act of pursuing or trapping wild animals in the park but makes no mention of the pursuit or trapping of wild animals beyond park boundaries. However, in the NP's definition of hunting, activities such as 'scaring' and 'chasing' wildlife are included, which implies that if pigs are chased from a private garden, they have been 'hunted'. The NP's definition of hunting also extends to the possession of feathers.

d. Domestic animals

In both Proclamations, domestic animals are not defined, which presents a challenge to conservation as domestic animals were once wild.

e. Protected species

Protected species (ie plants and animals that are legally protected by the state because they are either endangered, vulnerable or are of special concern) are not defined in either Proclamation. A list of protected species should be drawn up and included in the texts; CITES species *a priori* should be included on the list.

In addition, many words in the Proclamations require definition in order to avoid misinterpretation, including:

- Wildlife use right
- Problem animals
- Dangerous animals
- Hunter (Professional or Traditional, Poacher)
- Biosphere Reserve
- World Heritage Site
- Important Bird Areas (IBA)

In the National Proclamation, the definitions of Wildlife Sanctuary, Wildlife Reserve, Protected Area, Conservation Area and Controlled Hunting Area refer to the purposes of these areas, but do not define them.

A consequence of unclear land use policy (Grover & Temesgen, 2006) is that livestock and agriculture have taken up most of Ethiopia's land. With the impacts due to climate change increasing, alternatives to agricultural production should be revisited.

8.9.4 Establishing Community Conservation Areas (CCAs)

CCAs are usually based on customary law and traditional practice and were recognized at the IUCN World Parks Congress in South Africa in 2003[1].
According to Kothari (2006), the motivation for establishing CCAs includes:

- a concern for protecting wildlife outside PAs

[1] http://www.iucn.org/about/union/commissions/wcpa/wcpa_puball/wcpa_parksmag/?2137/2003-Durban-World-Parks-Congress

- securing sustainable access to livelihood resources
- obtaining sustained benefits from ecosystem functions
- sustaining religious or cultural needs (sacred sites)
- securing collective or community land tenure
- attaining security from environmental threats
- obtaining financial benefits (eg. from ecotourism and adventure tourism).

CCAs provide corridors facilitating the movement of animals and gene flow, as well as empowering communities to promote constructive development, thereby creating a sense of community identity and cohesion.

8.9.5 Collaborative Management (CM)

The current wildlife policy should be amended to promote collaboration management and enable Ethiopians to access wildlife resources through wildlife use rights where wildlife hunting, farming, ranching and trading are allowed with conditions under which these activities are allowed to operate.

With clear wildlife use rights the potential to attract investors for bio-trade initiatives, such as captive breeding, wildlife ranching and farming of high-value wildlife species is more likely to occur.

8.9.6 Non-Governmental Organizations (NGOs) and other Civil Society Organisations (CSOs)

There are many local and international NGOs in Ethiopia working in the areas of health and education. However there are few registered NGOs working on wildlife conservation issues. A more NGO-friendly environment is recommended to facilitate NGO formation, registration and operation, as well as treating CSOs as partners rather than competitors in conservation.

CSOs are flexible institutions skilled at helping local people to become self-sufficient. Their membership and areas of operation are diverse but they primarily emphasize participatory management that promotes capacity building at the village level. The government will benefit from the flexibility of CSOs by creating an enabling environment in which to work together and gain closer access to the communities. Through such strategies, the gap between resource managers and resource users can be narrowed.

8.9.7 Hippo Sanctuary

The habitat where the hippopotamus occurs in the LSB is increasingly threatened by development projects. The Department of Wildlife, Wetlands and Forests of Bahir Dar University should explore the possibility of establishing a ‘Hippo Sanctuary’, which may require the University to acquire more land to accommodate the population.

8.9.8 Ex-situ Conservation

Wilson (1992) reported that ex-situ conservation can save a few species, but emphasis should be on in-situ conservation of wildlife in its natural habitats. According to Western (1989), land beyond the parks is not only the best hope but also the biggest

challenge for biological conservation in the 21st century. Ex-situ conservation should aim at enhancing in-situ conservation, not competing with it.

Captive breeding may have to be considered to ensure continued survival of some endangered species (eg Walia ibex). The captive breeding operations that farm civets in Oromia Region should be modernized to improve and ensure humane treatment of the animals (Edem & Wondmagegne, 2007).

8.9.9 Churches and Monasteries

The religious sites confer protection on the sacred trees and provide refugia to the animals living in the sacred forests are free from human interference (Desissa & Adane, 2003). They should be recognized as tourist attractions where some of the endemic wildlife species can be protected and tourism revenue can be generated. It is recommended that the government recognizes the role that NGOs are playing in promoting ex-situ conservation.

8.9.10 Payment for Ecosystem Services (PES)

As mankind benefits from the services provided by a healthy environment, PES has arisen as an innovative financial mechanism to assist with the conservation of ecosystems. Involving local communities may involve compensations for their role in protecting natural resources. Payment for ecosystem services is being tested in Costa Rica, Ecuador and Bolivia. In Bolivia, 46 farmers in Los Negros Valley (near Amboró National Park) are being paid to protect 2,774 ha of a watershed containing the threatened cloud-forest habitat of 11 species of migratory birds (Asquith *et.al*., 2008). In the LTSB, similar initiatives could be initiated in the villages around Zeghe Forest.

A similar concept to PES has been the CAMPFIRE program (Communal Areas Management Program for Indigenous Resources) in Zimbabwe where wildlife and its habitats were managed for the benefit of the people living in those areas (Martin, 1986). The principle of wildlife production outside the PAs was recognized as early as the 1970s by the Parks and Wildlife Act (1975). CAMPFIRE was encouraged in the drier areas where wildlife production was financially and economically more viable than single-species livestock production (Jansen *et al*., 1992). CAMPFIRE's greatest achievement and legacy has been how it empowered communities to manage their own projects and revenues (Murphree, 2004; Child, 2004).

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Appendix

Appendix 1. IUCN categories for the threatened and extinct mammals of Ethiopia

Species	EXTINCT*	*CR	*EN	*VU	*END
Walia Ibex		√			√
African Wild Ass		√			
Ethiopian Wolf		√			√
African Wild Ass		√			
Greater Kudu	√				
Bushpig	√				
Bilen Gerbil		√			
Guramba Shrew		√			
Harenna Shrew		√			
MacMillan's Shrew		√			
Grevy's Zebra			√		√
Mt.Nyala			√		√
Nubian Ibex			√		
African Wild Dog			√		
Swaynes Hartebeest			√		
Tora Hartebeest			√		
African Elephant			√		
Gelada Baboon				√	√
African Elephant				√	
Ammodile Gerbil				√	
Bailey's Shrew				√	√
Bale Shrew				√	
Beira Antelope				√	
Cheetah			√		
Dibatag			√		
Dorcas Gazelle				√	
Glass's Shrew				√	
Large-eared free-tailed Bat				√	
Lesser Horse Shoe Bat				√	
Lion				√	
Morris's Hairy Bat				√	
Mouse-tailed Bat				√	
Natal Free-tailed Bat				√	
White-toothed Shrew				√	√
Nikolaus's Mouse				√	
Patrizis Trident Leaf-nosed Bat				√	
Red-fronted Gazelle				√	
Rupp's Mouse				√	
Scott's Hairy Bat				√	

Soemmerring's Gazelle				√	
Speke's Gazelle				√	
Spotted-necked Otter				√	
Stripe-backed Mouse				√	
Unstripped Grass Rat (**Ait**)					√
Groove-toothed Rat (**Ait**)					√
Soft-furred Rat (**Ait**)					√
Narrow-headed Rat					√

* Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) in the 2004 IUCN Red List of Threatened Animals.

SOCIO-ECONOMIC STUDIES OF THE LAKE TANA SUB–BASIN

Bezabih Emana (PhD)
Support Integrated Development Consult
P. O. Box 15805 Addis Ababa
emana_b@yahoo.com

9.Introduction

The Lake Tana sub-basin is rich in biodiversity with many endemic plant species, aquatic animals, birds, different breeds of cattle and cultural and archaeological sites, as well as large areas of wetlands and flood plains. However, the role of the existing wetlands, biodiversity and water resources in sustainable development of the Lake Tana sub-basin area is not well documented.

In order to fill the knowledge gap in the management of wetlands and biodiversity of the Lake Tana sub-basin, an in-depth water socio-economic study was necessary to collect information that will guide the sustainable management of the resources in terms of their support to livelihoods. Water, wetlands and their biodiversity resources in the Lake Tana sub-basin provide different benefits to the people, for example: water supply for human beings and livestock, economic activities through irrigation, fishery and water transport, etc. Hence, it was necessary to examine closely the values of the wetlands and obtain a better understanding of the people's interaction with the ecosystem.

9.1 Objectives

This chapter discusses and provides assessment of the studies carried out on the socio-economics and environmental valuation components of the Lake Tana sub-basin. The studies focused on the economic values of natural resources and major threats that affect wetlands, biodiversity and water resources and provide recommendations for effective management of the sub-basin, highlighting the trans-boundary management of these resources.

The specific objectives included investigating the linkage of the people with resources by assessing the following:

- the socio-economics of the Lake Tana sub-basin including the cultural, gender and indigenous values of the people to the resources
- the economic potential of the water, wetlands and biodiversity resources of Lake Tana sub-basin and Abay Basin
- the investment opportunities for water resources, wetlands and biodiversity resources in the Lake Tana sub-basin.

9.2 Methods

In order to achieve the objectives of the study, different research approaches were used to collect quantitative and qualitative data from primary and secondary sources. The primary data were collected using household surveys and holding focus group discussions with different social groups and institutions. Moreover, visual observations of the socio-economic, natural resources and environmental conditions were made. Secondary data were used to supplement the survey data.

a) Sampling procedure

Lake Tana sub-basin lies in three zones of Amhara Regional State, namely West Gojam, North Gonder and South Gonder. The basin has 9 districts, a total population of about 2.5 million and an estimated 446,238 households. A 3-stage sampling procedure was applied to select the households included in the survey:

(i) three representative districts were purposefully selected by involving key informants and knowledgeable persons from the Bureau of Agriculture and Rural Development of Amhara Regional State. The selection of districts considered diversity, accessibility and representation;

(ii) 10 kebeles[1] were selected purposefully within the selected districts in such a way that samples were drawn from kebeles adjacent and non-adjacent to Lake Tana;

(iii) sample respondents were randomly selected from the households registered as residents of the selected kebeles.

Accordingly, a total of four hundred and four (404) heads of farm households were randomly selected; 201 and 203 farm households from kebeles adjacent and non-adjacent to Lake Tana, respectively. Table 9.1 shows the distribution of the respondents by district and kebele.

Table 9.1: Distribution of sample respondents by district and kebele

No.	Kebele of the respondents	Proximity of the area	District of the respondent			Total
			Bahir Dar Zuria	Achefer	Fogera	
1	Zeghe	Adjacent	39			39
2	Robit	Adjacent	41			41
3	Qunzila	Adjacent		39		39
4	Nabega	Adjacent			41	41
5	Waqtera	Adjacent			41	41
6	Naguna	Non-adjacent	41			41
7	Forhe Sankera	Non-adjacent		44		44
8	Kuhar Abo	Non-adjacent			40	40
9	Woreta Zuria	Non-adjacent			37	37
10	Wogelsa	Non-adjacent	41			41
	Total		**162**	**83**	**159**	**404**

The sample covered people from different social groups. In terms of marital status, 89.9% of the sample respondents were married, 3.7% divorced and 6.4% widows. About 12% of the sample respondents were females representing female-headed households (Table 9.2).

Table 9.2: Distribution of sample households by proximity to Lake Tana (%)

Location	Sex		Total %	Total No. of cases
	Male %	Female &		

[1] Kebele is the administrative unit below district

Adjacent	91.0	9.0	49.8	201
Non-adjacent	85.7	14.3	50.2	203
Total	**88.4**	**11.6**	**100**	**404**

b) Questionnaire

The selected households were interviewed using a structured questionnaire (Appendix 9.1). The questionnaire covered different variables such as: the socio-economic features of the households, different means of livelihood and income-generating activities, gender differentiations in resources management, land resources and its utilization, economic benefits of natural resources such as wild animals, cropland, pastureland, water resources, fishery, forest and woodlands, and cultural and environmental values of trees. Qualitative and quantitative data were generated through the individual interview.

c) Focus group discussions

In all of the kebeles surveyed, discussions were held with farmers from different social groups. Male and female farmers from different age groups participated in the focus group discussions. The elders were an important source of information sharing their observations and experiences of the change in natural resource bases and their values. Checklists (listed in Appendix 9.2) were prepared to lead the discussions. The major focus of the discussions was to generate information at community level that could complement the survey data in the process of valuation of the natural resources. As far as possible, the discussions were supplemented with personal observations on the ground. A total of 63 people from 10 kebeles participated in the group discussions (see Table 9.3).

Table 9.3: Distribution of participants of the focus group discussions

No	District/kebeles	Participants		
		Male	Female	Total
1	Robit	7	1	8
2	Zeghe	6	0	6
3	Debre Tseyon	5	1	6
4	Wogelsa	5	1	6
5	Woreta Zuria	6	2	8
6	Nabaga	5	1	6
7	Qora Abo	4	2	6
8	Wogtera	3	1	4
9	Sankira	5	1	6
10	Qunzla	5	2	7
	Total	**51**	**12**	**63**

d) Secondary data

The information gathered through household survey, focus group discussions and field observations were supplemented with regional and district level reports and secondary data. Relevant documents of Nile Basin Projects (such as the Tana-Beles Integrated Water Resources Development Project, the Tana-Beles Strategic Environmental Assessment Project, Tana Irrigation Project and the Tana-Beles Hydro Tunnel Project), studies proposed by the regional offices and other agencies (especially project documents, proposals, progress reports, research reports and statistical bulletins), and other relevant reports were reviewed.

e) Valuation technique

The major purpose of the socio-economic analysis was to estimate the values of the key natural resources in the Lake Tana sub-basin. Land, forest/trees, water and fish were the key natural resources valued using different assumptions and techniques. The valuation technique used is based on the Total Economic Valuation (TEV) method. As far as possible, the valuation technique took into account the economic, ecological and social values of the natural resources in the area which support people's livelihoods.

The primary data were used to identify the extent to which these resources were used by the people of the sub-basin, the purposes for which the natural resources were used, the income generated per household and the unit prices or proxy prices of these resources. The secondary data on the number of households and other variables were used to aggregate the household level data at sub-basin level so as to estimate the total values of the natural resources. The details of how the aggregation was done are given in section 9.3.5 on Valuation of Natural Resources.

9.3 Results

9.3.1 Overview of natural resources in Ethiopia

Land

Ethiopian wetlands support diverse crops that people dwelling within or around the wetlands grow to earn food or cash. A number of cereals, pulses, vegetables, oil crops and bulbs that grow on the Ethiopian uplands also grow in the wetlands. Wetlands also provide pasture for livestock grazing in riparian areas. Approximately 20% of the total wetlands in Illubabor were cultivated each year between 1986 and 1998 (Hailu, 1998). Between 1.5 to 4.4 people dwell per hectare of agricultural land around lakes of Ziway, Langano, Shalla and Abiyatta and an estimated 6 million people in the Abaya, Chamo, Awassa and Chew-Bahir catchments, with an average population density of more than 160 persons/km^2 (Lemlem, 2003). Recently, the Ethiopian government proposed to initiate the drainage and irrigation of 40,000 hectares along the shores of Lake Tana. Although the available information is not comprehensive, there is increasing pressure on wetlands for agricultural uses which can compromise their hydrological and ecological functions. It was also reported that temporary and spatially extensive drainage of wetlands in Illubabor have affected the water level in wetlands and the groundwater level in the surrounding areas (Hailu, 1998). The loss of nearby spring water has had a number of serious impacts, including greater time and labor

effort for women to collect water from more distant springs, increased ill health, reducing food security and economic well-being.

Expansion of agricultural land to wetlands also increases the externality cost. The agro-chemicals (pesticides, herbicides, fungicides and fertilizers) leached from the cultivated areas have serious impacts on the water quality and aquatic life within the wetlands. In the Rift Valley area, for instance, cultivation of green maize, Teff and vegetables, as well as planting eucalyptus, banana, sugarcane and 'khat' on the edges of wetlands were identified as threats for the survival of the wetlands in the area (Zerihun, 2003). Although impacts of wetland transformation can be imagined, scientific studies are needed to assess objectively the impacts and the associated socio-economic factors.

Water and wetlands

Water is a key natural resource in the wetlands. Water and economic growth are inextricably linked, and water is an important input in all the productive sectors of the world's economies. Access to water is also a strong social indicator of progress. Ethiopia possesses a high potential of surface and ground water resources. There are 12 major river basins with total annual runoff of about 110 billion cubic meters (Bm^3), equivalent to an average continuous flow of 3,500 m^3/s (WAPCOS, 1990). About 80% of the water is said to flow to neighboring countries, namely the Sudan, Kenya and Somalia. The exploitable groundwater is about 2.77 Bm^3 (Table 9.4). Of the total exploitable groundwater, some 1.8 Bm^3 come from the Abay River Basin, which is approximately 65% of Ethiopia's water potential. This potential is a major source of the economic, social and political ties between the countries benefiting from the Blue Nile (Abay) River.

Table 9.4 The Water Resource Potential of the Country

No	River Basin	Basin area (Km^2)	Available Water (Annual Run-off)		Exploitable potential			
			Volume (Bm^3)	Depth (mm)	Irrigation (1000 ha)	Hydro-electric		Ground Water (Bm^3)
						(MW)	GWh/yr	
1	Tekeze	86,500	8.20	94.8	190	690	4,230	0.20
2	Abay	198,000	52.62	265.8	1,002	12,854	78,820	1.80
3	Baro-Akobo	75,900	11.81	155.6	600	2,244	13,760	0.31
4	Awash	112,700	4.60	40.8	205	729	4,470	0.14
5	Rift Valley	52,700	5.63	106.8	139	130	800	0.10
6	Omo-Gibe	79,000	17.96	227.3	87	3,662	22,454	0.10
7	Wabi-Shebele	202,700	3.16	15.6	204	887	5,440	0.04
8	Genale-Dawa	168,000	5.88	35.0	423	1,512	9,270	0.03
9	Mereb	5,900	-	-	68	-	-	0.05
10	Danakil	62,900	0.86	13.7	3	-	-	-
11	Aysha	2,200	0.02	10.0	-	-	-	-
12	Ogaden	77,100	0.82	11.2	-	-	-	-
Total		**1,123,600**	**112**	**99.3**	**2,920**	**22,708**	**139,224**	**2.77**

Source: National Water Resource Master Plan (WAPCOS, 1990), as cited in Genale-Dawa River Basin Integrated Resources Development Master Plan Study Report (2005), Ministry of Water Resources, Addis Ababa.

As shown in Table 9.4, Abay basin covers an area of 198,000 km^2 in Ethiopia. According to Assefa (2007) the Abay-Blue Nile sub-basin covers about 311, 482 km^2 area in Ethiopia and the Sudan. The sub-basin covers parts of Amhara, Benishangul-Gumuz and Oromia National Regional States in Ethiopia, and Blue Nile and Sinnar states in the Sudan. The sub-basin drains towards the Sudan on its western border and shares common boundaries with the Tekeze sub-basin to the north, the Omo Gibe basin to the south, the Awash basin to the east and southeast and the Baro-Akobo sub-basin to the southwest.

Wetlands are an important component of water resources in Ethiopia. The potential evapo-transpiration from wetlands is apparently very high because they lose water efficiently through dense hydromorphic vegetation. Wetlands, therefore, have an influence on rainfall humidity and microclimate stabilization and are, therefore, essential in the hydrological cycle and rainfall generation. Their hydraulic and hydrological functions and uses include ground water recharge, increased low flows (ground water discharge), water storage, flood protection, continued stream and river flow, sediment trapping, and water supply for people, livestock and wildlife. The water quality functions include filtration, nutrient stripping (nitrogen and phosphorus), biodegradation of toxic compounds, heavy metal stripping and accumulation, and wastewater treatment (Conway & Dixon, 2000). A hydrological monitoring program in Illubabor, for instance, revealed that less-disturbed wetlands possessed generally higher and more uniform water table levels, whilst disturbed wetlands had lower and more variable water tables. The disturbed sites exhibited much greater dispersion in their range of values over years and possessed lower absolute water table levels than undisturbed sites (Ibid).

(i) Water supply situation

Supply of adequate and safe water to the population has vital importance for economic and social development of the country as it improves human health and creates possibilities of using labor for other productive sectors. However, despite the country's high potential surface and groundwater resources, the water supply in 2003/04 was only 37.9% of total capacity, which was among the lowest in Africa (IMF, 2006). Although the government is making efforts to increase the water supply coverage, this problem will remain an issue for years to come.

The major sources of drinking water in rural Ethiopia include rivers, springs, shallow and deep wells, ponds, and sometimes lakes. For the majority of the urban population, however, springs, shallow and deep wells are the major sources of water. Lack of potable water is aggravated by lack of hygienic and sanitary services, whose coverage was only 14% in 2004.

(ii) Financing of the water sector

The Ethiopian government, donors, NGOs and the community contribute to the development of water resources. The donors' contribution to implementation of the water supply program

during 2005/06 to 2007/8 reached 49.5% of required funding (Table 9.5). NGOs have been responsible for many rural water supplies and sanitation facilities, spending ETB 50-75 million annually on water supply and sanitation activities. During 2005/06 to 2007/08, an estimated US$ 30 million was spent on water resources development by NGOs.

The communities also contribute resources needed for the implementation of water and irrigation projects in the form of labor and local materials. The national water supply development plan during 2005/06 to 2007/08 estimated the community contribution at 5.6% of the total funding needed (ADF, 2005).

Irrigation projects are financed through government budget, which is currently made available through the food security programs and regular capital budgets, donations and loans. Some of the donor funding is channeled to the NGOs who work closely on water resources development for irrigation and drinking water for people and livestock. A large number of NGOs implement integrated rural development projects in which irrigation is used as a means to increase agricultural productivity.

Table 9.5 Sources of funding for implementation of the water resources development project (2005/06-2007/08)

Source	Million USD	Percent
Required Funding	316.46	100.0
Donor Funding:		
World Bank	36.00	11.4
African Development Bank	64.00	20.2
Netherlands Government	18.00	5.7
UNICEF	15.00	4.7
UNDP	3.92	1.2
FINIDA	9.72	3.1
JICA	10.21	3.2
Sub-Total for Donors	**156.85**	**49.5**
Government	68.18	21.5
Communities	11.00	3.5
NGOs	30.00	9.5
Total Available Financing	**266.03**	**84.0**
Financing Gap	50.43	15.9

Source: African Development Fund (2005)

Forest resources

Ethiopia has a large number of plant species (i.e. about 7,000 species of higher plants) of which about 12% is probably endemic. Some plant species, ie *Cyperus latifolius* (cheffe), *C. brevifolius*, *Anagallis serpens* and *Fuirena stricta*, only occur in the wetlands due to the special characteristics of these areas that tend to favor particular types of plants and soils (Wood, 2001). These plants provide diverse benefits, such as: support people's livelihoods; conserve the environment; and used as shelter to wildlife. In Illubabor, some wetland plants, such as 'enna' (*Aeschynomene schimperi*), are used as animal feed, while others are used for human food, e.g. palm trees (*Triestemma auritanum*) (Hailu, 1999). Despite this, forest resources within the wetlands are increasingly deteriorating. Deforestation due to population

growth and the associated expansion of farming, increasing demands for fuel, construction wood and charcoal are critical factors contributing to the deterioration of forest resources in rift valley lake basins, the Lake Tana sub-basin and other basins. Charcoal production is becoming a serious cause for concern in the sub-Rift Valley System of Ziway, Langano, Abijatta and Shalla (Lemlem, 2003).

However, the existing information on forest resources within Ethiopian wetlands is neither exhaustive nor countrywide. For example, adequate information is not available on type/species and their values.

Birds

Mengistu (2003) reported that 204 bird species (around 25% of the total number of birds found in the country) are wetland-dependent, including endemic (e.g. blue-winged goose *Cyanochen cyanoptera*) and globally threatened species (e.g. white-winged flufftail). In addition, of the 73 hotspots identified in Ethiopia as important bird areas, 30 (41% of the total) of these sites comprise the wetlands, indicating the importance of wetlands as bird habitats (Tilahun *et al*., 1996). According to Lemlem (2003), a total of 538 species of birds - more than 65% of the country's total – are recorded from the Rift Valley Lakes' ecosystem. Of the 29 Ethio-Eritrean endemic bird species, eight are endemic to the Ethiopian Rift Valley (see Chapter 7 for bird lists for LTSB). The Ethiopian wetlands create habitats for birds of the world. Due to its geographical position, the Ethiopian Rift Valley serves as a wintering and maintenance station for a large number of terrestrial and aquatic birds, including southern African, sub-Saharan and Palearctic species. Lake Awassa supports more than a hundred species of water birds, including local and Palaearctic migrants and a notably dense population of Marabou storks (Zerihun, 2003).

Fish

Ethiopia is home to diverse lakes and rivers that host a significant fish resource. Six fish species have been identified in Lake Awassa (Dadebo, 1988), including *Oreochromis niloticus, Clarias gariepinus, Barbus* sp. and *Garra* sp. of which the first three are commercially important. Over 35 fish species have been described from the Rift Valley Lakes (RVLs) and the Lower Omo River Basin (Lemlem, 2003). The fish fauna is more diverse in the Southern RVLs of Abaya and Chamo and in the Lower Omo River basin (see Map 9.1). Despite this, the resource is being depleted at an alarming rate mainly due to human pressure. Under certain circumstances, over-fishing has resulted in the loss of some fish species and their replacement by others. On Lake Chamo, the '*gancho*' net has caused a rapid depletion of Nile perch stocks. Fish resources within Lake Ziway were also over fished as almost 70% of the fish landed from the RVLs comes from Lake Ziway alone. Tilapia stocks in Lake Awassa are also thought to be over-fished. Amongst the destructive fishing techniques employed on these lakes are the use of herbicides, fishing in reed belts, chase and trap fishing and shore beach-seining which depletes juvenile stocks and destroys nursery grounds. The immediate and long-term effects of over-fishing and destructive fishing on biodiversity resources have not been properly assessed and measures have not been put in place to mitigate the situation.

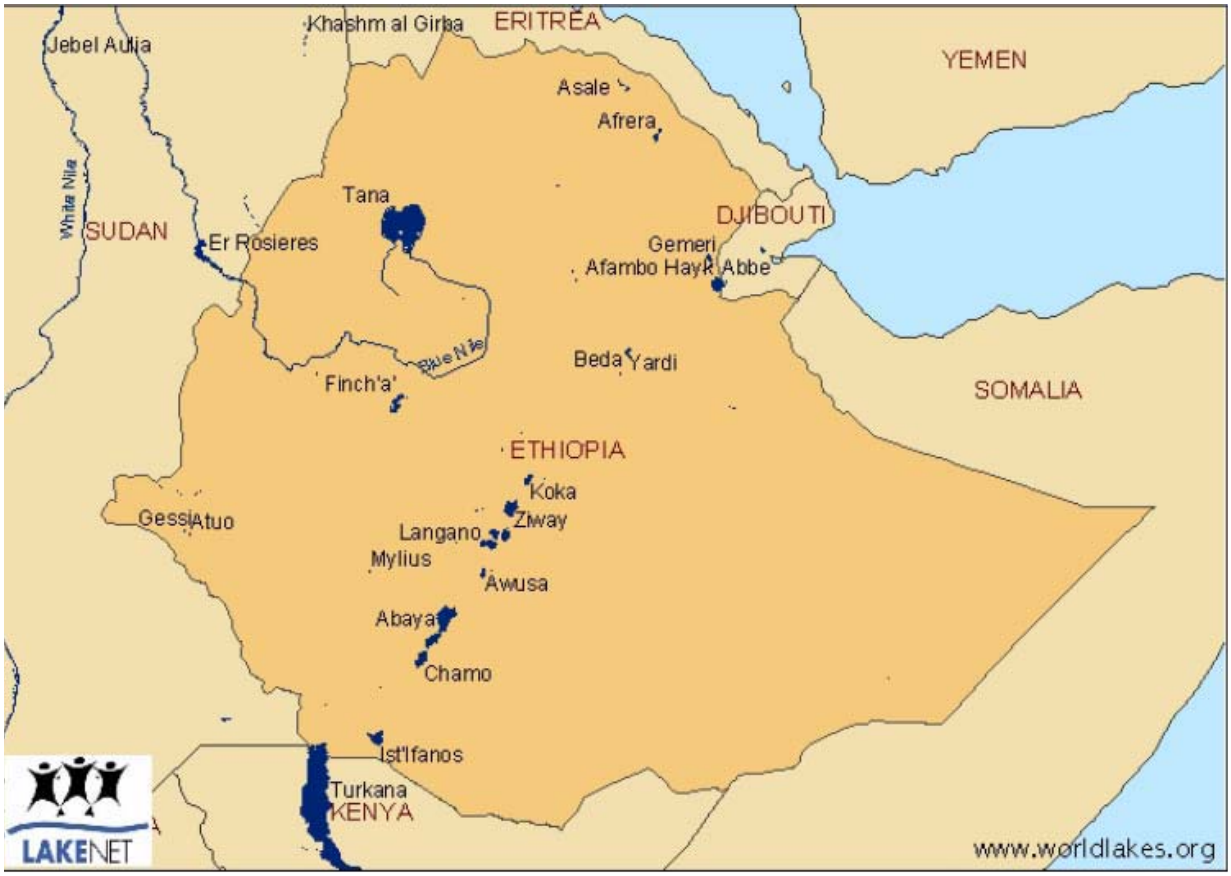

Figure 9.1 Major Lakes of Ethiopia

9.3.2 Overview of natural resources of the Lake Tana Sub-Basin

The Lake Tana sub-basin supports a riparian population of up to 2.5 million people who derive their livelihoods from the resources of the lake (Selome, 2006). The sub-basin is rich in biodiversity with many endemic plant species, aquatic life (fish species: *Clarias gariepinus*, *Oreochromis niloticus*, *Barbus* sp., etc [Wudneh, 1998]), cattle breeds, birds and cultural and archaeological sites. The wetlands in the Lake Tana sub-basin provide habitat for the Fogera cattle breed, which originated in the Fogera plain and is unique to the country. The large areas of wetlands and flood plains make a major input to agricultural production; the sub-basin has vital national significance as it has the potential to produce high value crops and livestock, develop vast water resources for irrigation and hydroelectric power, and as an ecotourism destination. Despite this potential, the socio-economic and cultural values of the diverse resources within the sub-basin have not previously been properly evaluated. However, the literature available (e.g. Eshete, 2003) has noted that the natural resource base of the sub-basin has been deteriorating over time and needs special and urgent consideration.

Rivers

There are several rivers within the sub-basin. The major rivers drain into the Blue Nile (Abay) River. Table 9.6 lists the rivers with their drainage destinations and estimated length in kilometers. The Blue Nile flows down stream into Sudan. The drainage destinations cover several zones in the Amhara region. The major rivers in west and east Gojam, north and south Gonder and south Wollo drain in to the Blue Nile. Moreover, tributaries of the Blue Nile also cover large catchments in Oromia and Benishangul-Gumuz regional states of Ethiopia.

Management of the drainage areas has significant impact on the sustainable use of the water resources within the sub-basin and downstream. Measures to control erosion reduce siltation in Lake Tana.

Table 9.6 Major rivers in the Abay Basin and Lake Tana sub-basin

No.	River	Zone	Drainage	Estimated length (km)
1	Blue Nile	West and East Gojam, South Gonder	Blue Nile	600
2	Bir	West Gojam	Blue Nile	105
3	Gilgel Abay	West Gojam	Lake Tana	150
4	Fetam	”	Blue Nile	95
5	Beles	”	”	125
6	Debohila	”	”	65
7	Zoma	”	”	*NA*
8	Jema	”	”	60
9	Ayehu	”	”	80
10	Gilgel Beles	”	”	*NA*
11	Abaya	East Gojam	”	70
12	Suha	”	”	90
13	Muga	”	”	75
14	Chemoga	”	”	45
15	Temicha	”	”	115
16	Chaye	”	”	45
17	Teme	”	”	55
18	Dinder	North Gonder	”	220
19	Rehad	”	”	170
20	Mengech	”	Lake Tana	*NA*
21	Rib	South Gonder	Lake Tana	80
22	Gumera	”	Lake Tana	70
23	Beshilo	South Goder and South Wollo	Blue Nile	*NA*
24	Chefa	”	Blue Nile	60
25	Yeshum	South Wollo	Blue Nile	*NA*
26	Mesble	”	”	*NA*
27	Mechal	”	”	*NA*
28	Selage	”	”	*NA*

NA = No information available

Source: Bureau of Finance and Economic Development of ANRS, 2006

Land

Agriculture, predominantly rain-fed, is the mainstay of Lake Tana sub-basin's economy. A large area in the sub-basin is put under cultivation (Francis and Shimelis, 2007) and the surrounding flood plains of Fogera, Dembia, Alefa and Achefer have been intensively cultivated for centuries. The plains are seasonally flooded and often used for rice farming or with field crops when the floodwaters recede. Many farming practices are still traditional, with little mechanization or advanced drainage technology. However, increased population pressure has increased small-scale, low-tech agricultural change, increased grazing pressures, and resulted in small-scale irrigation schemes being set up in certain areas (e.g. near the Dirma River). Traditional farming is also considered to be a contributing factor to erosion and increased sediment yields in the lake. In the subsequent sections, the areas under cultivation and the value of different land use systems will be discussed.

Forest

The sub-basin is covered by some natural forests, particularly around Zeghe peninsula, marshes and wetlands at the floodplains, especially near the lake, with a dominant flora type of Papyrus (*Cyperus papyrus*), bushes, shrubs and grasslands. The major habitats around Lake Tana are farmland, grassland, forest, rocky areas, marsh, reed beds and the lake itself. The Bahir Dar area is particularly well known for the safflower, *Carthamus tinctorius*. The marshes support a variety of grasses, sedges and climbers. The mixed forests comprise figs, *Syzygium guineense*, *Cordia africana*, *Albizia* spp., *Prunus africana* and the endemic *Millettia ferruginea* as common trees, together with a well-developed shrub layer and woody climbers. Huge figs, *Ficus vasta*, are also found as isolated trees in farmland and on the lake shore. The Zeghe peninsula is home to a distinctive coffee variety that grows in the shade of *Acacia* and *Millettia ferruginea* trees. One of the most striking features of the Lake Tana sub-basin is the extensive *Papyrus* beds from which the traditional reed boat, 'tankwa', is made. Other large plants in the reed beds are *Typha* sp, *Echinochloa* spp., various grasses and *Polygonum*. Several aquatic plants, including *Nymphaea coerulea*, are noticeable (Birdlife International, 2007). The indigenous people derive significant economic, social, medicinal and cultural values from these resources (Myles *et al*., 2006). However, such values were not properly analyzed or quantified and the measures needed to ensure their sustainability were not taken.

Birds

Lake Tana sub-basin supports diverse and valuable birds and is one of the most important sites in Ethiopia for wetland birds. The sub-basin may even hold, on average, more birds annually than anywhere else in the country (Francis & Shimelis Aynalem, 2007). About 32,471 birds of 83 wetland species were counted on the Lake Tana area in January/February 2007 (Ibid). Birds such as the Crested Francolin and Helmeted Guineafowl have important economic values (food & cash) for the local people while others have significant cultural values (tourism attraction).

Fish

Lake Tana sub-basin is an important source of fish both for the people immediately around the lake and elsewhere in the country. Lake Tana has a unique composition of fish fauna: an endemic species flock of 15 large *Labeobarbus* species (length up to 100 cm); 3 small *Barbus* species (<10 cm); 4 *Garra* species; *Varicorhinus beso* (Beso); *Oreochromis niloticus* (Nile tilapia); *Clarias gariepinus* (African catfish); and probably other small, not well known species in flood plains and papyrus beds (Eshete, 2007).

Lake Tana could potentially be a huge supply ground for fish, yet the previous estimate for Lake Tana's fish potential was 40 tonnes or tons/year, which may be unrealistic and needing debate. The findings of the study on fish (discussed in Chapter 4) refute the past assumptions and provide evidence of much higher annual harvests. Furthermore, there is no empirical finding to signal over-fishing beyond the acceptable threshold. Socio-economic and institutional factors fuelling fish over-exploitation were not thoroughly investigated. However, the lack of standardised fishing equipment, inadequate regulation of fishing sites and lack of control over fish maturity are major concerns for researchers regarding sustainable development of Lake Tana's fishery.

Invertebrates

According to a review by Emiru (Chapter 5), individual wetlands that are semi-permanently flooded were found to contain up to 90 invertebrate families. The invertebrates in Lake Tana sub-basin are diverse with a variation in diversity index between locations. Emiru discussed the role of invertebrates as indicators of ecosystem health and integrity as well as potential income-generators to supplement livelihoods.

Mammals

A large number of mammals are found in the Lake Tana sub-basin. Vervet monkey, Bushpig, Dikdik, Menelik's Bushbuck (Dukula), Grey Duiker (Midakwa), African Civet, Porcupine (Jarta), Hyaena, Leopard, Tree Hyrax, Rock Hyrax (Eshkoko), Hippo (Gumari), Olive Baboon, Banded mongoose (Anero), March Mongoose, White-breasted Hedgehog, Common Jackal, Black-and-white Colobus (Guereza), Abyssinian Hare (Tinchel), Honey badger, Crested Porcupine, Oribi (Midakwa), Bats (Microchiroptera), Wild cat, Anubis Baboon, Gelada Baboon, Ethiopian Wolf, Walia Ibex, Klipspringer and Mole Rat were reported to exist in the Abay basin area, which also includes the Lake Tana sub-basin.

Herpetofauna

Information on amphibians and reptiles in the Lake Tana sub-basin is scarce. The latest work of Saber (Chapter 6) reported 51 species, 35 genera, 16 families, 4 orders and 2 classes of herpetofauna. The study also reported ten endemic species (20%), of which three amphibians and two reptiles are Ethiopian endemic species and five reptilian species are regionally endemic in Ethiopia, Eritrea and Sudan.

Saber's study recorded 17 amphibian species (32.7 % of the total herps recorded in Lake Tana sub-basin) from the order Anura belonging to 9 genera and 5 families. Most amphibian species and some reptilian species are threatened by human impact, land degradation, deforestation, expansion of agricultural activities and pollution.

Transboundary water issues

Many rivers, lakes and underground aquifers cross the national boundaries of countries. This links riparian countries together in a complex system of interdependence covering the spheres of economics, environmental policies, politics and security (Jägerskog and Phillips, 2006). However, this relationship is mostly fragile in a situation with growing water scarcity and creates the potential for conflict between the countries that affects the sovereignty of the countries. According to Sandwidi and Stein (2003), the rivalry over water resources could be affected by factors such as geographic constraints, preponderance and alliances, democracy, economic interdependence and the role of international organizations. Nowadays, it is well recognized that trans-boundary water resources require close management at the national scale, with management regimes in each basin State needing to interface coherently across national boundaries (Jägerskog and Philips, 2006). If trans-boundary waters are cooperatively managed, the resource could be used for economic development of the riparian countries and create incentives for inter-country cooperation that could make a significant contribution to global peace and stability, as well as to poverty reduction in the respective countries.

Access to an adequate supply of clean water is a basic human right. Many of the poor communities along the downstream?, mainly in developing countries, depend on transboundary water for their economic, social and environmental welfare. This creates the link between water use and poverty reduction in the countries along the river basin. Blue Nile water which benefits from the Lake Tana sub-basin is a typical example in this case. Ethiopia, known for its low standard of living and extreme poverty, should develop its water resources as a strategy to alleviate poverty. The Sudan and Egypt, on the other hand, rely on the water resources supply from the upper stream, Ethiopia, for economic and social development. This relationship is a justification of existence of externalities in the river basin in which the activity of one country affects the welfare of the other. According to James (2005), externalities occur in transboundary water management due to: (i) hydrological linkages between upstream and downstream use of natural resources, and (ii) socio-economic linkages across property boundaries and common land.

Lake Tana basin has major global environmental benefits. It is the main source of the Blue Nile upon which the livelihoods of people in the sub-basin and downstream depend. The Blue Nile is an international public good. As the pressure on water resources increases, in terms of both quality and quantity of water needed, water resources are driven to the edge of their natural limits making consumers reliant on water development infrastructure and water management. Efficient transboundary water management, including efforts that address sediment control and ensure the wellbeing of the ecosystem, will contribute to the protection of public goods such as lakes and rivers (Jägerskog, *et al*., 2007). The natural resources management system in the Lake Tana sub-basin and erosion control in the watershed can positively affect the livelihood of the people in the sub-basin and further downstream. Water and associated resources are common property that should be properly managed to ensure sustainable use by countries along the river course. A better understanding of these facts will encourage transboundary interest in conservation of the natural resources.

Water Resource Development Programs and Schemes

The Government of Ethiopia prepared a National Water Supply and Sanitation Program in 2002 with the assistance of donors and participation of the key stakeholders in the sector. The objective was to increase rural water supply coverage to 71% and rural sanitation coverage to 24% by 2015. These targets have been brought in line with the Millennium Development Goals (MDGs) targets of reducing by half the proportion of people lacking access to adequate water and sanitation services.

The program addresses the needs of the different sub-sectors under different development programs and projects, namely: Water Supply and Sewerage Development, Irrigation Development, Hydropower Development, Water Resources Development, and Institution and Capacity Building Programs. The investment schedule for the implementation of the water resources development to meet the MDGs was estimated to cost US$ 7.44 billion (ETB 63,282.5 billion) sub-divided into short, medium and long-term programs of 5-year duration (Table 9.7).

Table 9.7 Investment plan for water and sanitary development (US$ million)

Sub-Sector	Short-term (2005)	Medium-Term (2010)	Long-term (2015)	Total
Water supply and sewerage	876.2	1,057.9	1,001.7	2,935.8
Irrigation	307.9	456.9	918.3	1,683.1
Hydropower	649.1	525.9	776.7	1,951.7
Water Resources	183.9	231.9	240.5	656.3
Institution/capacity Building	92.9	63.3	61.7	217.9
Total	2,110	2,335.9	2,998.9	7,444.8

Source: African Development Fund (2005)

The Government's five-year development plan, PASDEP[2], outlined the activities needed for the implementation of programs related to water resource development. The target of the government plan is to raise water supply coverage through: (i) the study and design of projects in 738 towns; (ii) construction works for 514 towns; (iii) rehabilitation works for 228 towns; and (iv) construction of – a) 1,870 deep wells in the rural areas, b) 12,755 shallow wells, c) 101,355 hand dug wells, d) 420 ponds, e) 780 cisterns, f) 15 surface water sources and g) 11,445 spring water sources.

The major activities under the PASDEP include:

(i) carrying out water resource assessment studies and inventory the quality and quantity of available surface water and groundwater resources in the country, both in time and space;

(ii) preparation of hydrogeological maps;

(iii) inventory of the existing water supply and irrigation schemes;

[2] Plan for Accelerated Sustainable Development to End Poverty (PASDEP) is the Ethiopian Government's Development Plan for the period of 2005-2009.

(iv) assess and evaluate the existing hydrological and meteorological network stations, and instruments and procedures for data compilation, processing and analysis;

(v) initiate a program for undertaking periodic review and updating of the Master Plans;

(vi) promote rainwater harvesting through the construction of small check-dams to meet domestic water supply and irrigation needs at local levels.

In order to ensure sustainability of the water supply schemes, it has been envisaged to establish tariff structures for water services based on site-specific characteristics of the schemes, and ensure that water prices lead projects to full cost recovery based upon users' payment capacities and by using appropriate technologies. Financial management rules and feasible arrangements of resource allocation, cost sharing and accessing funds for demand driven water supply systems and promotion of local self-financing of programs and projects, based on the overall socio-economic development condition of local communities, and through appropriate incentive mechanisms, were among the important instruments planned in the PASDEP. Equally important measures include:

- improved extension services, public awareness and regulatory measures that improve efficiency and conserve water resources;
- undertaking soil and water conservation measures that reduce soil erosion and reservoir siltation;
- encouraging and promoting local community participation in watershed management and water conservation measures.

Gender mainstreaming activities in the water resources development project aims at enhancing the active involvement of women in sustainable development and management of water projects, participation of women in decision making processes, building the technical capacity of women in the organization and management of water supply systems and small-scale irrigation schemes. The water development policy and programs are applied by all regions of Ethiopia, including Amhara region in which Lake Tana sub-basin is predominantly found.

Lake Tana is at or near the top of the list of "wetlands of international importance" that are not yet Ramsar sites (Barker, 2004). The Convention on Wetlands is an inter-governmental treaty where the Secretariat (or Bureau) is hosted by the International Union for the Conservation of Nature (IUCN) at their offices in Gland. There are presently 158 Contracting Parties to the Convention that have designated some 1,832 "Ramsar sites" totaling more than 170 million hectares of land and water (www.ramsar.org accessed March 2009). Participation in the Ramsar Convention is entirely voluntary for all of the Parties. Over the course of ten Conferences of the Parties, the Ramsar Convention has generated excellent technical guidance on the wise use of wetlands, and it sustains an active global network of wetland managers and policy makers. In the event that Ethiopia ratifies the Convention, Lake Tana is the most obvious candidate to be designated the first Ramsar site in Ethiopia, consistent with the requirement that every Party must designate at least one site at the time of accession to the Convention (Barker, 2004).

9.3.3 Socio-economic analysis

Lake Tana occupies an estimated area of 3,600 km^2. It is bordered by 3 zones in the Amhara Regional State and Bahir Dar town. The zones cover an area of 75,397 km^2 of which 18,742 km^2, which is about a quarter of the total surface area of the region, lies adjacent to Lake Tana (Table 9.8). Each of the zones is divided into smaller administrative units called districts (woredas), only a few of which are adjacent to the Lake. About 40% of the district areas in the west Gojam zone, 26% of those in the south Gonder zone and about 15% of the district areas in the north Gonder zone are adjacent to the lake. On average, about 25% of the districts in the Tana sub-basin are adjacent to the lake. The interaction of people within the lake in terms of economic activities, environmental protection or damages, pollution, etc, is affected by their proximity to the lake. Within the adjacent districts, only a few of the kebeles[3] are adjacent to the lake and hence, the household, which is the sub-set of the kebele, was used as the unit of analysis.

Table 9.8 Area of district in the Lake Tana sub-basin

List of districts in zones	Area of adjacent zones (sq. km)	Area of the adjacent districts (sq. km)	Proportion adjacent to the lake (%)
South Gonder Zone	**14,120.11**	**3,630.86**	**25.7**
Dera		1,561.83	
Fogera		1,117.58	
Libo Komkom		951.45	
North Gonder Zone	**44,634.42**	**6,621.41**	**14.8**
Dembia		1,294.93	
Gonder zuria		1,380.51	
Takussa/Alefa		3,945.97	
Lake Tana	**3,112.14**	**3,112.14**	**100.0**
West Gojam Zone	**13,497.35**	**5,344.63**	**39.6**
Bahir Dar zuria		1,519.25	
Mecha		1,491.19	
Semen Achefer		2,334.19	
Bahir Dar town	**33.1**	**33.10**	**100.0**
Grand total	**75,397.12**	**18,742.14**	

Source: Extracted from BOFED, ANRS (2007), 2005/2006 Annual Statistical Bulletin

Population of the Study Area

Nine districts border Lake Tana. The data on the population of these districts were collected from the Amhara Region Finance and Economic Development Bureau. Based on the proportion of the population of kebeles included in the survey, the proportion was divided into two classes: adjacent and non-adjacent. From a total of some 2.5 million people in the Lake Tana sub-basin, 13% live in the kebeles adjacent to the lake making the lake and its resources more accessible to them than to people living at distant places (Table 9.9). The

[3] A kebele is an administrative structure below the district administration and is empowered to define access to natural resources to people living within the kebele.

number of households in the respective locations was estimated by dividing the total population by the average household size of 6 persons (the findings of the survey). The households in adjacent and non-adjacent kebeles were used as units of analysis. Based on the parameters estimated from the focus group discussions and the sample survey, aggregations were made, as appropriate, using the number of households in the two locations of the sub-basin.

Table 9.9 Population of the districts located in the Lake Tana sub-basin (2007)

No.	List of districts	Total population	Population residing adjacent to Lake Tana	Non-adjacent population
	South Gonder Zone			
1	Dera	231,636	30,113	201,523
2	Fogera	217,965	28,336	189,630
3	Libo Komkom	176,863	22,992	153,871
	North Gonder Zone			
4	Dembia	289,428	37,626	251,802
5	Gonder zuria	204,327	26,563	177,765
6	Takussa/Alefa	289,787	37,672	252,115
	West Gojam Zone			
7	Bahir Dar Zuria	253,236	32,921	220,316
8	Mecha	328,597	42,718	285,880
9	Semen Achefer	328,597	42,718	285,880
	Total Rural	**2,320,437**	**301,657**	**2,018,780**
	Bahir Dar town	219,916	28,589	191,327
	Grand total	**2,540,354**	**330,246**	**2,210,108**
	Proportion (%)	**100**	**13**	**87**

Source: BOFED, ANRS (2007)

The available data shows that 50,276 households live in districts adjacent to Lake Tana. The number of households by district and proximity to Lake Tana is given in Table 9.10.

Table 9.10 Distribution of households by district and proximity to Lake Tana

Sr. No.	Districts	Adjacent	Non-adjacent	Total
1	Dera	5,019	33,587	38,606
2	Fogera	4,723	31,605	36,328
3	Libo Komkom	3,832	25,645	29,477
4	Dembia	6,271	41,967	48,238
5	Gonder zuria	4,427	29,628	34,055
6	Takussa/Alefa	6,279	42,019	48,298
7	Bahir Dar zuria	5,487	36,719	42,206
8	Mecha	7,120	47,647	54,766
9	Semen Achefer	7,120	47,647	54,766
	Total	**50,276**	**336,463**	**386,740**

Source: Computed based on Table 9.9 and an average family size of 6.

Sample Households

Age: The age distribution of the respondents ranges from 20 to 80 with an average of 42 years. About 11% of the respondents are of less than 30 years while 17% are more than 50 years. The sample respondents lived in the area for an average of 40 years.

Household size: A household size is defined as the number of people sharing the same kitchen. It is in a way the number of people under the responsibility of a household head. Thus, they could be family members, relatives or other people living with the household for an extended period of time, usually over 3 months. The survey results show that the household size ranges from 1 to 16 with an average of 6 persons (Table 9.11). The working age group accounts for 49% of the household size showing that there is a nominally larger number of people who depend on the others for subsistence.

Table 9.11 Average household size

Household member	Adjacent	Distant	Total
Average family size	6.49	6.25	6.35
Male	3.48	3.42	3.45
Female	3.01	2.83	2.92
Working age group	3.17	3.03	3.10
Male	1.81	1.74	1.77
Female	1.36	1.29	1.33
Dependent	3.32	3.22	3.25
Male	1.67	1.68	1.67
Female	1.65	1.54	1.60
% dependent	51.2	51.6	51.2

Source: Own survey (December 2007)

Education: Illiteracy is one of the features of the rural area. In the past, the education coverage in the study area was low and many farmers could not join schools. The education level of the sample respondents reflects this reality where some 52% had no formal education (Table 9.12). About 32% of the respondents attended primary education but the number of farmers who completed secondary education is low. Another 5% read and write by attending religious education and a further 5% attended adult literacy programs. During recent years, the education coverage in Ethiopia has been increasing and the proportion of educated farmers tends to increase over time.

Table 9.12 Proportion of sample respondents (201 adjacent, 203 non-adjacent) by education level (%)

Education level	Adjacent	Non-adjacent	Total
No formal education	47.3	57.9	52.5
Religious Education	5.8	4.1	5.0
Adult education	3.9	6.6	5.2
Primary education	36.7	27.4	32.2
Secondary school education	3.4	1.0	2.2
Certificate	2.9	3.0	3.0

[n = 201 adjacent; n =203 non-adjacent]

Religion: The Lake Tana basin is home for people with different faiths. Different religions co-exist in the area, Christian Orthodox being the dominant one in the study area. The islands in Lake Tana and on the Zeghe peninsula are homes for several historical churches attracting several thousand tourists every year. Followers of the Islamic faith often reside in the urban areas.

Land Use System

The regional Bureau of Agriculture and Rural Development categorizes land use systems of the region into Afro-montane, cultivated areas, pastureland, forests, water and wetlands, and others. Data on land use systems were also collected from the sample farmers and participants of the focus group discussions in all of the sample kebeles. The results conform with the regional information on the land use classification. Two types of information are useful to estimate the value of the land resources in the wetlands area: (1) the land allocation by size, and (2) the extent to which the system is widely adopted by the farm households.

Table 9.13 shows the farmers' estimate of land use and the proportion of farmers involved in this type of land use system. During the 2006/07 cropping season, the largest portion of the land in the sub-basin was used for crop production. Nearly 99% of the sample respondents had cropland.

Table 9.13 Proportion of land allocated to different uses and proportion of households involved (2007)

	Adjacent (%)		Non-adjacent (%)		Total (%)	
Land use type	Land	Households	Land	Households	Land	Households
Crop land	65.2	86.6	73.7	99.5	67.8	99.0
Grazing area	14.5	42.8	10.9	48.8	12.2	45.8
Forest and woodland	10.0	64.2	7.5	51.2	8.6	57.7
Marshy areas	12.0	23.9	8.0	1.5	11.3	12.6

Livestock production is an integral part of the farming system of the area. Livestock feed is provided from different sources. Pastureland is a major source of livestock feed. Pasture is provided from privately owned and communal grazing lands. The communal grazing area is less productive due to over grazing. Hence, about 45% of the sample respondents allocated a piece of private land for pasture production while 55% of the farmers did not dare to allocate mentionable land size for fodder production. On average, pasture occupies 12.2% of the total landholding. The reasons for not allocating private land for pasture production included land shortage, reliance on communal grazing land and few livestock holdings.

Land is also allocated to tree planting or part of the land belonging to a household is covered with forest or bushes. Natural forest has been degraded over the last several decades by cutting trees and expanding farm land, all in response to increased population pressure. Private woodlots are common in farm yards. Trees became economic goods and farmers have consciously invested in tree planting. Hence, some 64% of the farmers in the adjacent

kebeles and 51% in the non-adjacent kebeles own private trees, which occupy an average of 10% and 7.5% of the land respectively.

The size of land per household has declined over the last 10 years from 2.48 to 2.28 ha in the adjacent areas and from 2.71 to 2.34 ha in the non-adjacent areas (Table 9.14). The size of land allocated to crops, fodder production, private woodlots and private holding in the marshy areas has also declined over time due to increasing population pressure. Land was distributed by the government or by parents to the landless young farmers, resulting in small and fragmented farmland. On average, a household has 5 plots both in the adjacent and non-adjacent areas.

Table 9.14 Area of land under different use system (ha per household)

	Adjacent		Non-adjacent		Total	
Land use type	**1997**	**2007**	**1997**	**2007**	**1997**	**2007**
Crop land	1.60	1.46	1.96	1.73	1.78	1.59
Pasture area	0.32	0.32	0.34	0.26	0.33	0.29
Forest and woodland	0.23	0.22	0.20	0.18	0.21	0.20
Marshy area/wetland	0.34	0.27	0.22	0.19	0.33	0.26
Total	**2.48**	**2.28**	**2.71**	**2.34**	**2.66**	**2.35**

The respondents were asked how they accessed the land under their possession. About 84% of the sample respondents accessed farmland through inheritance of the parents while some 46% accessed land through government land redistribution (Table 9.15). Some 54% of the respondents participated in land transaction (share cropping, land renting and purchasing) to access land.

Table 9.15 Proportion of respondents by source of land owned (%)

	Location of the area		
Source of land	**Adjacent**	**Non-adjacent**	**Total**
Recent government land redistribution	27.9	23.6	25.7
Land redistribution during the 1974 land reform	18.9	21.2	20.0
Inherited from parents	83.6	84.2	83.9
Shared from parents/gift	4.0	3.9	4.0
Purchased	4.0	3.0	3.5
Rented	14.4	21.7	18.1
Share cropping	32.3	33.0	32.7
Total No. of cases	**201.0**	**203**	**404**

Traditionally land is the most important asset that is transferred to heirs. The Ethiopian farmers allocate land and give perennial crops and livestock as a gift to newly married sons, as a means of providing initial capital for the new household. Due to increased population pressure, which has resulted in reduced land size per household, the tradition of accessing land from parents has declined. Although the overall landholding size decreased over the last 10 years, about 31% of the households (29% in the adjacent and 33% in the non-adjacent areas) indicated that their land holding increased. The cultivated land size increased for some of the households due to land transactions through purchase or land rent (with a contract

period of 1 to 3 years). The poor households, especially female-headed ones, often rent out their land due to lack of oxen for traction power or working capital to use the land for production purposes.

(a) Annual crop production

The major source of livelihood for people in the Ethiopian highlands in general, and the Lake Tana sub-Basin and Abay Basin in particular is crop production. The largest part of the arable land is allocated to crop production. A diverse variety of crops are cultivated in the area with two types grown in the study area: annual crops and perennial crops. In order to understand the relative importance of the crops in the sub-basin, frequency distribution of the growers was computed as shown in Table 9.16. Maize was the dominant crop grown, by over 90% of the sample respondents, with millet and teff produced by more than 70% and 60% of the sample respondents. Rice is newly introduced in the Fogera plain, with about 38% of the sample respondents in the adjacent area producing it during 2006/07. The role of rice in the non-adjacent areas was small (8.9%), signifying the role of wetlands for other purposes.

Table 9.16 Proportion of households involved in the production of annual crops during 2006/07

Sr. No.	Types of crops produced	Adjacent	Non-adjacent	Total
1	Maize	87.1	96.1	91.6
2	Millet	58.2	89.7	74.0
3	Teff	57.7	70.4	64.1
4	Rice	37.8	8.9	23.3
5	Field pea	36.3	23.6	30.0
6	Chick peas	30.3	16.3	23.3
7	Niger seeds	22.4	36.5	29.5
8	Wheat	18.9	2.5	10.6
9	Barley	11.9	32.0	22.0
10	Sorghum	5.5	4.4	5.0
11	Horse bean	5.5	24.6	15.1
12	Oats	5.0	0.0	2.5
13	Sunflower	4.0	0.0	2.0
14	Lentils	2.5	1.0	1.7
15	White communes	2.5	3.9	3.2
16	Peas	0.5	3.0	1.7
17	Flax	0.5	3.4	2.0
18	Fenugreek	0.5	0.0	0.2
19	Linseed	0.0	2.5	1.2

The average size of land allocated to each crop, the average yield and production are shown in Table 9.17. Maize is one of the staple food grains produced by the majority of the farmers. On average, a household allocated about half a hectare of land for maize production. Maize productivity is high due to the use of chemical fertilizers and, compared to other crops, the availability of improved maize seeds. Teff productivity is low, but it is grown mainly for sale as it can command a high price at market. Teff is consumed by urban dwellers with high earnings and can afford to purchase it. Millet is produced both for consumption and sales.

The productivity of millet is moderate. Rice production is high (23.20 quintals[4]/ha) and attracts a good price on the market. It was noted during the study that the livelihood of rice producers has significantly improved following their engagement in rice production.

Table 9.17 Crop production and productivity

	Adjacent			Non-adjacent			Total		
Crop type	Area (ha)	Production (qt)	Yield (qt/ha)	Area (ha)	Production (qt)	Yield (qt/ha)	Area (ha)	Production (qt)	Yield (qt/ha)
Maize	0.53	12.28	24.57	0.53	13.97	25.85	0.53	13.18	25.25
Sorghum	0.44	3.32	7.98	0.50	6.61	15.52	0.47	4.80	11.37
Millet	0.54	5.97	11.85	0.58	8.44	15.69	0.56	7.52	14.25
Teff	0.39	2.40	5.92	0.45	2.62	6.73	0.42	2.52	6.37
Wheat	0.32	3.20	14.47	0.14	0.68	6.84	0.30	2.90	13.58
Barley	0.23	2.64	11.97	0.25	2.97	13.63	0.24	2.89	13.21
Oats	0.18	3.90	23.40	-	-	-	0.18	3.90	23.40
Rice	0.64	12.94	21.79	0.39	10.81	29.18	0.59	12.53	23.20
Horse bean	0.45	4.18	8.30	0.37	2.56	8.63	0.39	2.85	8.57
Peas	0.38	3.00	8.00	0.38	1.64	5.11	0.38	1.81	5.52
Chick peas	0.35	3.67	12.01	0.42	4.45	10.97	0.38	3.94	11.65
Lentils	0.23	2.08	13.00	0.38	2.00	4.00	0.27	2.07	11.50
Field pea	0.39	3.35	9.59	0.44	4.66	10.78	0.41	3.87	10.06
Flax	0.25	1.00	4.00	0.14	0.66	7.12	0.16	0.70	6.60
Niger seeds	0.35	1.08	3.62	0.34	1.26	4.64	0.34	1.20	4.28
Sunflower	0.22	1.97	15.15				0.22	1.97	15.15
Linseed				0.11	0.48	7.12	0.11	0.48	7.12
White communes	0.35	2.55	7.30	0.41	3.91	10.58	0.38	3.39	9.32
Fenugreek	0.25	1.50	6.00				0.25	1.50	6.00

The agricultural extension system implemented by the regional Bureau of Agriculture and Rural Development has had a huge impact on the use of yield-increasing inputs such as fertilizer and improved seeds. For example, with regard to maize, the use of improved seeds together with chemical fertilizers has resulted in an average yield of 25qt/ha. During the focus group discussions, the participants indicated that without the use of fertilizers, crop production is becoming impossible due to high soil degradation.

The survey results show that about 69% of the sample respondents use urea and di-ammonium phosphate (DAP) for maize production. The number of users is relatively higher in the non-adjacent areas (86%) compared to the adjacent area (50%).

The intensity of use of fertilizer in the non-adjacent areas is lower than the recommended rate of 200 kg per ha (Table 9.18). The rate of fertilizer use is slightly higher in the adjacent area with over 55% of the farmers in the adjacent area, compared to 77% of those in the non-adjacent areas, using less than the recommended rate of 200 qt/ha of fertilizer. The use of chemical herbicides and pesticides has external impacts with regard to environmental

[4] 1 quintal (qt) = 100kg

pollution, for example in terms of ground and surface water quality and the effect on human and animal health. The study shows, however, that chemical application in crop production is low (about 3% of all respondents) and, with an appropriate management system in effect, the magnitude of the externality could be quite low.

Table 9.18 Input use intensity during 2006/07 production year

	Adjacent			Non-adjacent		
Input type	Maize	Millet	Teff	Maize	Millet	Teff
Fertilizer (kg/ha)	218	119	163	176	112	118
Improved seeds (kg/ha)	30	0	20	20	0	58
Local seed (kg/ha)	28	39	58	17	36	56
Pesticide (Birr/ha)	45	102	138	50	71	65
Herbicide (Birr/ha)		91	123	49	78	77

Chemicals are applied by farmers to reduce yield losses caused by pests and diseases. Millet and teff require intensive labor for weeding and farmers therefore opt to apply herbicides in addition to manual weeding. Yield reduction can also occur due to wild animals, hail, pests and diseases and rainfall shortage (Table 9.19).

Table 9.19 Factors of crop yield loss (% of respondents)

Reason	**Frequency**	**Percent**
Hail	90	38.7
Pests and diseases	34	14.6
Erosion (flood)	31	13.3
Wild animals	70	30.0
Shortage of rainfall	8	3.4
Total	**233**	**100.00**

Crop damage by wild animals is a serious problem in areas where the forest cover is high. In Zeghe area, for instance, the damage caused by monkeys is threatening the livelihood of the people. The farmers complain that monkeys consume everything on the farm including fruits, annual crops, coffee beans, root crops, etc. The damage caused by wild animals ranges from 6-100%. The survey result also shows that 3-24% pre-harvest losses occur due to different agents (Table 9.20).

Table 9.20 Yield losses due to crop damage

Crop type	Adjacent area				Non-Adjacent				
	Loss by wild animals (qt)	Loss by Other causes (qt)	Total loss (qt)	Percent loss (%)	Loss by wild animals (qt)	Loss by Other causes (qt)	Total loss (qt)	Percent loss (%)	Loss by wild animals (qt)
Maize	0.55	1.27	1.82	11.56	0.42	0.16	0.58	4.91	0.48
Sorghum	0.45	0.82	1.27	18.34					0.25
Millet	0.12	1.16	1.28	12.51	0.37	2.03	2.40	1.76	0.49
Teff	0.28	0.55	0.83	22.54	0.14	0.21	0.34	7.41	0.20
Wheat	0.30	0.25	0.55	15.84	0.00	0.20	0.20	16.00	0.27
Barley	0.02	0.33	0.35	7.39	0.02	0.18	0.20	1.74	0.02
Rice	0.70	2.58	3.28	15.81					0.56
Horse bean	0.09	0.00	0.09	1.82	0.16	0.18	0.34	10.80	0.15
Pea					0.00	0.29	0.29	7.14	0.00
Chickpea					0.41	0.30	0.72	15.32	0.38
Niger seeds	0.30	0.17	0.47	17.11	0.17	0.06	0.24	12.33	0.22
Lentils	0.00	0.67	0.67	13.33					0.25
Field pea	0.47	0.42	0.88	12.62	0.52	0.43	0.95	14.27	0.49
Sunflower	1.00	0.22	1.22	24.69					1.00
White commune	0.00	1.40	1.40	29.60					0.00
Oats	0.55	0.00	0.55	8.33					0.55

(b) Perennial crops

Perennial crops have a dual purpose: (i) the production of fruits that can be consumed by the household or sold to generate income; and (ii) ecological values since they help in maintaining the soil fertility, erosion control and serve as shade trees. Sixty nine percent of the sample respondents own perennial crops mainly for income generation and home consumption. As shown in Table 9.21, coffee, khat, hops and fruit trees are the most commonly grown perennial crops. Most of the fruit trees have been introduced by the agricultural extension system and NGOs in order to diversify livelihood means of the rural people. Khat production is rapidly expanding even without the support of the extension system due to the lucrative market price. The emerging khat expansion has been simulated on the khat system in the eastern part of Oromia National Regional State of Ethiopia, which contributes significantly to household income, export income and serves as a biological soil and water conservation technique.

Table 9.21 Proportion of respondents involved in perennial crops production

Type of perennial trees	**Location of the area**		**Total**
	Adjacent	**Non-adjacent**	
Coffee	40	22	31
Khat	32	39	36
Orange	10	6	8
Mandarin	6	0	3
Mango	37	33	35
Banana	9	9	9

Lemon	30	22	26
Avocado	26	19	22
Papaya	15	34	25
Hops	34	55	45
Guava	3	6	5
Sugar cane	2	0	1
Peach	1	0	1
No. of cases	**201**	**203**	**404**

On average, a household in the study area has more than 1,000 trees of perennial crops, where the ownership size is higher in the areas adjacent to the lake. The overall average annual income from the perennial crop production is Birr 1,452 while this proportion is higher in the areas adjacent to the lake (Table 9.22). It is important to note that the potential for perennial crop production lies in the wetlands where tree cover and water resources are available for irrigation.

Table 9.22 No. of trees and income from perennial crops per HH

Details	Adjacent	Non-adjacent	Total
No. of trees/bushes of perennial plants owned	1,657	608	1,240
Average income from perennial crops (Birr)	1,773	1,189	1,452
Average value of perennial crops lost due to wildlife (Birr)	467	50	456
% of HH owning perennial crops	62	75	69

(c) Pastureland

Livestock production is an integral part of the farming system in the study area. Livestock feed is a crucial factor affecting livestock production and is supplied from green pasture, dried hay, tree leaves, crop residues and by-products, as well as supplementary feed from industrial products, although this is rarely available in the rural areas. The wetlands serve as the major source of livestock feed during both the dry and rainy seasons. In the rural areas, farmers depend on pasture production from communal grazing land and private feedlots. The farmers have less control over the communal grazing area while they have full control over private pastureland. As shown in Table 9.23, 91% of the households use the communal grazing area. The sample respondents were asked to estimate the share of the communal pasture area that they use: the results show that 0.25 ha of communal pasture area is used per household for grazing. The major reasons given by the 9% of respondents who do not use communal grazing land included the lack of communal land, lack of labor for herding or some restrictions on the use of the land.

Table 9.23 Pastureland and average holding size

Type of pasture land	Adjacent	Non-adjacent	Total
Average private grazing area per HH (ha)	0.32	0.26	0.29
Proportion HH having private pasture area	43%	49%	46%
Average communal pasture area per HH (ha)	0.30	0.25	0.25
Proportion of HH having communal pasture area	85%	96%	91%

The survey result shows that only 46% of the sample households have private pasture land of 0.29ha. In order to overcome potential feed shortages, farmers practice different strategies. For example, it is a common practice in the study area to purchase fodder for livestock feed. Also, the farmers opt to rent degraded land for grazing purposes. In some cases, the farmers grow grasses on a small plot of land and sell the grass. It is in this manner that the urban dairy producers get access to hay. Generally, degraded land is allocated to grass production or planting eucalyptus trees for income generation.

(d) Irrigation

There is a huge irrigation potential in Ethiopia, although the extent of irrigable land in Ethiopia is not precisely known as the literature gives different figures for the country. For instance, WAPCOS (1990) estimates the potential irrigable land in the 12 major river basins of the country at 2.9 million ha, while the latest estimate by Tilahun and Paulos (2004) is 4.3 million ha (Table 9.24). Adugna (2003) also estimated the area under traditional irrigation and modern small scale irrigation at 140,000 and 47,000 ha, respectively.

Table 9.24 Existing irrigation schemes by region

Sr. No.	Region	Irrigable potential (ha)	Current irrigation activities				
			Traditional area (ha)	Modern irrigation (ha)		Total irrigated (ha)	% of potential
				Small	Medium and large		
1	Oromia	1,350,000	56,807	17,690	31,981	106,478	7.9
2	Amhara	500,000	64,035	5,752	-	69,787	14.0
3	SNNPR	700,000	2,000	11,577	6,076	19,653	2.8
4	Tigray	300,000	2,607	10,000	-	12,607	4.2
5	Afar	163,554	2,440	-	21,000	23,440	14.3
6	Benishangul Gumz	121,177	400	200	-	600	0.5
7	Gambella	600,000	46	70	-	116	0.0
8	Somali	500,000	8,200	1,800	2,000	12,000	2.4
9	Harari	19,200	812	125	-	937	4.9
10	Dire Dawa	2,000	640	860	-	1,500	75.0
11	Addis Ababa	526	352	-	-	352	66.9
	Total	**4,256,457**	**138,339**	**48,074**	**61,057**	**247,470**	**5.8**

Source: Tilahun and Paulos (2004).

It is clear that the existing irrigation potential is not adequately utilized. Existing data reveal that only 5.8% of the irrigation potential of the water resources of the country has been utilized; about 55% of the irrigated area is traditional irrigation The proportion of potential irrigation use in the Amhara region, in which the Abay basin in general and Lake Tana sub-basin in particular are located, is 14%.

In the Lake Tana sub-basin, the people recognize and value the benefits of the wetlands (lake, rivers and marshes) in the area. The irrigation potential of the Lake Tana sub-basin is about 3,300 ha, which is 75% of the irrigation potential in the three zones surrounding Lake Tana (Table 9.25), excluding the traditional irrigation practiced by smallholder farmers. The irrigation area will surely increase as the huge plan to develop irrigation schemes in the area is fully implemented.

Table 9.25 Irrigation potential in the Lake Tana sub-basin

Zone	Modern small scale irrigation (ha)
West Gojam	1,724
North Gonder	1,036
South Gonder	558
Total for the three zones	3,318
Total for Tana Sub-basin	2,500
Total for Amhara region	17,862
Share of Tana sub-basin:	
in the three zones	75%
in Amhara region	14%

Source: Computed based on data from Water Resources Bureau of Amhara National Regional State

The survey result shows that 72% of the respondents indicated at least one benefit of the water resources in their area. About 54% of the respondents in the adjacent area use water available in the area for crop production, in the form of irrigation proper or use of moisture deposit after the flood retreats. Fishing, water supply for human beings and animals are among the benefits provided by the water resources (Table 9.26).

Table 9.26 No. of respondents benefiting from Lake Tana and its feeder rivers

	Adjacent		Non-adjacent		Total	
Benefits	No	%	No	%	No	%
Irrigation	94	53.7	44	25.1	138	47.3
Fishing	33	18.9	6	3.4	39	13.4
Water supply for human and animals	48	27.4	67	38.3	115	39.4
Total	175	87.1	117	57.6	292	72.3

In a situation where the climatic risk affects crop production, irrigation helps farmers to mitigate the risk of crop failure and increases yield. About 18% of the farmers in the adjacent area use Lake Tana for irrigation. Most of the farmers in the adjacent and non-adjacent areas

use river water for irrigation. The use of other water sources such as water harvesting is minimal (Figure 9.2).

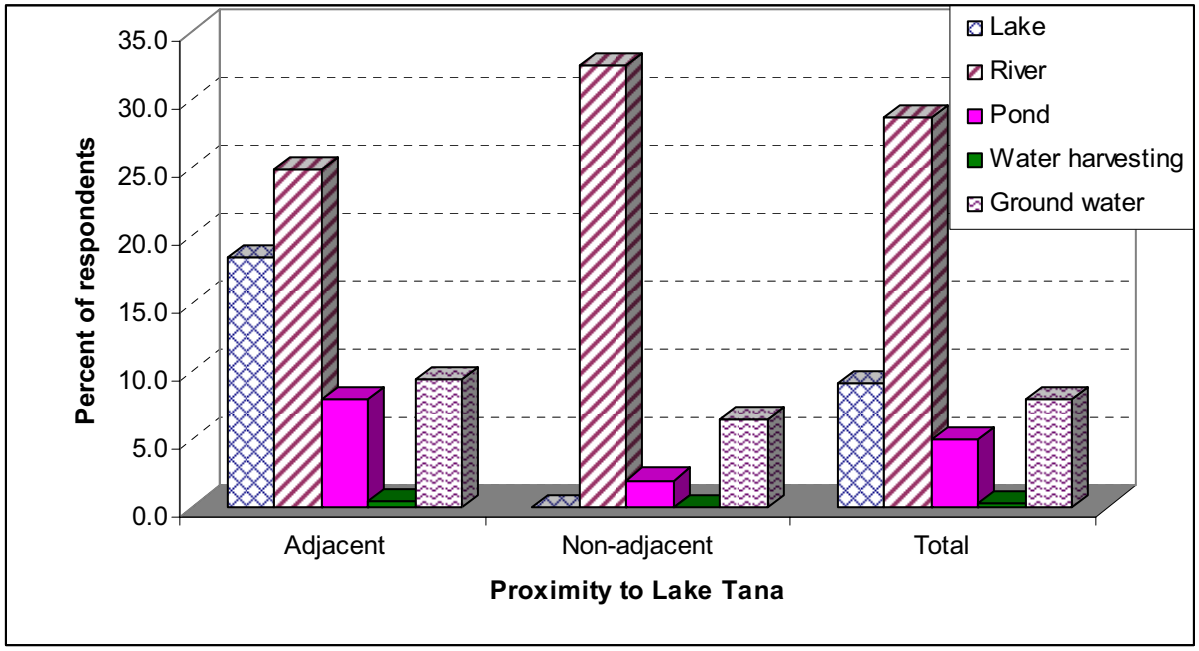

Figure 9.2 Proportion of respondents by irrigation use (%)

The survey results show that the number of irrigation users increased over the last 10 years although the irrigable land size is getting smaller (Table 9.27). In general, the benefit of using wetlands resources to increase welfare is increasing. The Government has planned to invest in irrigation to overcome the food security problem in the country. Development of Tana Beles project and other large scale irrigation projects in the area are part and parcel of this strategy.

Table 9.27 Size of irrigable land and proportion of households owning it

	Irrigated area (ha)		% of households	
Location	**1997**	**2007**	**1997**	**2007**
Adjacent	0.53	0.47	24.38	34.83
Non-adjacent	0.62	0.42	14.29	25.62
Total	0.56	0.45	19.31	30.20

e) Livestock

Livestock production benefits from the wetlands resources. Water supply and fodder supply are essential factors for livestock production. Livestock is an integral part of the mixed farming system. Crop and livestock production complement each other through input supply systems. Crop residues are important sources of livestock feed while livestock provide draught power for cultivation, transportation and manure for improved soil fertility. In the study area, the number of households owing livestock and the average number of livestock owned increased during the last ten years (Tables 9.28 and 9.29). Oxen are the most

commonly owned livestock due to their traction service. On average, the sample household owns a pair of oxen.

Table 9.28 Comparison of the proportion of respondents who owned livestock 10 years ago and in 2007

Type of livestock	Adjacent		Non-adjacent		Total	
	1997	2007	1997	2007	1997	2007
Oxen	71	80	84	70	77	85
Cows	62	67	79	77	71	72
Heifers and bulls	52	71	65	80	58	76
Sheep	11	27	12	29	12	28
Goat	7	10	23	26	15	18
Donkey	31	38	44	47	38	43
Horse	0	0	0	0	0	0
Mule	1	4	2	4	2	4
Camel	0	0	0	0	0	0
Poultry	65	85	68	90	67	87

Livestock is also a supply of animal protein for households. In the rural areas of Ethiopia in general and the study area in particular, households produce and consume milk, butter, meat and eggs. Animals and animal products (mostly butter and eggs) are sold to generate income. The tradition of selling milk in the rural area is remote. Livestock also provide a means of savings for rural households as there is no access to financial institutions that can provide saving facilities. Farmers invest in livestock when they earn a relatively good income and sell them when there is a food gap or need for cash to meet household, social or tax obligations. Hence, rearing livestock serves as a risk mitigation strategy for households. The notion of using livestock as 'savings' can result in increased pressure on the limited natural resources and lead to further land degradation.

Table 9.29 Comparison of the average type of livestock owned in 1997 and 2007

Type of livestock	Adjacent		Non-adjacent		Total	
	1997	2007	1997	2007	1997	2007
Oxen	2.18	2.24	2.59	2.41	2.41	2.33
Cows	3.07	2.21	3.06	2.15	3.06	2.18
Heifers and young bulls	3.22	2.61	3.39	2.63	3.31	2.62
Sheep	5.09	3.67	3.79	3.75	4.43	3.71
Goat	5.07	4.75	5.79	3.88	5.62	4.13
Donkey	1.13	1.48	1.21	1.48	1.18	1.40
Horse	0.00	1.00	1.00	1.00	1.00	1.00
Mule	1.00	1.00	1.00	1.00	1.00	1.00
Camel		1.00		1.00		1.00
Poultry	7.05	5.69	5.92	4.99	6.47	5.33
Average TLU	**2.30**	**2.47**	**2.81**	**2.77**	**2.56**	**2.61**

(f) Fishery

As discussed earlier, wetlands are located all around the Lake Tana, with the exception of the northeast region. The plains consist of permanent and seasonal swamps. The wetlands are connected with the lake and act as nurseries for most of the fish populations in the lake, and serve as breeding grounds for water fowl and mammals. About 8 of the 15 *Labeobarbus* species and three other commercially important fish species, Nile tilapia (*Oreochromis niloticus*), African catfish (*Clarias gariepinus*) and Beso (*Varicorhinus beso*) spawn in the wetlands and their juveniles feed and grow there during the first years of their life (Eshete 2008).

Lake Tana is one of the major fish supply sources in Ethiopia. Fishing is carried out all around lake shore. The Zeghe Fishers' Cooperative listed the following major fishing ports by different fisher groups all around the lake: Bahir Dar, Robit, Karata, Gugube, Gumara, Gangut, Sandaye, Nabega, Ingor, Eribi, Saben, Lange, Kirign, Gebeta Mewucha, Metiria, Dambia, Gorgora, Cawduba, Dalge, Saidaber, Dengel Ber, Kunzila, Abay Dar, Ijomi, Sakalat, Zeghe, Atangessa, Debelewa, Lumami, Salchan, and Woramit.

The lake is arbitrarily delineated into localities and spawning is mostly localized, which in a way limits the exploitation of the public goods in the lake to the localities. People from Bahir Dar area, for instance, cannot fish in Fogera area, and attempts to do so result in conflict. As reported by all fisher groups, there is fierce competition for fishing sites. Some members of the Zeghe Fish-for-All Association estimate that the number of people involved in fishing along the lake circumference is between 5,000 to 10,000. The large number of fishermen signifies the intensity of fishing around Lake Tana.

Commercial fishing is undertaken by cooperatives and private fishermen. Four groups of fishers were identified: The Bahir Dar Cooperative #1, the Kidus Giorgis Fishers' Association, Bahata Fishers' Group and unaffiliated private fishermen. Many of the other fishers' groups around Lake Tana sell to the organized fish marketing associations/cooperatives or to the Fish Production & Marketing Enterprise (FMPE). For instance, the Zeghe Fishers' Cooperative, with 38 members (8 of them female), harvested 20,376 kg of fish during 2007 alone, which they sold to Kidus Giorgis Fishers' Association.

The Bahir Dar Cooperative #1 was established in December 1994 and has a total of 150 members of which 16 are female. The members live in two districts of West Gojam zone (Bahir Dar Zuria and Achefer) and three districts of South Gonder Zone (Libo Komkom, Dera and Fogera). The cooperative has 36 fishing boats. The members are grouped into 18 teams and the cooperative provides them with two boats. Some members have their own private boats for fishing. The cooperative not only fishes, but also purchases fish from members and non-members. During the last three years, Bahir Dar Cooperative #1 collected and sold 305,400 kg, 400,900 kg and 681,400 kg of fish, and earned Birr 1,593,580, 1,363,360 and 2,651,800 during the respective years (Table 9.30).

Table 9.30 Amount of fish harvested by Bahir Dar #1 Coop. and Georgis (kg)

Year	Barbus	Tilapia	Catfish	Quantity (kg)	Annual increase (%)
2005	60,900	187,000	57,500	305,400	-
2006	116,950	344,800	176,400	638,150	109

2007	161,950	634,700	268,000	1,064,650	67

Source: Bahir Dar Cooperative # 1 Office (2007)

The Georgis Fishers' Association conducts fishing and collects fish from its members and organized and individual fishers. During 2006 and 2007, Kidus Georgis Fishers' Association collected 237,250 and 383,250 kg of fish and earned Birr 720,875 and 1,314,000 during the respective years (Figure 9.3). This shows that fish supply is increasing over time and the income from the fishery sector is increasing at a higher rate. Bahir Dar #1 Cooperative and Kidus Georgis Fishers' Association sell fish to the Ethiopian Fish Marketing Enterprise and consumers.

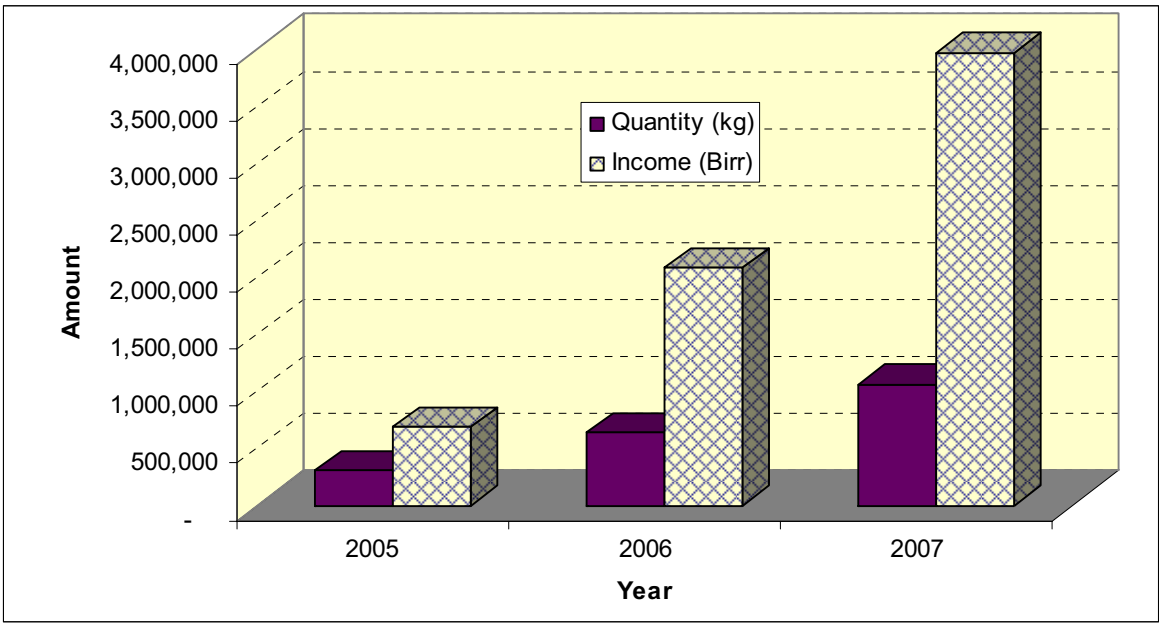

Figure 9.2 Quantity of fish sold and income of Bahir Dar #1 Cooperative and Georgis Fishers' Association

Another large fish supplier is the Bahata Fishers' Group, a semi-recognized fishers' cooperative, which, although not registered collects a large number of fish from Lake Tana. It has 270 members who collect fish intensively from the lake. Compared to the two associations (Bahir Dar #1 and Giorgis), this group uses traditional fishing techniques, collects fish of nearly all sizes and fishes irrespective of the breeding season. The group members estimated the supply at 3 million fish, worth about Birr 2.6 million in 2007. Although data was provided only for the survey year, the group assumes a similar harvest level every year. Bahata group is said to have the largest share in Bahir Dar town's fishery market. It supplies fish to most of the hotels in Bahir Dar as well as selling it to the private consumers. While the males concentrate on day-to-day fishing activities, the women are responsible for processing and selling.

The fourth group of commercial fishers comprises individuals who collect fish and sell them to the associations, cooperatives and consumers. The survey results show that about 7% of

the sample respondents in the adjacent area harvested fish for sales during 2007. This means that there are at least 4,061 people who practice fishing for commercial purposes. At an average fishing rate of 282 fishes per year per private fisherman, the estimated total value of fish collected by private fishermen was about Birr 1,145,136.

The survey also shows that some 10% of the sample respondents in the adjacent area and 1% in the non-adjacent areas practice fishing for home consumption. Accordingly, an estimated 5,800 people are involved in occasional fishing for home consumption (Table 9.31).

Table 9.31 Proportion of households fishing for different purposes (%) and average No. of fishes harvested

Purpose of fishing:	Adjacent	Non-adjacent	Total
For consumption	10	1	9
For sales	7	0	1.7
Average no. of fish per fisherman per year:			
For consumption	120	60	156
For sales	282	0	200
Average price of a fish (Birr)			1.00

The fish market chain involves the fishermen, assemblers or collectors, the associations or cooperatives, the Fish Production & Marketing Enterprise and the consumers. This chain increases the price of fish at different markets. Fish from Lake Tana is sold at different zonal markets in Amhara, Addis Ababa and exported to the Sudan. The data collected from fishing cooperatives show that the price of fish has been increasing during the last three years due to increased demand. *Tilapia* is in high demand and sold at higher prices (Figure 9.4).

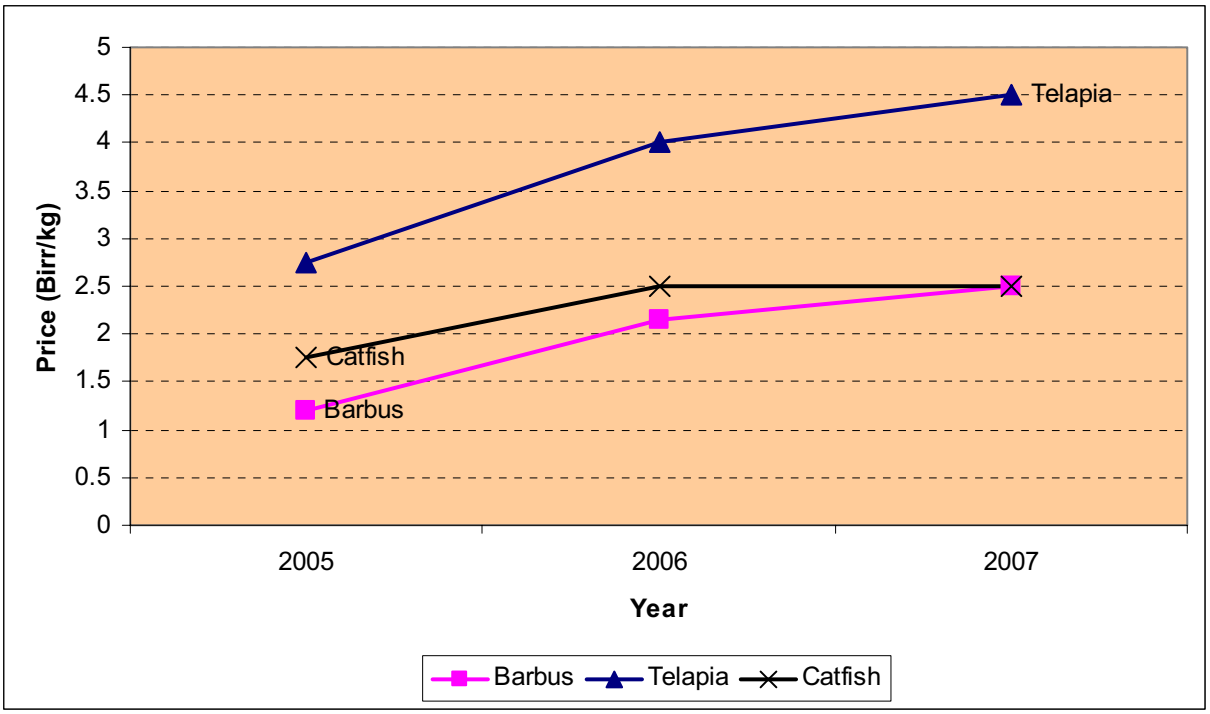

Figure 9.4 Trend of fish price in Bahir Dar

Source: Bahir Dar # 1 Cooperative

Bahata Fishers' Group harvests a large number of fish including small ones and sells at a low price. The average price per fish was Birr 1 for *Tilapia* and *Barbus* while catfish is sold for Birr 0.25 per piece. Catfish is not consumed by many of the rural people due to traditional barrier. Fish is an important source of nutrition especially for people living near the lake. The survey result shows that 60% of the sample respondents eat fish while the proportion declines as the proximity to the lake declines. The proportion of people consuming hunted wildlife is very low (Table 9.32).

Table 9.32 Proportion of respondents consuming meat of different sources (%)

Sources of meat	Adjacent	Non-adjacent	Total
Own livestock	54.7	68.5	61.6
Meat/mutton purchased	87.6	90.1	88.9
Fish	60.2	28.6	44.3
Wild animals including birds (hunted)	0.5	1.0	0.7

Due to the increasing demand for fish and the people's interest to generate income from the sector, there is high pressure on the fish population in Lake Tana. The survey result shows that about 37% of the sample respondents in the adjacent area felt that the fish population is declining while 46% could not judge the trend (Figure 9.5). About 15% of the respondents felt that the population has been increasing. From the focus group discussions on the trend of the fish population it was understood that lack of rules and regulations regarding fishery, lack of skill by many fishermen, lack of accountability in respecting fish breeding seasons and no standardization of fishing equipments have contributed to a declining trend.

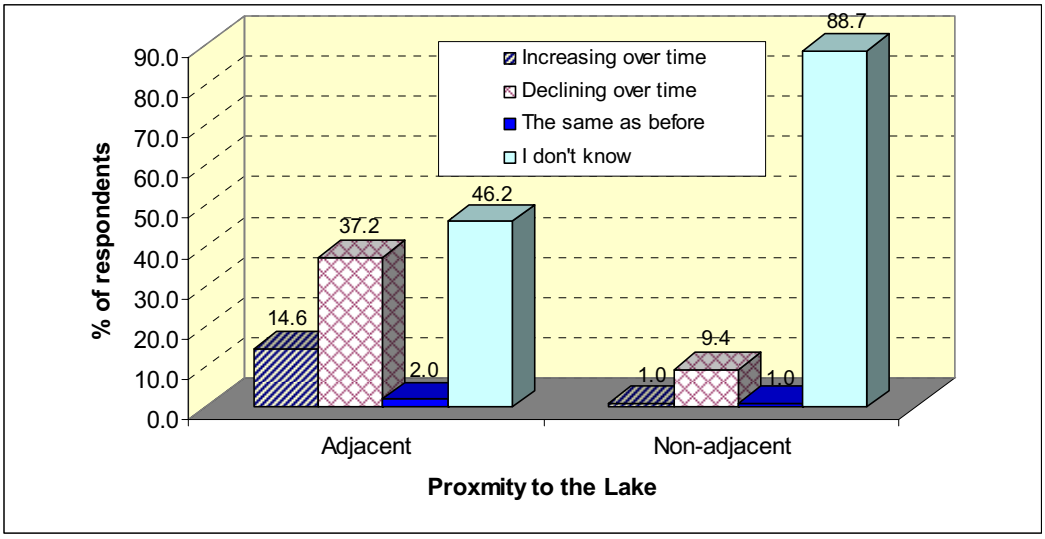

Figure 9.5 Proportion of respondents evaluating the trends of fish populations in Lake Tana (%)

(g) Forest products

Forest trees have multiple economic uses: for construction, fuel wood, income generation and nectar for honey production. Trees also have ecological and social values. Trees are available on private plots and communal forests. The farm households planted trees in their backyards and borders of their plots as well as in marginal areas. In Zeghe, coffee production is commonly practiced in the dense forest there. The farmers claim that the trees were planted by their grandfathers as shade for coffee plants. This contradicts the local government's view that the Zeghe forest is communal, a public good. The eucalyptus tree is the most commonly owned tree in the area with some 88% of the households owning this tree. *Cordia africana, Ficus vasta,* and *Croton macrostachyus* are also common trees in the area. Table 9.33 shows the list of economically important trees in the Lake Tana sub-basin reported by the respondents.

Table 9.33 Proportion of respondents by type of trees they own (%)

Type of tree	Adjacent	Non-adjacent	Total
Eucalyptus	90	87	88
Cordia Africana	66	85	75
Ficus vasta	34	53	44
Croton macrostachyus	28	64	46
Albizia schimperiana	14	7	11
Millettia ferruginea	14	1	8
Ehretia cymosa	11	2	7
Acacia spp.	8	32	20
Syzygium guineense	7	7	7
Olea europaea	5	9	7

Ficus sur	5	2	4
Sesbania sesban	5	4	5
Sapium ellipticum	4	3	4
Podocarpus falcatus	3	2	2
Juniperus excelsa	2	2	2
Mimuspos kummel	2	3	2
Vernonia amygdalina	2	4	3
Others*	5	5	5

* Other trees include: *Azadirachta indica, Erythrina abyssinica, Calpurna aurea, Bersama abyssinica, Gardenia lutea, Ficus vallis-choudae, Capparis tomentosa, Carissa spinarum, Pouteria adolfi-friederici*

Most of the farmers (97%) have at least one type of tree. The average tree holding size in 2007 was 1,633 trees of which some 177 trees were harvested for different purposes. The total value of trees used or sold per household was Birr 1,850, of which 35% constituted income from tree sales and 65% represented value of home-used trees at the prevailing market price. Farmers identify economic, ecological and social values of trees (Table 9.34).

Table 9.34 Private tree ownership and value of trees harvested during 2007

Particulars	Adjacent	Non-adjacent	Average
No. of trees owned	1,820	1,450	1,633
Total number of trees (used or sold)	170	184	177
Value of trees sold or used	1,511	2,184	1,850
Sales income (Birr)	574	677	648
Households involved	97%	98%	97%
Share of cash in the total value of trees	38%	31%	35%
Price (Birr per tree)	8.91	11.86	10.46

The responses of the farmers show that economic benefits of trees dominate the environmental and cultural values of trees. The price of a tree is a function of species, size, age and purpose for which the tree can be used. Hence there is high variation in the prices of trees, which rang from Birr 2 to 350, though high values are paid for a tree that can be used for timber or furniture. Eucalyptus is the most commonly sold tree, which can be harvested every 3-4 years and attracts Birr 3-20 per tree.

Table 9.36 Proportion of respondents by the purpose of trees planted

Type of tree	Construction	For sale	Firewood	Conservation	Prestige	Tree shade	Fodder
Eucalyptus	84.4	64.6	71.0	0.2	0.0	0.0	0.0
Ficus tree	16.6	6.7	32.9	2.5	0.5	4.0	0.7
Wanza (*Cordia africana)*	50.7	29.5	39.9	1.2	0.0	4.0	0.7
Bisana (*Croton macrostachyus)*	20.3	2.7	38.1	1.2	0.0	2.0	1.0
Acacia	13.6	3.7	11.6	0.7	0.0	0.7	0.0

Olive	4.2	2.2	4.7	0.0	0.0	0.2	0.0
Sasa (*Albizza schimperiana)*	5.2	1.7	7.2	0.7	0.0	3.2	0.0
Birbira (*Millettia ferruginea)*	3.5	1.5	4.5	0.2	0.2	2.2	0.2
Dokima (*Syzygium guineense)*	3.0	0.5	3.7	0.7	0.2	1.7	0.2

Source: Own survey (December, 2007)

Trees are also harvested from communal forests. On average, the sample respondents cut 47 trees from communal forests for home use and sales in 2007, with an average value of Birr 951 (Table 9.37). Only 6% of the households reported that they cut and sell trees from the communal forest. It is important to note that the forest tree is sold at higher prices due to its large size, which can produce a large body mass of wood.

Firewood is sold to the urban population and provides income for the rural poor. This sector provides a coping strategy for the people who face food shortage. The Zeghe forest is a major firewood supplier to Bahir Dar town. It was estimated that firewood with a value equivalent to Birr 633,600 was transported to Bahir Dar from Zeghe in 2007. The value chain comprises the tree owners, assemblers/traders, boat owners who transport wood across the lake, brokers/carriers and consumers. Each actor in the market chain earns income from the wood market in Bahir Dar. The rate at which trees are cut and used for energy production in Bahir Dar poses a great challenge on the tree population unless mechanisms for sustainable use are designed and implemented.

Table 9.37 Average number of trees cut and income from communal forest in 2007

Particulars	Adjacent	Non-adjacent	Total Mean
Number of trees cut	55	39	47
Number of trees sold	30	20	25
Number of trees used for construction or firewood	25	19	22
Amount of income earned from selling of trees (Birr)	500	452	476
Households involved in harvesting communal forest	5%	8%	6%
Price (Birr per tree)	19.7	23.8	21.5
Value of trees collected from communal forest	1000	903	951

Source: Own survey (December, 2007)

h) Wildlife

Different wildlife in the Lake Tana sub-basin plays different roles in the rural economy. Birds, reptiles, amphibians and mammals are important tourist attractions. There are about 217 bird species in the Lake Tana sub-basin (Birdlife International 2007). Some birds are also hunted for consumption, the most commonly-hunted being the Helmeted Guineafowl (*Numida meleagris)* and the Crested Francolin (*Francolinus sephaena)*. The survey result shows that about 0.7% of the sample respondents hunted these birds during 2007 and, on average, a household hunted 2 Helmeted Guineafowl and 3 Crested Francolin in 2007. The

aggregate figure shows that some seven thousand birds were hunted in 2007 in the sub-basin. Porcupines (*Hystrix cristata*) are also hunted for consumption, though they are rarely found.

Household Income

(i) Income analysis

The sample respondents were asked about the sources of their income and the relative importance of the different income sources. Households generate their livelihood from an array of activities. Obviously, crop and livestock production are the major sources of livelihood for the rural community. Nearly all of the sample respondents earned income from crop production while about 98% of the respondents in the non-adjacent and 85% of those in the adjacent areas earned their livings from livestock production during 2007. About 28% of the households generated part of the income needed for their households from sales of firewood and charcoal. From an environmental point of view, dependence on income generation from forest products could indicate forest degradation. Fishing and petty trading are also important sources of income for about 15% of the sample respondents in the adjacent area (Table 9.38).

Table 9.38 Proportion of HH by source of income (%), N=404

Source of household income	Rank of income source					Total	Proximity to Lake Tana	
	1st	2nd	3rd	4th	5th		Adjacent	Non-adjacent
Crop production	97.3	1.7	0.0	0.0	0.0	99.0	98.0	100.0
Livestock production	0.0	80.9	8.4	1.7	0.5	91.6	85.6	98.5
Handicrafts	0.0	1.5	4.0	0.0	0.5	5.9	4.5	7.4
Grain trading	0.0	0.5	3.0	0.5	0.2	4.2	7.0	1.5
Livestock trading	0.0	1.5	7.2	2.2	0.0	10.9	10.0	11.8
Fishing	0.5	1.7	3.2	2.0	0.7	8.2	15.4	1.5
Selling forest product (firewood, etc)	0.0	5.7	18.1	3.5	1.0	28.2	29.4	27.6
Employment (wage/salary)	0.5	1.0	4.2	0.5	0.2	6.4	6.5	6.4
Remittance	0.0	0.2	0.0	0.0	0.0	0.2	0.0	0.5
Honey production	0.0	0.5	3.2	1.7	0.2	5.7	5.5	5.9
Petty trading	1.2	3.7	3.0	2.5	1.2	11.6	14.4	8.9
Traditional medicine/healer	0.0	0.0	0.2	0.0	0.0	0.2	0.5	0.0

Source: Own survey (December, 2007)

Household income was computed by valuing crop production at market prices together with the income of the households during the 2006/07 as indicated by the respondents. The average household income was Birr 8,915, with no significant difference between the adjacent and non-adjacent areas (Table 9.39).

Table 9.39 Mean household income (Birr)

Source of income	Adjacent	Non-adjacent	Total
Annual crops	5,452	6,056	5,765
Perennial crop	1,773	1,199	1,481

Total crops	6,136	6,723	6,432
Cash income from trees	778	1,000	890
Livestock	1,082	1,220	1,153
Non-farm activities	1,658	1,340	1,508
Value of fish	1,750	-	1,250
Total disposable income	8,978	8,852	8,915
Disposable per capita income (Birr/AE)	2,742	2,531	2,636

Source: Own survey (December, 2007)

Crop production accounted for 60% of the household income followed by livestock income, which contributed about 13%, excluding the values of traction service, which is a major reason for rearing bulls and oxen. Fishery and other non-farm activities contributed about 10% of the household income each while sales of trees and firewood accounted for 7% of the household income (Figure 9.5).

The farmers were asked if there had been any change in their income over the past ten years. The result shows that the income from some activities increased for some of the households while it decreased for others. The overall direction of change was an increase for most of the households. It appears that income from livestock production declined for a significant number of households and more than 60% of the respondents felt that the income from fishing declined (Figure 9.6).

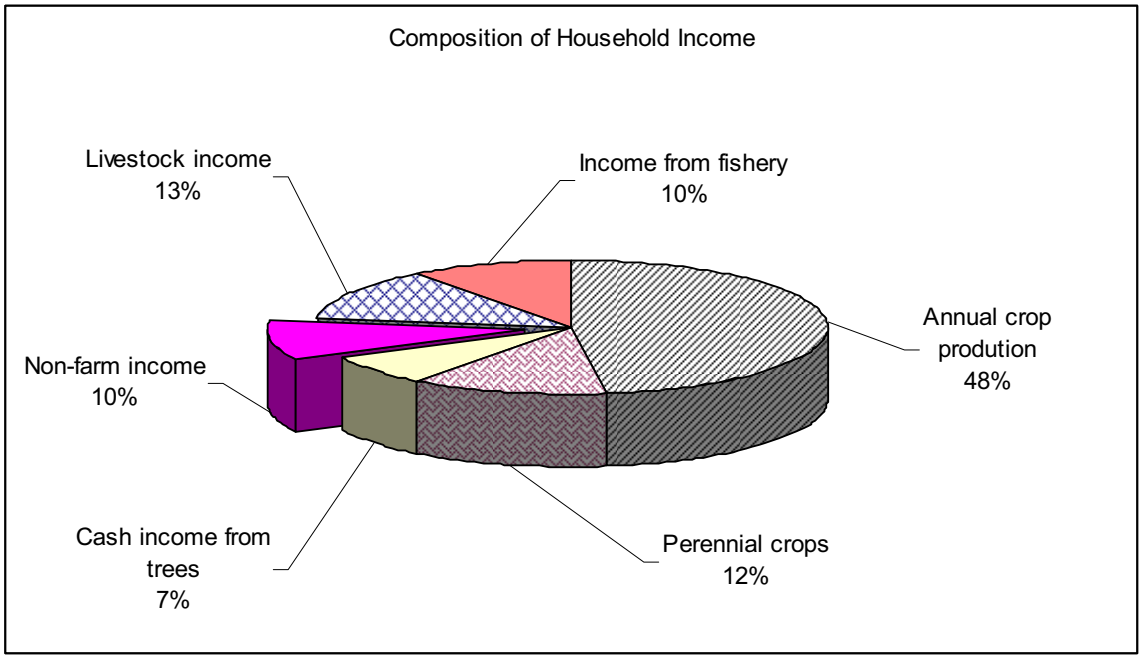

Figure 9.5 Composition of household income

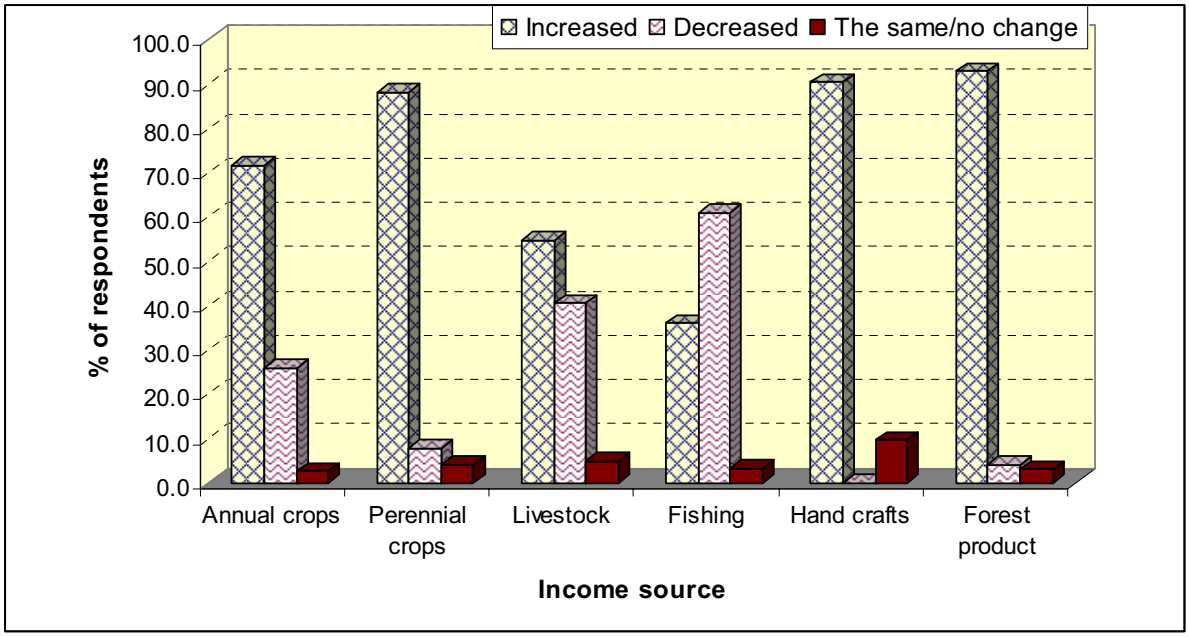

Figure 9.6 Proportion of respondents indicating change in income from different sources (%)

(ii) Food security

Low income levels are a prominent feature of food-insecure households. Food availability, access and utilization determine the extent of food security. Per capita household income is a good indicator of an individual's access to food since; this is because income reflects not only the value of food produced but also the ability to purchase food for susbsistence. Per capita income was computed by dividing the disposable household income by the adult equivalent of the household. The average per capita income in 2007 was about Birr 2,600. If we compute the consumption need of the household on the basis of US$ 1 per day per person, the entire sample could provide food for the household for about 10 months only. On the other hand, about 71% of the households cannot feed their household members for 12 months. In general, about 15% of respondents earned less than US$ 100 per year and 50% had a per capita income of less than US$ 200 per annum (Figure 9.7). The income distribution pattern of the households in the adjacent and non-adjacent areas followed similar patterns.

The sample respondents indicated that their food security status has increased over time due to improved crop production and income diversification. The dependence of some of the households on natural resources such as sales of trees, firewood and charcoal has potentially negative consequences on the environment.

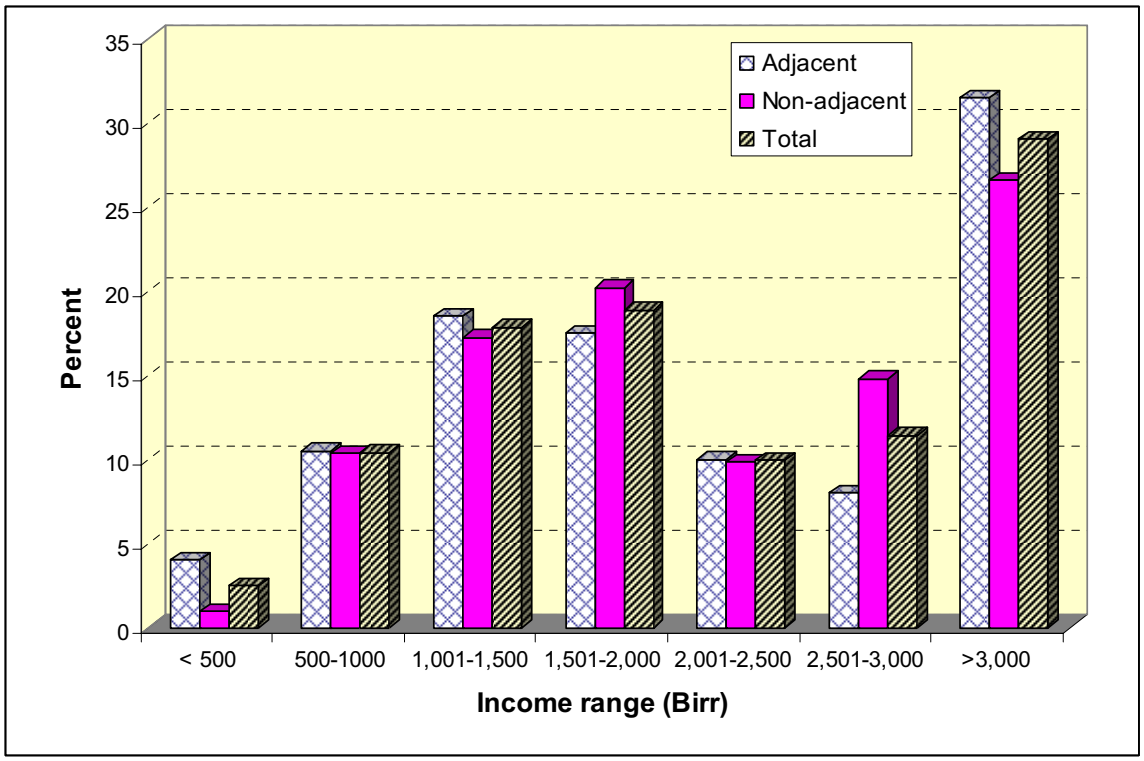

Figure 9.7: Distribution of per capita income of the sample respondents in 2007

(iii) Coping strategies

When households are unable to meet their basic food requirement, they opt for alternative food-procurement strategies. In the study area, about 35% of the households opt for selling livestock to meet their food gap. This is considered to be the first action that they take if there is food shortage. The second majority of the respondents opt for cutting trees to generate income, which is the top priority for some 52% of the respondents. Borrowing money or grain, working for a wage, fishing and selling other household assets such as jewelry and implements are also alternative coping mechanisms for some of the households (Table 9.40). There is no significant difference in household coping strategies between the adjacent and non-adjacent kebeles.

Table 9.40 Coping strategies during times of food deficit (% of respondents)

Coping mechanism	Adjacent	Non-adjacent	Total
Sell livestock	34.8	35.0	34.9
Sell household assets	15.9	14.8	15.3
Cut trees and sell firewood/charcoal	22.9	17.7	20.3
Fishing	13.4	0.5	6.9
Ask for food aid	14.4	2.5	8.4
Work as daily laborer	3.5	3.0	3.2
Borrow money or crop from other sources	13.9	8.4	11.1
Handicraft	1.5	3.0	2.2

Petty trade	2.0	0.0	1.0

Source: Own survey (December, 2007)

Some 78% of the households that considered selling livestock and working as daily laborers followed this course of action as their first option to cope with food deficit problems.

9.3.4 Natural resource management

Cultural Issues

The management and protection of natural resources is, in part, determined by the culture of a society. The largest majority of the sample respondents (99%) were followers of the orthodox faith. The sites where Orthodox churches occur host some tree species the existence of which was threatened elsewhere in the area. For example, the survey found that the number of all tree species, except eucalyptus, are decreasing at an alarming rate except around churches, which are the only places where trees like *Millettia ferruginea* and *Mimuspos kummel* can be found. Churches appear like oases in the island of degraded land. People plant trees around churches for various reasons: to express loyalty to the church, to identify grave yards of relatives, to mark their future grave site, etc. All trees planted and/or grown around churches are not meant for private use; rather they belong to the churches and are rarely encroached.

In the past, trees like *Ficus vasta*, *Syzygium guineense* and *Mimuspos kummel* were grown for cultural purposes and cutting them down was forbidden. However, poor people have started to earn their living from the sale of firewood with the result that poverty is undermining the sustainable use of trees with high social and ecological values and exacerbating deforestation.

The local administration is currently imposing restrictions on tree-cutting in an attempt to reverse the danger posed by deforestation. Nowadays, it is forbidden to cut trees in the communal forest, even though people do it in secrecy.

Conflict

Land, as a crucial factor of production, is the major cause of conflict in the society. The survey shows that some 29% of conflicts encountered by the sample respondents were related to land. As the population increases and the land size per household become smaller, the value of land is increasing. Planting eucalyptus trees on the border of a farm plot has a negative impact on land productivity, and creates conflict between neighboring farmers. The farmers avoid such a conflict by leaving border lines of 5-10 meters to absorb the impacts. The conflicts are often resolved through arbitration and payments of penalties in accordance with traditional conflict resolution practices. Box 9.1 below shows the roles of indigenous institutions in key resources management and conflict resolution.

Gender

The roles of different gender groups in production and resource management processes has implications on targeting development interventions. In the rural areas of Ethiopia, including the study area, males and females of different age groups play different roles in agricultural production and conservation of natural resources. Land clearing and ploughing are the main tasks for men. Weeding and cultivation are carried out by both males and females, adult and youth. Livestock herding is the major activity of the youth, both boys and girls. Elders also take care of the herd. It is, however, the responsibility of the men to make feed available for the livestock through pasture production.

Women and girls are solely responsible for household activities such as child rearing, food preparation, collection of firewood and water supply for the household. This makes them important actors in forest/tree management and water resources development and management. As there is no electric power supply in the rural areas, people depend on firewood for heating and cooking. The current rural energy system is based on open fire which requires a large volume of firewood. As major users, women recognize the various values of trees and engage in planting and managing trees. They are also involved in cutting trees to sell firewood and charcoal to generate income. Selling wood for construction and firewood is also done by men.

Fishing is the task of men. Females play important role in processing and marketing of fish –. Despite the efforts made by the government to bridge the gender gaps in accessing resources and controlling income, the male still plays a dominant role in the rural areas. Achieving gender equality requires investment in education so that the attitude of male and females towards gender equality is improved.

Box 9.1: Indigenous institutions and culture affecting natural resources management

	Land (allocation, Management,)	***Forest tree conservation***	***Wildlife conservation***
Indigenous Institutions	Elders & priests (churches) negotiate and resolve conflicts on land related transactions (share cropping & rent).	Churches have standing committees that look after the natural resources belonging to the church.	Churches prohibit killing of some wild animals like Speckled Pigeon (*Columba guinea*) and Colobus monkey (*Colobus guereza*)
Culture/ traditions governing land use	- Traditionally accepted rules have been in place to allow people to access land for agricultural production. These include share cropping and land renting. The value of land depends on access to irrigation water and soil fertility. In the case of share cropping, if the production is only rainfed, the harvest is shared equally between the land owner & the other party. In the case of irrigated land the land owner receives 67% of the harvest while the share cropper receives 33%. For marshy land, the land owner receives only 33% while the share cropper receives 67% of the proceeds due to heavy work and high labor requirement. Female headed households often share-crop their wetland (irrigated & wetland) due to labor and capital shortage, and hence less benefited? from wetlands. - The culture of boundary maintenance and planting trees/grasses is an essential means of soil conservation. It is said: "*dinber yaferesse, warsa yeweresse.*" meaning "*destroying farm boundary is like taking over the wife of own brother.*"	- The Orthodox church encourages families to plant trees within its boundary. The church also encourages tree plantation and management in the community. *Syzygium guineense*, a tree which was almost lost in the past is now recovering due to Church based advocacy in North Achefer (Qunzila kebele). According to the local belief, *Syzygium guineense* improves the climate and increases moisture. Elders express: **"***Tiliq sewu ena tiliq zaf yelelebet mander qolle yelewum*" meaning "*a village without an elder and an aged tree is graceless.*" - Land contracting involves an article to protect trees on the land. The one who shared in/rented in land is obliged not to cut down the trees.	Traditionally, all wildlife with flat foot & all aquatic life with shell cover are prohibited for human consumption. For instance, catfish is rarely used for food in the rural communities. The presence of some wildlife is expression of lack. The following quotations were made during the group discussions: "*Zinjaro kaxafa hageru berakat yaxal*" meaning "*Disappearance of baboon signals loss of yield.*"
	In some areas of Qunzila, the church has already banned the conversion of communal grazing land into private ownership.		

Source: Focus group discussions (December, 2007)

Conservation

The Lake Tana sub-basin provides major global environmental benefits, including the following:

(i) it is a major source of the Blue Nile and impacts on rain regimes;
(ii) it is rich in biodiversity with many endemic plant species and cattle breeds;
(iii) it contains large areas of wetlands;
(iv) it is home to many endemic birds and cultural and archaeological sites;
(v) it has an enormous potential to develop hydroelectric power;
(vi) it has a vast water resources potential for irrigation and rich potential for development of high value crops and livestock production;
(vii) it has a high potential for ecotourism and other livelihood strategies outside farming.

The many threats on the Lake Tana sub-basin include: silt loading, pollution, drainage, water level fluctuation, over-exploitation of specific fish species, conflicts of interest over the use of water, deforestation, water logging, flooding, overgrazing, population pressures and land degradation. Due to increasing land degradation and other factors, different conservation measures have been used.

Traditional methods of natural resources management

Farmers practice indigenous ways of controlling erosion and soil and water conservation. The most common practice used in the area to prevent soil erosion is making furrows to divert run off. This practice has long been used and in some instances has resulted in small gully formation. The angle of the furrow, the width and its depth are determined by the farmers and no appropriate recommendations to improve the traditional practices have been made. Farmers use traditional farm implements and technical backstopping is lacking in soil and water resources management.

Crop rotation is a traditional means of maintaining soil fertility, and has been applied with great effect by many farmers. Legumes and cereal crops are planted in rotation to enable nitrogen fixation and improve soil texture. Maize and field peas are the two most important crops frequently planted due to their higher yield, reduced susceptibility to disease and suitability to the land compared to other crops. As population pressure and land shortage increases, there is a tendency to move to a system of mono-cropping, which can affect the soil nutrient cycling. As a result, many farmers have become dependent on chemical fertilizers for improved crop production.

Decomposition of crop residues was used for organic matter recycling to increase soil fertility. However, this practice has been ineffective as crop residues are increasingly used for livestock feed, construction and as a source of energy for cooking. Moreover, due to land shortages, fallowing has become impractical to maintain soil fertility as continuous cultivation becomes common practice, further exposing the land to erosion and nutrient deficiency.

In the perennial croplands of coffee and khat plants, mulching is a good means of retaining moisture and improving soil fertility. Coffee is often grown under shade and the leaves of the trees make good compost. This practice is widely and effectively used by the farmers in the Lake Tana sub-basin. This is also a major environmental factor farmers associate to trees in their crop field.

Plate 9.1 Removal of maize straw from the field to feed livestock

Another important soil fertility management technique is the application of livestock manure in the field. Farmers usually rotate cattle barn on farmland or spread cattle dung to increase soil fertility. This practice is now limited due to the increased demand for dung as an energy supply, which generates income for the farmers.

Perennial trees and agro-forestry practices are used by the farmers to maintain farm boundaries and improve soil fertility. Multipurpose trees and grasses are planted as hedges to control run off and prevent soil erosion. Planting trees and grasses on farmland boundaries helps to prevent conflict arising from encroaching boundaries as farmers expand their area of cultivation. The continued removal of organic matter, reducing vegetation cover, cultivation of land and poor erosion control measures have aggravated natural resources degradation through top soil removal and increased siltation in the lake. The government therefore introduced different soil and water conservation techniques to curb the problem of soil and water degradation.

Introduced methods of natural resources management

Improved soil and water conservation techniques have been introduced through the bureau of Agriculture and Rural Development of Amhara National Region State. Physical and biological conservation methods have been introduced and practiced by the farmers in the study area. The physical soil and water conservation works include terracing using different conservation techniques such as soil and stone bunds. According to the BoFED of the Amhara National Regional State (2007), about 375,000 ha of land were conserved in 2005/06. Moreover, maintenance of 394,000 ha conserved land was made during the

same year. Approximately 30% of the conserved area lies in the Lake Tana sub-basin. The regional statistics also show that 26% of new terracing and 28.6% of the maintenance efforts were made in the zones in which the sub-basin is found (Table 9.41). This has a significant impact on the sustainable use of natural resources in general and Lake Tana in particular by contributing to reduction of siltation.

Table 9.41 Soil and Water Conservation Works in Zones adjacent to Lake Tana

Type of conservation	Zone				Total for the region	% of the region
	West Gojam	North Gonder	South Gonder	Total for zones		
Terracing (ha)	16,062	42,726	38,889	97,677	374,940	26.1
Maintenance of Terraces (Ha)	41,685	28,455	42,656	112,796	394,222	28.6
Planting feed and fruit trees (ha)	1,179			1,179	9,437	12.5
Area closure (Ha)	394	6,340	605	7,339	13,077	56.1

Source: Annual Statistical Abstract of the 2006, BFED of Amhara National Regional State (May 2007)

Biological conservation techniques being implemented include planting of multi-purpose trees, such as *Lucinia* and *Sasbania*, and grasses as well as area closure to rehabilitate the natural vegetation of degraded areas. Planting seedlings on hedges of soil bunds has multiple benefits, ie conservation, feed for livestock and fruits for consumption. The extension services also strive to improve soil fertility by building the farmers' technical capacity to make compost.

Plate 9.2 Multipurpose grass and trees introduced by the ARDB

9.6.9 Perceptions of the people on conservation measures

Due to vulnerability of farmlands to erosion and soil degradation, the demand for soil and water conservation is high. The survey result shows that 25% of the land owned by the sample respondents is vulnerable to degradation. The sample respondents have taken measures to conserve their lands with about 73% of the respondents having conserved

part of their farmlands. As shown in Figure 9.8, a large proportion (88%) of farmers residing in non-adjacent areas has conserved their lands. It is important to make conservation in all of the vulnerable areas though an intensified conservation work is necessary to reduce siltation and ensure sustainable use of the water resources in the wetland along the down stream.

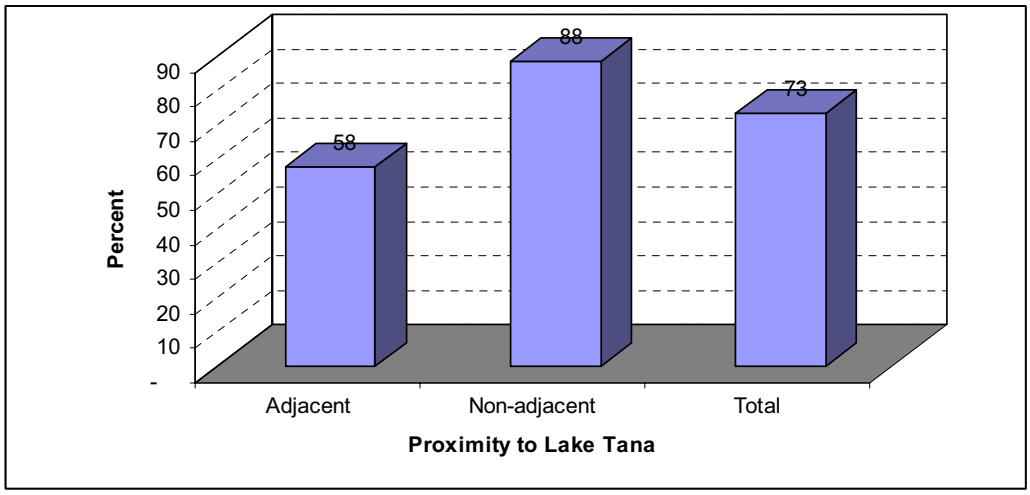

Figure 9.8 Proportion of respondents who conserved land (%)

From those who have conserved their lands, about 66% of them did it using own family labor while the plots of about 7% of the respondents were conserved through the government conservation program. Tree planting is one of the biological conservation measures applied in the area.

The survey results show that most of the sample respondents (67%) have plots with physical land conservation such as terracing and trench making (Table 3.34). This technique is used for water harvesting and erosion control. The terraces are used for growing fruit trees and fodder plants. This technique helps to stabilize the soil structure and conserves soil and water on the farm. Trenches are used to increase water infiltration and recharge the ground water which contributes to increased surface water supply in the long run. Furrow making helps to decrease the velocity of run-off and decreases soil erosion if the slope of the furrow is properly designed. Although furrow making is a common practice in the Lake Tana Basin, only 17% of the sample respondents feel that it serves the purposes of conservation. Tree planting on individual farmers' field is also practiced only by 18% of the sample respondents, which is considerably low in view of the high soil degradation and deforestation in the area.

Table 9.42 Area and extent of land conservation

Type of conservation	Adjacent		Non-adjacent		Total	
	Average area (ha)	% of HH	Average area (ha)	% of HH	Average area (ha)	% of HH
Tree planting	0.42	15	0.60	21	0.52	18
Terracing/trenching	0.82	47	0.96	87	0.91	67
Furrow making	0.71	15	0.80	18	0.76	17

Source: Own survey (December, 2007)

9.6.10 Perception of people on pollution

The assessment of the perception of the respondents on pollution of Lake Tana water shows that about 20% of the households residing in the adjacent areas observed that the Lake Tana water became highly polluted while about 11% observed pollution but to a limited degree (Figure 3.9). Only 17% of the respondents stated that the water is not polluted. Apparently, the majority of the respondents could not judge the water quality showing that the water quality cannot be easily determined and requires detailed laboratory analysis of the biological, physical and chemical properties. The perceptions of the respondents were based on observed odor and color of the water, which varies from one location to the other. The quality of Lake Tana water seems worst in the parts nearer to Bahir Dar town.

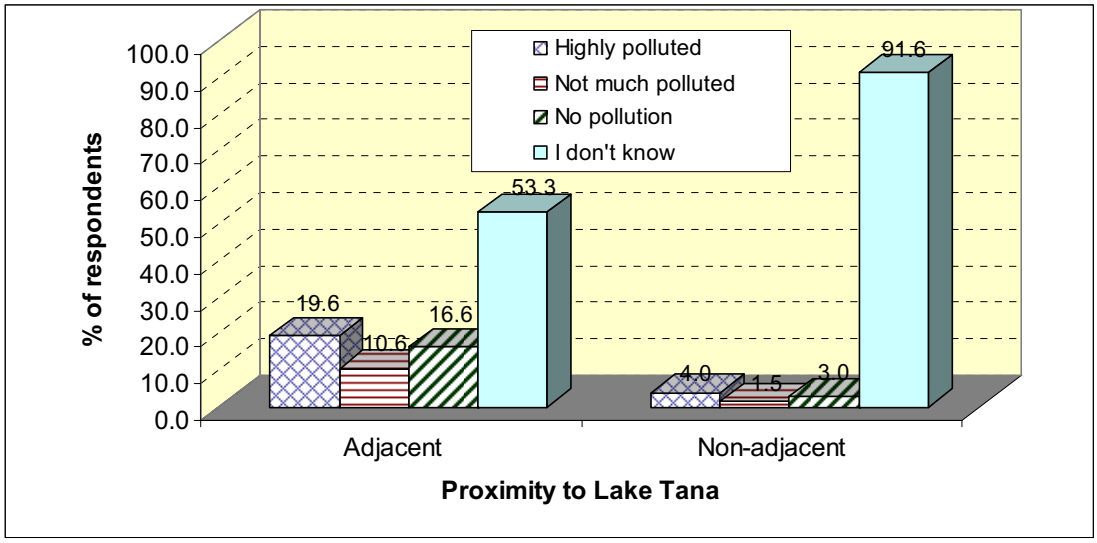

Figure 9.9: Proportion of respondents indicating pollution status of Lake Tana (%)

9.6.11 Benefits of soil and water conservation

The soil and water conservation works have been practiced in Ethiopia since the 1970s. However, the sample farmers stated that their plots have been conserved during the last 6-9 years. Comparison of productivity of conserved and non-conserved land was made by inquiring the experiences of the farmers. The farmers were first asked if there is change in yield due to SWC, assuming similar quality and quantity of inputs and similar agronomic practices. Economic and environmental benefits of SWC were well recognized by the farmers. As shown in Table 9.43, 73% of the respondents agreed that SWC had impact on yield of crops through maintenance of soil. The majority of the farmers indicated an increase of 25% yield while 8% stated a doubling of yield as a result of SWC. Other economic benefits include increase in livestock production due to increased fodder and increase in honey production.

Table 9.43 Extent of economic benefit of conservation

Type of benefit	Adjacent	Non-adjacent	Total
Crop yield increased	55	90	73

by 25%	37	55	46
by 50%	13	25	19
by 100%	5	10	8

Source: Own survey (December, 2007)

Ecological improvements due to conservation works were observed over a long period of time. In the long run environmental protection leads to increased vegetation cover, decreased soil erosion, increased soil fertility, increased biodiversity, (number and species of wildlife and flora), etc. For instance, area closures have been made on degraded land and the vegetation rehabilitation requires longer time. Area closure is one of the environmental rehabilitation strategies through which degraded areas are set free from livestock and human activities for some years so that the vegetation cover regenerate. The management of area closure and the benefits earned by the community determines the sense of ownership and sustainability of the impacts. Currently, the sense of ownership of the communally protected land is low. In some areas, gully reclamation has been implemented to rehabilitate degraded land for sustainable use.

Assuming that natural resources conservation increases soil fertility which determines the rental value of land, a scenario of conserving cropland to increase its fertility will raise its rental value from Birr 1,600 to 3,000 per ha in the adjacent area and from Birr 1,300 to 2,000 per ha in the non-adjacent areas. This analogy applies to the pasturelands. Besides, the increased rental values, the use of the conserved land for economic activities will result in higher economic return.

9.3.5 Valuation of Natural Resources

The people's preference to environmental quality is measured to express the change in the wellbeing of the people due to environmental quality. Environmental valuation is therefore anthropocentric in that it relates to preferences held by the people and the economic value embedded in natural resources transaction. Total Economic Value (TEV) measures the wellbeing of the individuals derived from the environmental quality or from use of natural resources. The economic taxonomy of an environmental resources valuation includes Use Values (UV) and Non-Use Value (NUV). The use value could be the benefits generated through a direct use of natural resources, indirect use of natural resources or option values.

Direct use values are related to food production or income generation values of utilities obtained from recreation. These are directly consumed by individuals to get satisfaction or create utility. Indirect uses of environmental resources are functional benefits such as flood control, storm protection and nutrient cycles. Option values are related to future direct and indirect benefits such as biodiversity conservation of habitats. The non-use values could be bequest value - expressed in terms of environmental legacy, and existence value - value from knowledge of continued existence. The relationships between the different components of the TEV can be shown as follows:

$$TEV = UV + NUV \quad \text{----------(1)}$$
$$UV = DUV + IUV + OV \quad \text{----------(2)}$$
$$IUV = BV + EV \quad \text{----------(3)}$$

where TEV = Total economic value
UV = Use value,
NUV = Non-use value
DUV = Direct use value
IUV = Indirect use value
OV = Optional value
BV = Bequest value
EV = Existence value

The natural resources valuation is basically done based on assessment of willingness to pay for the use of these resources since many of the environmental resources are not traded. In this study, key natural resources in the Lake Tana sub-basin have been identified. The benefits the people reap from these resources have been defined through group discussions. The direct and indirect economic benefits are the most commonly emphasized by the farming community. Optional values are hardly captured in quantitative terms. Attempts were made to generate economic values of the wetland. The following section discusses the values of natural resources including land, water, forest/trees and wildlife.

(i) Valuation of Cropland

Cropland has direct economic value and indirect existence value. The farm households consider land as basic means of livelihood and cannot be disposed of easily. It is an asset that can be inherited to children. Its value should be estimated taking different factors into

consideration. For this study, the valuation of cropland was based on the following assumptions and procedures:

1. The value of land is what the land user is willing to pay for a unit of land. In this case land is a natural resource which can be used as a factor of production. The use of land with other factors of production such as labor and capital can lead to income which is higher than the land rental value.
2. As discussed earlier, the average cropland holding per household in the adjacent and non-adjacent areas was 1.46 and 1.73 ha, respectively. About 26% of the cropland was also identified as degraded land with low productivity. For valuation purpose, cropland was divided into high and low productivity groups. Then, the average cropland was aggregated by multiplying the average holding by the number of households in the adjacent and non-adjacent areas.
3. The proxy value of cropland was estimated from the land renting practice in the study area. The land rental value was estimated based on the results of the survey as well as group discussions. The rental value depends on the quality of land, which is determined by soil fertility and access to water (irrigable or flat land with good water holding capacity). The result shows that the average rental value of fertile land in the adjacent and non-adjacent areas was Birr 3,000 and 2000 per ha, respectively. The degraded land with low productivity is rented for Birr 1,600 and 1,300 per ha in the adjacent and non-adjacent areas, respectively. The rental value of irrigated land, which is often not available for rent was high, ranging between Birr 2,600 to 4,000 per ha. Attempts were made to distinguish the value of water used for irrigation and the land as factors of production. In this section, emphasis was given to the land and the benefit of irrigation water was assessed separately.

According to the land law of the Federal Democratic Republic of Ethiopia, land cannot be sold or mortgaged. In practice however, people transfer the land use right on an extended lease contract which in some instances is tantamount to a sale. In effect, due to land scarcity, not much of the land is available for sale, even if selling land is permitted. About 93% of the sample respondents are not willing to sell their land even if a high price is offered. Only 7% of respondents would sell part of their cropland if a higher price than the current rental value is offered (Table 9.44).

Table 9.44 Proportion of respondents who would sell out their cropland if high price is offered

How much to sell?	Frequency	Percent
Do not sell	376	93.1
<25%	11	2.7
25-50% of the total land	7	1.7
50-75% of the total land	6	1.5
>75%	2	0.5
All of the land I own	2	0.5
Total	28	6.9

Source: Own survey (December, 2007)

The major reasons the majority of respondents gave for not willing to sell their cropland were the high economic and social values attached to land. As shown in Table 9.45, 97% of the respondents feel that land provides a fundamental means of livelihood for the household while 61% of them attached social values to land expressed in terms of bequeathing land to their children.

Table 9.45 Proportion of respondents by reasons for which land will not be sold

Reasons	Frequency	%
Land is the basis of household's livelihood	366	97.3
No other income generation activity	78	20.7
The value of land is appreciating	5	1.3
Land is what I can inherit to my children	230	61.2
Loss of social value if became landless	23	6.1
No. of cases	376	100.0

Source: Own survey (December, 2007)

It is, therefore, assumed that the rental value of land has been established based on supply of land and the prevailing rental value estimated by a group of farmers in the study area. The assumption to base the land value on rental price seems realistic due to the high demand for land, which is one of the scarce factors of production.

4. The land value is then estimated by multiplying the total area of highly productive and less productive land by the respective rental values, which are summed up to estimate the economic value of the cropland in the Lake Tana sub-basin.
5. As shown in Table 4.3, the estimated total economic value of cropland in the Lake Tana sub-basin at the 2007 rental value was Birr 1.1 billion per year.

Table 9.46 Estimates of the economic values of cropland

Column		Adjacent	Non-adjacent	Total*	Remark
A	Number of households	50,276	298,565	386,740	
B	Average cropland (ha/HH)	1.46	1.73	1.59	
C	Highly productive land	1.080	1.280	1.177	C=B-D
D	Low productivity	0.380	0.450	0.413	D =B*E
E	Proportion of degraded land	0.26	0.26	0.26	
F	Total cropland (ha):				
G	Highly productive land	54,318	382,223	436,541	G=C*A
H	Low productivity	19,085	134,294	153,379	H=D*A
I	Sub-total	73,403	516,517	589,920	I=G+H
J	Rent (Birr per ha):				
K	Highly productive land	3,000	2,000		PRA data
L	Low productivity	1,600	1,300		PRA data
M	Value of cropland (Birr):				
N	Highly productive land	162,955,019	764,445,072	927,400,091	N=G*K
O	Low productivity	30,535,715	174,582,726	205,118,441	O=H*L
P	Total Economic Value	193,490,734	939,027,798	**1,132,518,532**	P=N+O

* Total is the sum of adjacent and non-adjacent

Source: Own survey (December, 2007)

In order to assess the value of investment in land conservation, a scenario of increasing the rental value of the degraded land was considered. If the land quality is increased through land conservation, the rental value of the cropland would increase to the current level of renting land with high productivity. Accordingly, all the croplands in the adjacent

area would be rented for Birr 3,000 per ha while that of the non-adjacent area would be rented at Birr 2,000 per ha. This will increase the TEV of cropland to Birr 1.25 billion, which is a 13.6% increase.

(ii) Valuation of Pastureland

Pastureland provides economic benefits through supply of feed for livestock production. Pastureland is often covered by grasses which have the benefits of erosion control. It is also source of income for some farmers. The farm households who rear livestock access feed from private grazing land, communal pasture area, crop residues and purchased hay. The survey result shows that 43% of the sample households in the adjacent area have access to private grazing area of 0.32 ha while 49% of those in the non-adjacent areas have private grazing area of 0.26 ha. Communal grazing area provides feed for the majority of the farmers (85% in the adjacent and 96% in the non-adjacent areas). The households estimated the average area of communal pasture that supports their livestock by approximating equivalent area that they should have rented or allocated for pasture if the communal grazing land were not available. On average 0.3 ha of communal grazing area is available per household.

Valuation of both private and communal pastureland was made. The total number of households having private/communal pastureland was estimated by multiplying the total number of households in the study area by the proportion of households who have private/communal pastureland, respectively. The area of private/communal pastureland was estimated by multiplying the number of households who have pasture area by the average area.

One of the difficulties in the valuation of pastureland was the variation in the productivity of pastureland. In order to capture this variation, two land qualities were considered: high productivity and low productivity pasturelands. The results of the focus group discussions indicated that 65% of the grazing land was characterized by low productivity while 35% could be rated as highly productive. This proportion was used to divide the pasture area into high and low productivity classes.

The valuation technique also involved estimation of value of pasture per unit area. The results of the group discussions revealed that pasture on good land can be sold for Birr 4,000 per ha while this figure falls to Birr 1,600 per ha if the pastureland is relatively degraded. The total value of pastureland was estimated by multiplying the land in the respective quality classes by the value of pasture per ha of the respective land quality. The result shows that the value of pastureland in the Lake Tana sub-basin in 2007 prices was approximately Birr 309 million per year (Table 9.47).

If the pastureland quality could be increased to high productivity level through conservation and field management practices, the income from all pasture areas would be Birr 4,000 per ha. This scenario implies that the TEV of pastureland could increase to Birr 506 million, which is a 64% increase in the value.

Table 9.47 Estimates of economic values of pastureland

Column	Variable	Adjacent	Non-adjacent	Total*	Remark
A	Number of households	50,276	298,565	386,740	
B	Average private grazing area (ha)	0.32	0.26	0.29	
C	Average area of communal pasture (ha)	0.3	0.3	0.3	
D	Ratio of HH having private pasture area	0.43	0.49	0.46	
E	Ratio of HH having communal pasture	0.85	0.96	0.91	
	Total pasture area (ha)				
F	Private	6,976	37,208	44,184	F=A*B*D
G	Communal	10,693	71,700	82,393	G=A*C*E
H	Total	17,669	108,908	126,577	H=F+G
	Proportion of pastureland quality:				
I	Highly productive pastureland	0.35	0.35	0.35	
J	Low productivity pastureland	0.65	0.65	0.65	
	Pasture area by quality (ha):				
K	Highly productive	6,184	38,118	44,302	K=H*I
L	Low productivity	11,485	70,790	82,275	L=H*J
	Price of purchasing grass (Birr/ha):				
M	Highly productive pastureland	4,000	4,000		
N	Low productivity pastureland	1,600	1,600		
	Value of pasture (Birr):				
O	Highly productive	24,736,405	152,471,024	177,207,429	O=K*M
P	Low productivity	18,375,615	113,264,189	131,639,804	P=L*N
Q	Total	43,112,021	265,735,213	**308,847,233**	Q=O+P

* Total is the sum of adjacent and non-adjacent

Source: Own survey (December, 2007)

(iii) Valuation of Water Resources

The use of water resources is apparent. Surface and ground water play important role for environmental improvement. Wetlands are often covered with grasses and trees due to water availability, which is necessary for increased biodiversity. This in effect is what is called option values of the environmental resources. In this study, due to data limitation, direct values of water resources were estimated by considering the use of water for different purposes. These include irrigation, public water consumption, and water transport. The benefits obtained in different direct ways are discussed below.

Irrigation water

The value of irrigation water has been captured through extra yield that can be attributed to irrigation. Obviously, availability of irrigation water enables farmers to increase production cycle and produce crops during the dry seasons. Most importantly, perennial crops such as khat attract very high price if sold during the dry seasons, which is possible only if irrigated. The extra benefits of irrigating crop have been recognized by the group discussants. As a result, some farmers in the study area started to invest in developing shallow wells to uplift water for irrigation.

In order to estimate the extra benefits of irrigation, data on total irrigated area, the most commonly grown crop and the yield of this crop with and without irrigation were collected. According to the Bureau of Water Resources of the Amhara National Regional State, 2,500 ha of land was irrigated during 2006/07 production season. Onion is the most commonly irrigated crop. Farmers estimated the yield of onion with and without irrigation with the assumption that the crop variety, agronomic practices and all other

inputs were the same except irrigation. It was indicated that the irrigated crop could yield 5qt more than the rainfed system. At a price of Birr 200 per qt, irrigation water resulted in Birr 2.5 million per year (Table 9.48).

Table 9.48 Value of irrigation water

Column	Variable	Amount	Remark
A	Area under irrigation (ha)	2,500	
B	Yield of onion with irrigation (qt/ha)	25	
C	Total production with irrigation (qt)	62,500	C=A*B
D	Yield of onion without irrigation (qt/ha)	20	
E	Total production without irrigation (qt)	50,000	E=A*D
F	Price of the crop (Birr/qt)	200	
G	Extra value of irrigation water (Birr)	**2,500,000**	G=(C-E)*F

Source: Own survey (December, 2007)

Public water use

Public water supply is adequately recorded in the urban area. In Bahir Dar town, for instance, 4,465,470 m^3 water was supplied in one year (2006/07) for public use. At water price of Birr 1.75 per m^3, about Birr 7.8 million was collected by the municipality. Although there is no complete recording of water use in the rural areas, estimation of the water use was made based on water consumption estimate made by the participants of focus group discussions. Accordingly, the per capita water consumption in the rural area was estimated at 12 liter per day. This implies that about 11 million m^3 of water was used by the rural population per year. At the price of water taken from Bahir Dar, the value of water used in the rural area is Birr 19.6 million per year. Thus, the total value of public water use in 2007 was about Birr 30 million (Table 9.49).

Table 9.49 Value of water used for consumption

Column	Variables	Amount	Remark
	Bahir Dar City Water Supply:		
A	Total volume of water supplied to Bahir Dar (m^3/year)	4,465,470	
B	Price of water (Birr per m^3)	1.75	
C	**Value of water (Birr)**	**7,814,572.50**	**C=A*B**
	Rural Water Supply:		
D	Water consumption per day per person (m^3)	0.012	
E	Population in the Tana Basin	2,540,354	
F	Total water required (m^3)	11,227,133	F=D*E*365
G	Value of water (Birr)	19,647,482	G=F*B
H	**Total economic value of water (Birr)**	**29,962,054**	**H=C+G**

Source: Own survey (December, 2007)

(iv) Transport service

One important direct benefit of Lake Tana is the transport service, which creates utility for the users and means of livelihood for the service providers. The assessment of the

water transport sector shows that both the government and the people involved in the transport sector generated income by transporting goods and people. The public water transport sector increased from Birr 1.95 million in 2000/01 to 3.38 million in 2006/07, an annual increase of 13% (Figure 9.4).

The local people generated income by transporting wood and grasses from areas like Zeghe to Bahir Dar town. During the field work, it was observed that the supply of these products was frequent and a large quantity was supplied every week. The market actors were asked to estimate the number of loads of wood and grass transported every week to Bahir Dar and the seasonal fluctuations. They also estimated the transport cost per load of these goods. These variables were used to estimate the income from the sector. In 2007, the income of the local transporters was estimated at Birr 58,000 from transporting wood and grass to Bahir Dar through two routes, locally known as 'Radio Station' and 'Agip'. In general, the water transport sector generated about Birr 3.44 million during 2007 (Table 9.50).

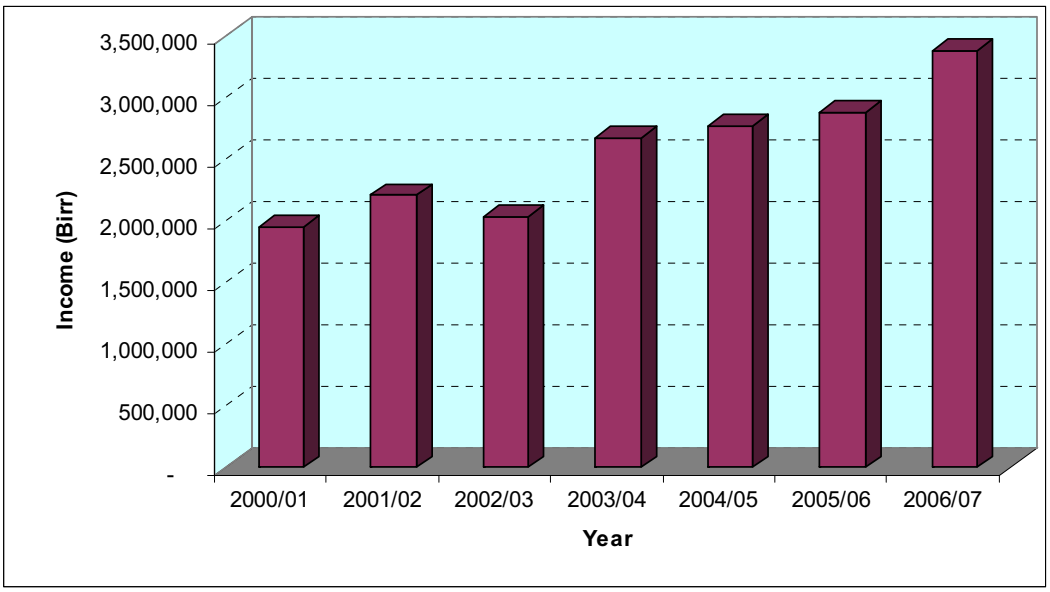

Figure 9.4 Trend of income generated from public water transport

Table 9.50 Income of local people from water transport to Bahir Dar city in 2007

Column	Components	Amount	Remark
	Wood transport:		
A	No. of load	3,840	
B	transport cost per load	7.14	
C	Sub-total 1	27,429	C=A*B
	Grass transport:		
D	No. of load	4,320	
E	Sub-total 2	30,857	E=B*D
F	Total transport cost of wood and grass	58,286	F=C+E
G	Income by public transport serve	3,383,475	
H	**Total income from water transport**	**3,441,761**	**H=F+G**

Source: Own survey (December, 2007)

(v) Fisheries

The fishery industry provides means of livelihood for many people organized into cooperatives or associations and some farmers who are involved in fishing to generate income. The incomes generated by the Bahir Dar Fishery Cooperative #1 and Giorgis Fishery Association were gathered from the records of the associations. The number of fish that were supplied by the Bahata group was inquired from the group leaders and members and valued at the average price of a wet whole fish (i.e. Birr 1 per piece). The individual fisher's income was estimated based on the proportion of farmers who participated in fishing for income generation and the number of fish sold per household. In the same fashion, the value of fish consumed at home was estimated (Table 4.8). The total value of fish harvested from Lake Tana during 2007 was estimated at Birr 8.3 million.

Table 9.51 Valuation of fish resources from Lake Tana in 2007

Column		**Adjacent**	**Non-adjacent**	**Total**	Remark
	Commercial fishing				
	Quantity of fish (kg)				
A	Bahir Dar Fishery Cooperative #1 (kg)			681,400	
B	Giorgis Fishers' Association (kg)			383,250	
C	Bahata group (No.)			3,240,000	
	Individual farmers				
D	Households in the area	50,276	298,565	386,740	
E	Proportion fishing for sales	0.07	0		
F	No. of farmers fishing for sales	3,519	-	3,519	F=D*E
G	No. of fish per farmer	282			
H	Total No. of fish sold	992,451		992,451	H=F*G
	Fish harvested for consumption				
I	Proportion of households	0.10	0.01		
J	No. of farmers fishing for consumption	5,028	2,986		J=D*I
K	No. of fish per farmer per year	120	60		
L	No. of fish consumed	603,314	179,139	782,452	L=J*K
	Value of fish (Birr)				
M	Bahir Dar Fishery Association #1			2,651,800	
N	Giorgis			1,314,000	
O	Bahata group			2,592,000	
P	Sub-total, organized commerce			6,557,800	P=M+N+O
Q	Sales by farmers*			992,451	Q=H*1
R	Value of consumed fish*			782,452	R=L*1
S	Total value of fish			8,332,703	S=P+Q+R

* Price of a fish= Birr 1 per fish

Source: Own survey (December, 2007)

The summary of TEV of water resources show that the values of water used for irrigation, water supply for public use, transport services for public and goods transport and values of fishery harvested in 2007 amounts to an approximate value of Birr 42 million. The largest share of the value went to water supply followed by fishery (Table 9.51).

Table 9.52 Summary of Values of Water Resources*

Type of use	Amount (Birr)	Percent
Irrigation	2,500,000	5.99
Water supply	27,462,054	65.80
Water transport	3,441,761	8.25
Fishery	8,332,703	19.97
Total	41,736,519	100.00

* Note: The value of water use for livestock, wild animals and non-irrigated plants was not included due to lack of data.

Source: Own survey (December, 2007)

(vi) Valuation of Trees

Trees[5] are important natural resources with direct use and non-use values. The concept of TEV has been demonstrated for the trees as key natural resources. In this study, the direct use value of trees was expressed as economic values while the indirect use value was expressed in terms of environmental protection. The option values that can be expressed in terms of contribution to biodiversity were relatively difficult to capture. The non-use values were deduced from the people's interest to keep selected trees as bequest value or existence value, which is called 'social value' of trees, in this study. The following sub-sections discuss the valuation technique applied to trees.

Direct economic value

The direct economic values of trees include the proxy value of using the trees for construction, farm tools, livestock feed and firewood and the income generated from sales of wood. The survey data provided the number of households who had trees, the number of trees they sold and income generated from sales of trees. These data were used to estimate the total income generated from sales of wood/firewood and use of woods for own construction or energy supply. Similarly, households cut trees from communal forests for sale and home use. Based on the proportion of farmers engaged in harvesting trees from the communal forests and the volume of trees harvested as well as the income generated from sales of these trees, the price of trees was determined. The trees used for construction and other purposes were valued at the market price. The total direct economic value of trees harvested in 2007 was estimated at Birr 737 million of which 96% was from private woodlots and 4% was from communal forest (Table 9.53).

Table 9.53 Economic value of trees harvested in 2007

Column	Particulars	Adjacent	Non-adjacent	Total	Remark
	Private holding:				
A	No. of households	50,276	298,565	386,740	
B	Proportion of HH having trees	0.97	0.98		
C	No. of trees per household, used or sold per year	170	184		
D	Total No. of trees	8,268,152	53,878,565	62,146,717	D=A*B*C
E	Average price of a tree (Birr)	8.91	11.86		
F	Value of trees (Birr)	73,699,982	638,981,156	712,681,137	F=D*E

[5] In this analysis, trees of high economic value, as perceived by the farmers, were considered. Valuation of forest is more complex since there are several interacting factors affecting the values.

	Communal holding:				
G	Proportion of HH having trees	0.05	0.08		
H	No. of trees per household, used or sold per year	55	39		
I	Total No. of trees	138,259	931,522	1,069,781	I=A*G*H
J	Average price of a tree (Birr)	19.7	23.8		
K	Value of trees (Birr)	2,728,804	22,135,902	24,864,705	K=I*J
L	Total value of trees (Birr)	76,428,785	661,117,057	737,545,842	L=F+K

Source: Own survey (December, 2007)

Indirect use value

The indirect (or environmental) value of trees include the shade provided by trees for people (serves as assembly area), livestock and crop production, control of erosion, improvement of soil fertility, etc. Coffee is produced under shades of some trees. Some trees are preferred to others in increasing productivity of coffee. The group discussions held with the community members in the study area identified three types of trees with high environmental value in coffee production. These are *Albizza schimperiana (Sisa), Cordia africana (Wanza) and Croton macrostachyus (Bisana).* These trees serve as shade for the coffee plant and their leaves decompose to improve soil nutrient. The valuation of the indirect economic benefits of these trees was made by taking into account the proportion of farmers who have these trees, the proportion of farmers who produce coffee, the number of trees owned per farmer, and the estimated environmental benefit per tree.

The indirect benefit of each of the trees was estimated by asking the farmers the incremental income from coffee production with and without the tree species. In the group discussions, farmers estimated the environmental benefits of trees in terms of differential income from coffee under shade of trees compared to if the trees were not there. The extra benefit was considered as the indirect benefit of growing the tree. The total environmental benefit of these trees in the Lake Tana basin in 2007 was estimated at Birr 5.5 million per year (Table 4.11).

Plate 9.3 Trees used as shade for coffee production

Table 9.54 Environmental value of trees, 2007

Column	Particulars	Adjacent	Non-adjacent	Total	Remark

A	No. of households (HH)	50,276	298,565	386,740	
B	Proportion of HH having trees:				
C	*Albizza schimperiana*	0.14	0.07		
D	*Cordia africana*	0.66	0.85		
E	*Croton macrostachyus*	0.28	0.64		
	No. of households having the trees				
F	*Albizza schimperiana*	7,039	20,900	27,938	F=A*C
G	*Cordia africana*	33,267	252,971	286,238	G=A*D
H	*Croton macrostachyus*	14,257	191,199	205,456	H=A*E
	Environmental value of a tree (Birr):				
I	*Albizza schimperiana*	21	21	21	
J	*Cordia africana*	42	42	42	
K	*Croton macrostachyus*	51	51	51	
	Total environmental value (Birr)				
L	*Albizza schimperiana*	147,812	438,890	586,702	L=F*I
M	*Cordia africana*	1,397,226	10,624,785	12,022,012	M=G*J
N	*Croton macrostachyus*	727,128	9,751,153	10,478,281	N=H*K
O	Total	2,272,166	20,814,828	23,086,994	O=L+M+N
	Adjusted environmental value:				
P	Ratio of HH growing coffee	0.4	0.22		
Q	Total adjusted value	908,867	4,579,262	5,488,129	Q=O*P

Source: Own survey (December, 2007)

Non-use value/Cultural values

The cultural values of trees include use of shades of trees for conducting ritual feasts and negotiation of conflicts; inheritance of trees to ones heir i.e. existence value that carries owner's name after his/her death (e.g. *Millettia ferruginea (Birbira));* prevention of lightening. For instance, people plant *Croton macrostachyus (Bisana)* and shelter under it with the perception that it prevents lightening while they avoid sheltering under *Ficus vasta* when it rains perceiving that Ficus attracts lightening. Eucalyptus tree is considered as an important economic tree that should be inherited by parents to their children so as to sustain their livelihood in the future.

The cultural values of trees are difficult to evaluate. It was found out that farmers identify some trees of cultural importance and retain the existence of one of these trees for cultural reasons. Hence, cultural value was assumed for only one tree per species in the valuation processes. Elicitation approach was used to estimate the value. Farmers were asked to estimate the price they would receive to cut down the tree they categorize as culturally important. As shown in Figure 4.2, there is a significant difference in the cultural and market prices of *Cordia africana*, which could be the reflection of scarcity of this species in the area.

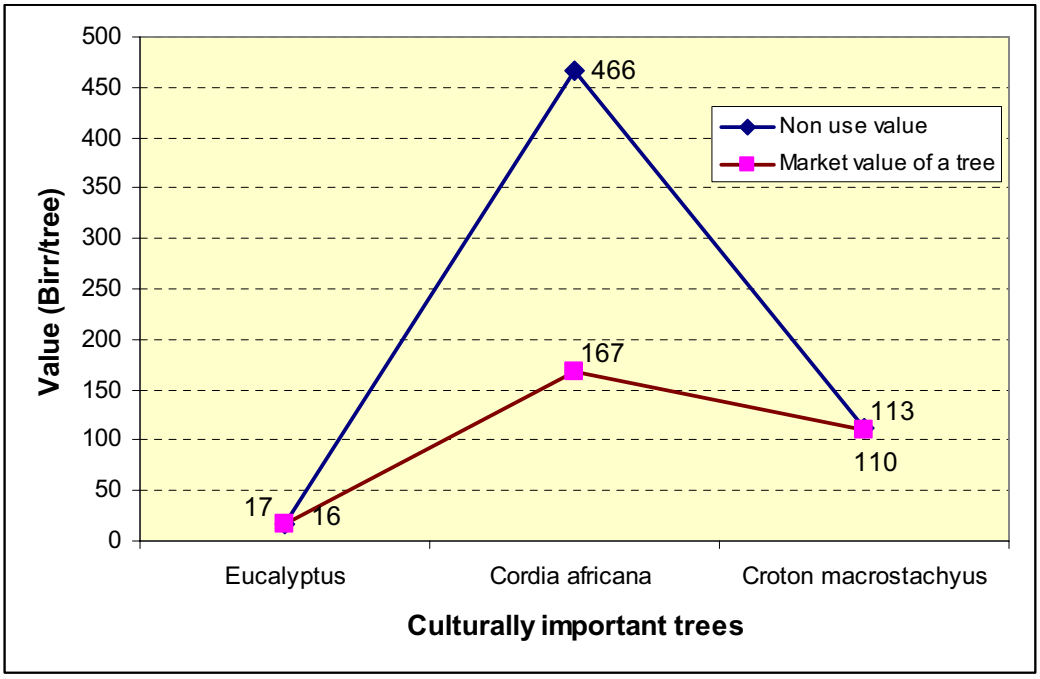

Figure Comparison of market and cultural values of selected trees in the Lake Tana Sub-basin

The cultural values of the trees were estimated by taking into consideration the number of farmers who have such trees of cultural value and the unit value of the trees. The total cultural value of the trees was estimated at Birr 162 million (Table 9.55).

Table 9.55 Estimated cultural value of trees

Colum	Particulars	Adjacent	Non-adjacent	Total	Remark
A	No. of households	50,276	298,565	386,740	
B	Proportion having trees				
C	Eucalyptus	0.90	0.87		
D	*Cordia africana*	0.66	0.85		
E	*Croton macrostachyus*	0.28	0.64		
	No. of HH having the trees:				
F	Eucalyptus	45,023	258,854	303,878	F=A*C
G	*Cordia africana*	33,267	252,971	286,238	G=A*D
H	*Croton macrostachyus*	14,257	191,199	205,456	H=A*E
	Cultural value (Birr/tree):				
I	Eucalyptus	17	17		
J	*Cordia africana*	466	466		
K	*Croton macrostachyus*	113	113		
	Total cultural value (Birr)				
L	Eucalyptus	754,419	4,337,400	5,091,820	L=F*I
M	*Cordia africana*	15,509,677	117,938,646	133,448,324	M=G*J
N	*Croton macrostachyus*	1,607,095	21,551,951	23,159,046	N=H*K
O	Total	17,871,191	143,827,998	161,699,189	O=L+M+N

Source: Own survey (December, 2007)

In summary, the trees in the Lake Tana sub-basin generated a total economic value of Birr 905 million in the year 2007 (Table 9.56). Direct economic benefits account for 80% of the tree values while 17.5 and 2.5% of the values are attributed to cultural and environmental values, respectively.

Table 9.56 Summary of total economic values of trees

Elements of TEV of trees	Adjacent	Non-adjacent	Total
Economic value			
Private plot	73,699,982	638,981,156	712,681,137
Communal area	2,728,804	22,135,902	24,864,705
Sub total 1	**76,428,785**	**661,117,057**	**737,545,842**
Option value			
Type of tree			
Eucalyptus	754,419	4,337,400	5,091,820
Cordia africana	15,509,677	117,938,646	133,448,324
Croton macrostachyus	1,607,095	21,551,951	23,159,046
Sub total 2	**17,871,191**	**143,827,998**	**161,699,189**
Environmental value			
Type of tree			
Albizza schimperiana	147,812	438,890	586,702
Cordia africana	1,397,226	10,624,785	12,022,012
Croton macrostachyus	727,128	9,751,153	10,478,281
Sub total 3	2,272,166	20,814,828	23,086,994
Adjusted environmental value			
Proportion of HH growing coffee	0.4	0.22	
Total adjusted value	908,867	4,579,262	5,488,129
Total Economic Value	**95,208,843**	**809,524,317**	**904,733,160**

Source: Own survey (December, 2007)

(vii) Wildlife

Forest, pastureland, marshy areas, area closures, and mountainous areas shelter different types of wildlife. The wild animals have different economic benefits and costs. In Zeghe area, for instance, vervet monkey (*Ceropithecus aethiops)* and baboon (*Papio hamadryas)*, bush pig (*Potomachoerus porcus)* and warthog (*Phachocoerus aethiopicus)* are reported to threaten crop production. Both annual crops and perennial crops were attacked by wild animals. In order to estimate the value of crop loss due to wild animals, the following estimation procedure was adopted.

(i) The cropland was assumed to be allocated to the three most commonly produced annual crops: maize, millet and teff.

(ii) The proportion of farmers who produced these crops and the proportion of households who reported losses were used and the number of households in the adjacent and non-adjacent areas who encountered crop loss.

(iii) The average amount of yield losses of these crops per household was computed from the survey result to estimate the total crop loss. The quantity of yield loss of each crop was valued at the prevailing prices of the respective crops.

(iv) The most common loss of perennial crops was reported for coffee. Tthe proportion of households who produce coffee, the proportion of households who reported loss of coffee due to wildlife attack and the average value of coffee lost per household were used to estimate the total loss of perennial crops. The loss of perennial crops was indicated only in the adjacent area.

The total economic loss of crop production due to wildlife attack was estimated by summing up the value of annual and perennial crop losses. During 2007, the total loss was estimated at Birr 2 million, which reduces the TEV of natural resources (Table 9.57). This is an indicative figure showing the costs of maintaining wildlife to the welfare of the rural community.

Apparently, wildlife also has other values. People hunt some of the wild animals for consumption. The survey result shows that Helmeted Guinea fowl and Crested Francolin were hunted by a small segment of the population for subsistence. Only 2-3 of these birds were caught per hunter in the year 2007. The proxy values of these birds were estimated by the farmers when they responded to the question 'how much would you pay if you were asked to purchase the bird?' Surely, the estimated prices were smaller than the value of poultry.

Table 9.57 Estimation of losses due to wildlife

Column	**Annual crops**	Adjacent	Non-adjacent	Total*	Remark
A	No. of households (HH)	50,276	298,565		
	Proportion of HH reporting loss				
B	Maize	0.17	0.18		
C	Millet	0.01	0.03		
D	Teff	0.06	0.05		
	Proportion of growers:				
E	Maize	0.87	0.96		
F	Millet	0.58	0.90		
G	Teff	0.58	0.70		
	Loss per HH (qt):				
H	Maize	0.55	0.42		
I	Millet	0.12	0.37		
J	Teff	0.28	0.14		
	Amount lost (qt):				
K	Maize	4,072	3,697	7,769	K=A*B*E*H
L	Millet	52	575	628	L=A*C*F*I
M	Teff	525	244	770	M=A*D*G*J
	Price (Birr/qt):				
N	Maize	180	180		
O	Millet	240	240		
P	Teff	350	350		
	Value (Birr):				
Q	Maize	733,030	665,469	1,398,500	Q=K*N
R	Millet	12,580	138,023	150,603	R=L*O
S	Teff	183,907	85,487	269,394	S=M*P

T	Total annual crop loss (Birr)	929,517	888,980	1,818,496	T=Q+R+S
	Perennial crops:				
U	Proportion of HH reporting loss	0.09	0		
V	No. of HH	4,502		4,502	V=A*U
W	Average loss (Birr)	300			
X	Total perennial crop loss (Birr)	270,140		270,140	X=V*W
Y	Total crop loss (Birr)	1,199,657	888,980	2,088,637	Y=T+X

*= sum of adjacent and non-adjacent

Source: Own survey (December, 2007)

The value of wildlife hunted per year was estimated at Birr 105,300 (Table 9.58). This indicates that the wildlife population in the Lake Tana sub-basin was low and the dependence on hunting as a means of livelihood was low. The economic value of wildlife was estimated by adding up the benefits and losses incurred due to wildlife, which is equivalent to a loss of Birr 1.98 million. Conservation of the wildlife should weigh the economic benefits and costs.

Table 9.58 Benefits (loss) of wild animals during 2007

Particulars	Value	Remark
Benefits:		
No. of households	386,740	
Proportion of hunters		
Helmeted Guinea fowl (Jigira)	0.0050	
Crested Frankolin (qoq)	0.0025	
No. of hunters		
Helmeted Guinea fowl	1,915	D=A*B
Crested Frankolin	957	E=A*C
No. of animals per hunter		
Helmeted Guinea fowl	2	
Crested Frankolin	3	
Total number		
Helmeted Guinea fowl	3,829	H=D*F
Crested Frankolin	2,872	I=E*G
Estimated value per bird (Birr)		
Helmeted Guinea fowl	20	
Crested Frankolin	10	
Value (Birr)		
Helmeted Guinea fowl	76,582	L=H*J
Crested Frankolin	28,718	M=I*K
Total benefit (Birr)	**105,300**	N=L+M
Losses of crop due to wildlife (Birr)	2,088,637	
Net benefit (Loss) (Birr)	**(1,983,336)**	**P=N-O**

Source: Own survey (December, 2007)

(ix) Total Economic Values

This sub-section summarizes the TEV of natural resources in the study area. The total annual economic value of the environmental resources of the Lake Tana sub-basin was estimated at Birr 2.385 billion (Table 9.59). The rental value of cropland accounts for the largest share (47%) followed by trees (38%). Wildlife and fish contribute less than 1% to the TEV.

Table 9.59 Summary of Value of Natural Resources in the Lake Tana Sub-Basin

Type of resource	Total value (Birr)	% of total
Crop land	1,132,518,532	47.47
Pastureland	308,847,233	12.95
Trees		
Economic value	737,545,842	
Option/cultural value	161,699,189	
Ecological value	5,440,017	
Total value of trees	904,685,049	37.92
Fish	8,332,703	0.35
Water resources*	33,403,815	1.40
Irrigation	2,500,000	
Water supply	27,462,054	
Water transport	3,441,761	
Wildlife (loss)	(1,983,336)	-0.08
Total economic benefits	**2,385,803,996**	100.00

* Note: The value of water use for livestock, wild animals and non-irrigated plants was not included due to lack of data.

Source: Own survey (December, 2007)

9.4 Investment Opportunities in the Wetland

9.4.1 Agricultural Development Projects

Private floriculture development has been considered as a new venture to boost agricultural product export in Ethiopia. Currently a large cluster of cut flower industries are found in Oromia within some 50-200 km radius of Addis Ababa. Conducive climate and access to transport facilities triggered the development of this sector. The Amhara National Regional State has also planned to promote the flower industry in its region. Few such industries also started operating in the region. One best example of the flower industry in the Lake Tana Basin is located at Robit kebele, which have evicted some 133 farm households with some compensation. Although such an investment entails good economic impact, its impacts on the people, water use and environmental pollution have not been rigorously assessed.

The agriculture and rural development also focuses on increasing crop and livestock productivity. To this end, the regional government planned to increase seed multiplication. In the Lake Tana sub-basin, there is an on going seed multiplication on 600 ha of land, which farmers claim that they were not compensated for. Improved forage production which has positive impact on environmental improvement is also one of the government motivated public investment in the rural areas. Basically, the extension system provides the skill and varieties needed to develop fodder species on farmers' field.

The regional investment bureau envisages large investment in livestock and other agricultural development in the Lake Tana sub-basin.

Land conservation practices like soil bund, compost preparation and tree planting are well applied and significant number of rural households benefited from the investment. The government is also encouraging other conservation practices like Check Dam, Agro forestry, crop rotation, counter farming, etc. to enhance land productivity. However, the impact so far is less significant given the scale of the problem. Further development interventions in this area will have positive impact on sustainable use of the wetland resources without affecting the beneficiaries in the downstream.

Government planned to develop irrigation projects in Lake Tana sub-basin. These include Gilgel Beles (11,508 ha), Megech (7,311 ha), Ribb (19,925 ha), Jemma (7,786 ha), Gumera and Koga (20,976 ha) and other irrigation projects in the north west, north east and south west of Lake Tana. This creates investment opportunities in agriculture to bring about economic growth. It is, apparent that the investment will create pressure on the use of water enriching the lake or the down stream. The impact can be minimized by developing effective water management system and conservation of soil that helps to reduce siltation.

9.4.2 Fishery Development

Fishery is considered as one of the income generation activities for the unemployed youth. The youth is encouraged to be organized into associations or cooperatives to generate income from fishing activities. Some organizations like ILRI (International Livestock Research Institute) also organized the Wageta Fishers Group, trained them and provided them with fishing facilities to generate income from fishing. These groups sell the fish to Giorgis and the Bahir Dar Fishers Cooperative #1. The major concern here is the growing demand for organized fishing, which unless properly guided would create pressure on the fish stock making it unsustainable.

9.4.3 Water Resources Development

The Bureau of Water Resources of the Amhara National Regional State estimates the planned irrigation development scheme in the Lake Tana sub-basin will cover some 85,299 ha. These irrigation schemes will be developed through projects such as dam construction and the application of different irrigation systems. The Gilgel Beles irrigation project, with an irrigation potential of 11,508 ha, and the Koga irrigation scheme, with a potential of 7,000 ha are both under construction. The feasibility study for the Ribb irrigation project to develop 19,925 hectares has been completed and the fund for its implementation has been secured. The Jemma and Gumara irrigation projects have the potential to irrigate 7,786 and 13,976 ha respectively. Moreover, the irrigation potential in the southwestern region of Lake Tana is estimated at 5,131 ha while that of the northwest and north eastern area of Lake Tana covers 7,187 and 5,475 ha of land, respectively.

Investment in irrigation has impacts on the society whose land will be used for large scale irrigation. Its use ? also affects the downstream dwellers unless plans are made to use the water resources in an equitable and sustainable manner. The social, environmental and economic impacts of these projects should be studied.

9.4.4 Forest Resources

Forest resources development has been a key area of intervention to reverse the degradation of natural resources in the area. Area closures, planting of seedlings, agro-forestry practices, private tree nursery development and commercial forest development have been pursued. Sanctuaries, reserve areas for wildlife protection and an increased scale of forest protection will help to increase the forest cover of the area. The problem of tree ownership and associated tenure systems are major challenges in the communal forests. The increasing price of wood creates incentive to invest in woodlots.

9.4.5 Integrated Watershed Management

Watershed management is considered by the Ethiopian government as a means to the sustainable use of natural resources to improve the livelihood of the people. The strategic framework of implementing integrated watershed management has been prepared by the Ministry of Agriculture and Rural Development. Integrated watershed management requires definitions of watershed elements in terms of enterprises, resources, potentials, constraints, opportunities, etc. to design intervention mechanisms to use the natural resources in a sustainable manner. Crop and livestock improvement, land management, water resources development, alternative income generation activities, social and human capitals, infrastructure development, agricultural technologies, etc. are key components of the integrated watershed management that can improve the livelihoods of the people. Proper definition of the elements of the watershed and interventions will make a significant contribution to the sustainable use of the wetland resources.

9.4.6 Promotion of Eco-tourism

Investment in hotels, recreation centers and transport facilities, including water transport is necessary to generate income from the environmental factors??. Several hotels around Lake Tana benefit from the recreational functions of the lake. The potential threat on the lake from ecotourism ventures comes from the waste disposal system, which could lead to deterioration of the water quality of the lake. However, investment in the service sector should consider the environmental impacts of the enterprise.

Involving the local people in investment of eco-tourism enables reaping of the economic benefits of the tourism sector and contributes to sustainable natural resources management in the sub-basin. Note to self – re-read this section as it needs to be re-written.

9.4.7 Investment in Biodiversity

The attempts made to rehabilitate the degraded areas through area closure and enrichment plantation, delimitation of parks and sanctuaries, etc will be useful for long-term environmental rehabilitation and improved diversity of the flora and fauna of the area. It is also necessary to capitalize on the cultural values of trees in the investment process.

9.5 Conclusions

The Lake Tana sub-basin is home to about 2.5 million people of which 13% live in the adjacent kebeles. The socio-economic analysis shows that the wetland resources provide basic means of livelihood for the people. Wetland resources such as land, water resources

and forest/trees provide economic, social and ecological services supporting the livelihoods of the people. Land was classified into cropland, pastureland and forest/woodlot land. Cropland is used for crop production or rented for income generation. Pastureland is either owned as a private plot or as communal grazing areas. The farmers have strong control over the management of privately owned pastureland. In addition to feed supply, the pasture produced is sold to generate income. Renting cropland and income generation from pastureland are dependent on the land's fertility. Land degradation due to erosion and poor management is a major threat to sustainable land use. The findings show that 26% of the cropland and 65% of the pastureland were degraded, producing smaller yields than previously.

As the population pressure increased over time, the land holding size declined. For instance, the size of land per household declined during the last 10 years from 2.48 to 2.28 ha in the adjacent areas and from 2.71 to 2.34 ha in the non-adjacent areas (see table*** above). Due to the high demand for farmland, there has been a decline in the application of traditional means of land fertility management, such as crop rotation and fallowing, and a large number of the farmers are now using chemical fertilizers to aid crop production.

Valuation of the cropland was made using the rental values of two classes of cropland: high and low productivity classes. The cropland with high productivity was rented for Birr 3,000 and 2,000 in the adjacent and non-adjacent areas, respectively while the cropland with low productivity was rented at Birr 1,600 and 1,300 per ha in the respective locations. The overall economic value of cropland was estimated at Birr 1.1 billion per year at the 2007 rental value. If the land management system and the productivity of the land are improved, the TEV of cropland could increase to Birr 1.25 billion.

The pastureland was valued taking into consideration the economic benefit obtained from the land without additional labor or capital inputs. During 2007, pasture produced on a hectare of land was sold for Birr 4,000 and 1,600 in adjacent and non-adjacent areas depending on the land fertility. In addition, the proportion of households accessing private and communal pastureland as well as the pastureland quality classes were also considered in the valuation process. Accordingly, the TEV of pastureland was Birr 309 million during 2007. If the pastureland quality could be increased to a high productivity level through conservation and field management, the TEV could increase to Birr 506 million.

Water resources in the Lake Tana sub-basin provide different benefits to the people: water supply for human beings and livestock, and economic activities through irrigation, fishery and water transport. The ecological factor is also immense. The town municipality generates income from urban water supply. During 2007 alone, the Bahir Dar town administration generated Birr 7.8 million from water sales. At a daily per capita rural water consumption rate of 12 liters and price of Birr 1.75 per m^3, the value of rural water supply in the sub-basin was estimated at Birr 19.6 million. Lake Tana is also used for public transportation with both goods and people being transported. During 2007, the public transport generated Birr 3.38 million, while private local water transport service providers earned Birr 58,000 from the transport of wood and grass. SEE LIMNOLOGY CHAPTER It was also estimated that irrigation water has an added value of Birr 2.5 million in the sub-basin, assuming 2,500 ha of land is irrigated, excluding small scale traditional irrigation.

Fishery is one of the economic activities practiced on Lake Tana. Organized fishers' groups and unorganized rather 'non-affiliated'? fishermen earn their living from the fisheries sector. Some households also practice occasional fishing for personal

consumption. Fishing is not strictly regulated, thus creating serious concerns for the sustainable use of fishery resources. Unorganized fishers' groups harvest fishes of all sizes and do not respect the fishing seasons. These groups harvest an estimated 2.5 million fish per year, which is quite high. In total, the fishery sector provides Birr 8.3 million to the economy of the sub-basin. In total, the TEV of water resources in the sub-basin was estimated at Birr 41 million per year, where 65% of the value was allocated to water supply and 20% to fishery production.

Trees have use and non-use values. The direct use value of trees was expressed as an economic value, while the indirect use value was expressed in terms of environmental protection. The option values that can be expressed in terms of contribution to biodiversity were relatively difficult to capture. The non-use values were deduced from the people's interest to keep selected trees as bequest value or existence value, which in this study is called the 'social value' of trees. The valuation process involved estimating the following factors: (i) the economic benefits that households obtained by selling or using trees from their own plots or from communal forest areas, (ii) the proportion of households benefiting from trees, (iii) identifying the trees with environmental and social values, (iv) the unit values of these trees, and (v) the number of these trees per household, so that appropriate aggregation can be made. The TEV of trees in the Lake Tana sub-basin was estimated at Birr 905 million at the 2007 price. Direct economic benefits account for 80% of the tree values while 17.5% and 2.5% of the values are attributed to cultural and environmental values, respectively. The role of gender and culture in natural resources management was high.

The economic values of wildlife as natural resources in the wetlands were assessed. The results indicate that damages caused by wildlife on crop yields accounted for an estimated Birr 2 million, while the proxy values of birds hunted for consumption was Birr 105,000. The damage caused was high in the adjacent areas where the forest cover is relatively dense. In general, the TEV of the natural resources in the wetlands of Lake Tana sub-basin was estimated at Birr 2.385 billion.

The major threats to natural resources use are environmental degradation in the area, high population pressure, poverty and pollution of Lake Tana. Poverty is a major factor in human encroachment into the forest area to cut and sell trees. In order to overcome the problem of food insecurity, which affected 71% of the population, different investment options have been planned and implemented by the Ethiopian government.

9.6 Recommendations

Wetlands resources provide means of livelihood for people in the Lake Tana sub-basin and downstream along the Blue Nile River. In order to reduce over-exploitation and enable sustainable use of these natural resources, the following recommendations are suggested:

i. The economic values of the wetlands prevail. The resources valuation process attempted in this work covered a wide range of resources and in many instances was limited by the lack of technical information. It is recommended that an in-depth environmental valuation of the key resources in the Lake Tana Sub-Basin be carried out, such as: the value of trees including their medicinal use value, amount of firewood used per household, the erosion control values of a wider range of tree species, etc. Moreover, the polluting impact of chemicals on water quality and on

the biodiversity and the economic costs of improving the water quality should be measured.

ii. It was observed that the rental values of cropland and rangeland depend on the land quality. It is therefore apparent that the value of natural resources can be enhanced through adoption of different conservation strategies. Soil and water conservation through physical and biological conservation techniques should be further enhanced. In addition to increasing land productivity, conservation measures reduce siltation in the lakes and rivers, increase rainfall infiltration and thereby improve ground water discharge, increase biodiversity and ultimately ensure sustainable supply of water.

iii. Comprehensive implementation of integrated watershed management envisaged by the Ethiopian Government is a good instrument for sustainable use of the natural resources. It should be appropriately planned and implemented in such a way that SWC and erosion control receive due attention. This may require capacity building and technical support in an integrated watershed management.

iv. In order to diversify the household incomes and reduce the burden on natural resources, human resources capacity building through awareness creation on environmental protection, optimum livestock size, agri-business enterprises, etc. are necessary. Income diversification in non-agricultural activities through capacity building and credit facilities helps reducing the pressure on land. Promoting saving and credit facilities and providing financial facilities with compatible terms and conditions, investment in children education are some of the strategies.

v. Improved agricultural technologies that economize the use of water resources increase productivity of land is crucially important. Investment in agricultural development has been envisaged as the best way of overcoming food insecurity in the country and attaining economic growth. Some agricultural enterprises such as floriculture and irrigation schemes are appropriate in this regard. Yet, the environmental and social impacts of these investments should be adequately addressed.

vi. Forest cover near the Lake Tana controls erosion. The ownership of the community forest in Zeghe is in contest. The community argues that it is planted by grand fathers and it is the source of livelihood. Trees ownership should be agreed upon by all concerned since tenure systems affect the sustainability.

vii. The sustainability of this forest depends on alternative livelihood systems since the farmers use income generated from tree selling for subsistence. In fact the wildlife hosted by the forest is considered a threat for crop production. Quantitative assessment also shows an economic loss of Birr 2 million due to wildlife. Poor living standard coupled with negative impacts of wildlife can easily lead to exhaustion of the forest unless alternative and viable income generation activities are implemented in the area. In effect, the forest can be considered as an opportunity for expanding production system suitable to the area such as apiculture and forest-based production systems such as korarima. The monkey population needs to be controlled.

viii. Trees are widely considered as economic assets. Several farmers plant trees and supplement their income from trees. This can create good opportunity for private woodlot development for commercial purposes. This strategy can help to increase

tree cover of the area and contribute to soil and water conservation. Involving women in private woodlot development provides alternative mechanisms of providing firewood and reducing work burden of women.

ix. Provision of energy saving technologies and alternative energy sources in Bahir Dar can reduce the demand for firewood, which is eroding the forest in the sub-basin in general and Zeghe area in particular.

x. Promote area closure and enrichment plantation, delineation of parks and sanctuaries as a means of rehabilitating the environment and improving the diversity of flora and fauna of the area. It is also necessary to capitalize on the cultural values of trees in the investment process.

xi. Sustainable use of fishery resources requires enforcement of the legal framework for fishery development and marketing. Legalizing fishing activities, establishing fishing standards, delineation of breeding areas and fishing seasons, accountability and quality control should all be put in place.

xii. Sanitary policies that safeguard lake water quality and reduce pollution should be applied and enforced. A good starting point would be development of the urban sanitary facilities and waste disposal systems at Bahir Dar.

xiii. The support of countries downstream of the Blue Nile is needed for cooperative water resource management in order to ensure sustainable use of the transboundary resources.

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Appendices

Appendix 9.1 Household Survey Questionnaire

Instruction:

1. This questionnaire refers to the household (HH) and should be administered with the head of the HH, male or female.
2. Before starting with the interview, explain the purpose. The purpose of the interview is to assess the importance of natural resources around Lake Tana and the value the community attaches to these resources. The opinion of the respondents on how the resources are used and managed and the type of protection they give will help to draw conclusion how the resources can be used in a sustainable manner.
3. All information given will be held confidential and will not have any negative consequences to the respondent.

I: GENERAL

1. Enumerator

1.1 Name of the enumerator: _____

1.2 Signature of the enumerator ensuring completeness of the questionnaire and correctness.

Sign: _____ Date: _____

II. Identification of the Respondent and Household Characteristics

2.1. Zone: _____

2.2. District: _____

2.3. Locality (Kebele): _____

2.4. Name of the household head (respondent): _____

2.5. Age of the respondent (years) _____

2.6. Sex of the respondent (√): [ ] 1. Male [ ] 2. Female

2.7. Education level completed by the respondent (√):

[ ] 1. No formal education [ ] 2. 1st cycle (1-4th grade)
[ ] 3. 2nd cycle (5 to 8th grade) [ ] 4. High school (9-10th grade)
[ ] 5. Completed preparatory [ ] 6. Certificate
[ ] 7. Diploma [ ] 8. Degree [ ] 9. Religious education

2.8. Current marital status of the respondent (√) [ ] 1. Married [ ] 2.Unmarried [ ] 3.Divorce [ ] 4.Widowed

2.9. Religion of the respondent (√):

[ ] 1. Orthodox [ ] 2.Islam [ ] 3. Protestant [ ] 4. Catholic

[ ] 5. Others (specify) _____

2.10. How long have you lived in this place? _____ years

2.11. Family size of the household: [__] Male [___] Female [____] Total

2.12. No. of persons with age of above 60 years: [___] Male [____] Female [__] Total

2.13. No. of persons in the HH with age of 15-60 years who are not able to work due to illness: [_____] Male [_____] Female [_____] Total

2.14. No. of children with age of 10-15 years: [___] Male [____] Female [____] Total

2.15. No. of children less than 10 years old: [____] Male [____] Female [____] Total

2.16 What are your household's means of income generation? (multiple answer possible, rank as 1st, 2nd, 3rd , etc)

1. [ ] Crop production
2. [ ] Livestock production
3. [ ] Handicrafts
4. [ ] Grain trading
5. [ ] Livestock trading
6. [ ] Fishing
7. [ ] Selling forest product (firewood, etc)
8. [ ] Employed and earn salary
9. [ ] Selling proceed food (also drink)
10. [ ] Remittance
11. [ ] (specify): _____

2.17 Which of the following income generation activities are performed by women, men and children?

No.	Income generation	Work of women?	Work of men?	Work of children?
1	Crop production			
2	Livestock production			
3	Handicrafts			
4	Grain trading			
5	Livestock trading			
6	Selling forest product (firewood, etc)			
7	Employed and earn salary			
8	Wage/casual work			
9	Selling proceed food (also drink)			
10	Remittance			
11	Others (specify)			

III. Natural Resources and Use

3. Land and Land Use System (crop and livestock production, land conservation,)

3.1 How did you get the land you are currently using?

[ ] 1. Recent government land redistribution
[ ] 2. Land redistribution during the Derg regime
[ ] 3. Inherited from parents
[ ] 4. Shared from parents/gift
[ ] 5. Purchased
[ ] 6. Rented
[ ] 7. Share cropping
[ ] 8. Others (specify) _____

3.2 Size of land owned by the household and its use (ha)

Sr. No	Type of use	Before 10 years	Current year (2007)	Reasons for change between the two years*
1.	Total land owned			
2.	Crop land (including gardens)			
3.	Grazing area (own)			
4.	Forest and woodland			
5.	Marshy area			
6.	Proportion of degraded land (% of total land owned)			
7.	Irrigated area (ha)			
8.	No. of plots owned			

Note: *#2 to 5 will add up to #1.*

* Use: 1= Land redistribution by government 2= Land distributed to grown up children
3= Expansion of lake; 4= Expansion into uncultivated land; 5= others (specify) _____

3.3 Have you ever had conflict with your neighbors or relatives on the use land?
[ ] 1. Yes [ ] 2. No

3.4 If Yes, what was the effect of the conflict?
[ ] 1. A person/s wounded (give number) _____ persons
[ ] 2. Death of people in the conflict (give number) _____ persons
[ ] 3. Resolved without any damage (give number if there is expense for resolving
the conflict) _____ Birr
[ ] 4. Others (specify) _____

3.5 What is the cause of conflict on land?
[ ] 1. Shortage of land
[ ] 2. Inequitable distribution of fertile land
[ ] 3. Increasing demand on land due to population increase
[ ] 4. Others (specify)
_____

3.6 How was your cultivated area allocated and how much was the production level

Sr. No	Type of crop produced in 1999 EC	Area (timad)	Area (ha)	Actual total production harvested		Estimated loss by wild animals (qt)
				Production (qt)	Price per qt. (Birr)	
1	Maize					
2	Sorghum					
3	Millet					

4	Teff					
5	Wheat					
6	Barely					
7	Rice					
8	Haricot beans					
9	Horse bean					
10	Peas					
11	Chickpeas					
12	Oil crops (list)					
13	Vegetables (list)					

3.7. What yield increasing inputs did you use to produce outputs given in Table 3.6 above?

Sr. No	Type of crop produced in 1999 EC	Urea (Kg)	DAP (KG)	Local seed (kg)	Improved seeds (kg)	Pesticide (Birr)	Herbicide (Birr)	Irrigation (Yes/No)	What would be the yield if not irrigated (qt)	Is the plot conserved ? Yes/No	What would be the yield if not irrigated and conserved? (qt.)
1	Maize										
2	Sorghum										
3	Millet										
4	Teff										
5	Wheat										
6	Barely										
7	Haricot beans										
8	Horse bean										
9	Chickpeas										
10	Peas										
	Oil crops (list)										
11	Vegetables (list)										

3.8 Do you grow perennial crops? [ ] 1. Yes [ ] 2. No

3.9 If Yes to Q3.8, list the type and income generated during the 1999 EC.

Sr. No	Type of perennial crop owned	Area (timad)	Area (ha)	No. of trees	Actual total production harvested in 1999 EC		Estimated loss by wild animals (qt)
					Production (qt)	Value of output (Birr)	
1	Coffee						
2	Chat						
3	Orange						
4	Mandarin						
5	Mango						
6	Banana						
7	Lemon						
8	Avocado						
10	Others (list)						

3.10 What is the source of irrigation water?

[ ] 1. Lake [ ] 2. River [ ] 3. Pond [ ] 4. Collected/harvested water

[ ] 5. Other sources (specify) _____

3.11. Did you use rent land for production during the last two years? [ ] 1. Yes [ ] 2. No

3.12 Is the land irrigated or marshy area? Please fill the following table:

Sr. No	Nature of the land rented	Area (Timad)	Rent value for 1 production cycle (Birr)	Rent value if the land is not irrigable or 1 production cycle (Birr)
1	Irrigated			
2	None irrigated			
3	Marshy area			

3.13. What is the proportion of land that is vulnerable to erosion hazard? _____ %

3.14. Do you have conserved land? [ ] 1. Yes [ ] 2. No

3.15. If Yes to Q3.14, who conserved the land?

1. [ ] My self using own labour arrangement
2. [ ] Government did it through productive safety net program
3. [ ] NGOs 4. [ ] Parents did it before 5. [ ] Others (specify)

3.16. What type of conservation is made on your land, when and current status?

Sr. No.	Conservation methods	Yes/No	Area conserved (Timad)	No. of years since conserved	Current status*
1	Tree planting				

2	Terracing/trenching				
3	Furrow making				
4	Others (Specify)				

* 1= Structure in good condition; 2= Structure partially damaged; 3= Damaged

3.17. Extent of economic benefit of conservation (compare conserved and non-conserved area used for production of the same crop using similar inputs):

1. [ ] Yield of crop increased by about 25%
2. [ ] Yield of crop increased by about 50%
3. [ ] Yield of crop increased by about 100%
4. [ ] Yield of crop remained the same
5. [ ] Honey production increased
6. [ ] Livestock productivity increased
7. [ ] Others (specify)_____

3.18. Change in environmental benefit of conservation (compared to before conservation):

1. [ ] The vegetation cover increased 2. [ ] Soil erosion decreased
3. [ ] No. of wild animals increased
4. [ ] Type of plants and animals in the area increased
5. [ ] Others (specify)_____

3.19. Type and number of livestock owned (Head count)

Sr. No	Type of livestock	Before 10 years		Current year (2007)	
		No.	Value	No.	Value
1	Oxen				
2	Cows				
3	Heifers and bulls				
4	Sheep				
5	Goat				
6	Donkey				
7	Horse				
8	Mule				
9	Camel				
10	Poultry				

3.20. Do you have access to communal grazing land? [ ] 1. Yes [ ] 2. No

3.21. If No to Q3.20, why not?

[ ] 1. No communal land
[ ] 2. Use of communal land is restricted/forbidden
[ ] 3. Does not have livestock
[ ] 4. Labour shortage of herding

3.22. If Yes to Q3.20, what would be the value of feed your livestock graze from communal pasture (ask by an example of if a given plot of pasture area is purchased in the area)? _____ Birr

3.23. If you are asked to sell out your land at very high value, would you sell your land?
[ ] 1. Yes [ ] 2. No

3.24. If Yes to Q3.23, what is the proportion of land you would sell?
[ ] 1. Less than 25% of the total land
[ ] 2. 25-50% of the total land
[ ] 3. 50-75% of the total land
[ ] 4. More than 75% of the total land
[ ] 5. All of the land I own

3.25. If you sell a portion of your land, what type of land would you sell first?
[ ] 1. None irrigable cultivated land
[ ] 2. Irrigable cultivated land
[ ] 3. Perennial crop land
[ ] 4.Grazing land
[ ] 5. Marshy area
[ ] 6. Forest/wood land
[ ] 7. Others (specify) _____

3.26. If No to Q3.23, why not? (Multiple response possible)
[ ] 1. It is the base of my family's livelihood
[ ] 2. I will not know other ways of income generation other than agriculture
[ ] 3. The value of land is appreciating
[ ] 4. It is what I can inherit to my children
[ ] 5. I will loss social value if I become landless
[ ] 6. Others (specify) _____

4. Forest and Woodland

4.1 Do you have trees in your garden or plots? [ ] 1. Yes [ ] 2. No

4.2 If yes to Q4.1, please tell us the type, how many they are and the purpose

No.	Type of tree	No. of trees owned now	Purpose: (1=Construction, 2= Sale; 3= Firewood; 4=Conservation; 5=Prestige	No. sold in 1999EC.	Income earned (Birr)	No. cut in 1999 EC for construction or firewood
1	Eucalyptus					
2	Ficus tree					
3	Zigba					
4	Acacia spp.					
5	Coniferous/Tid					

6	Olive/Woira					
7	Wanza					

4.3. Are there cultural values of these trees? [ ] 1. Yes [ ] 2. No

4.4. If Yes to Q4.3, how do you rate this value?

[ ] 1. Equal to the market value of the tree
[ ] 2. Double the market value of the tree
[ ] 3. Three times the market value
[ ] 4. Four times the market value
[ ] 5. Others (specify) _____

4.5. If Yes to Q 4.3, which trees have cultural value? _____

4.6. Would you cut these threes for different uses? [ ] 1. Yes [ ] 2. No

4.7. If Yes to Q4.6, what is the condition? _____

4.8. Does cutting of these trees depend on selling price? [ ] 1. Yes [ ] 2. No

4.9. If Yes to Q4.8, what is the maximum price you would accept to cut it?

No.	Type of tree having cultural value	Maximum acceptable price to cut
1		
2		

4.10. Have you ever thought of keeping the trees to stand as a symbol after your death?

[ ] 1. Yes [ ] 2. No

4.11. If Yes to Q4.10, which trees? _____

4.12. Have you ever thought of keeping the trees to inherit your children?

[ ] 1. Yes [ ] 2. No

4.13. Do you see the presence of trees as threat or beneficiary to your livelihood?

[ ] 1. As a threat [ ] 2. As beneficiary [ ] 3. As both

4.14. If response to Q4.13 is a threat, explain reasons: _____

4.15. Have you ever thought of keeping trees for soil and water conservation?

[ ] 1. Yes [ ] 2. No

4.16. Do you use trees from communal forest?

No.	Type of tree	No. of trees cut in 1999 EC	Purpose: (1=Construction, 2= Sale; 3= Firewood; 4=Conservation; 5=Prestige/cultural 6= Honey production 7= Wild life	No. sold in 1999EC.	Income earned (Birr)	No. cut in 1999 EC for construction or firewood
1	Eucalyptus					

2	Focus tree					
3	Zigba					
4	Acacia					
5	Coniferous/Tid					
6	Olive/Woyra					
7	Wanza					

4.17. Did you hunt wild animals during 1999 EC? [ ] 1. Yes [ ] 2. No

4.18. If yes to Q4.17, what type of animals and how many animals?

Sr. No.	Name of wild animal (Birds and others)	No. hunted in 1999 EC	Estimated value of meat from one animal (Birr)*
1			
2			
3			
4			
5			

* Estimate as equivalent to domestic animals of same size, at market price

4.19. Is there traditional law that governs tree planting?

[ ] 1. Yes [ ] 2. No

4.20. If Yes to Q4.19, please explain the law: _____

5. Water Resources and Use

5.1 Do you benefit from Lake Tana or rivers feeding to the lake? [ ] 1. Yes [ ] 2. No

5.2 If Yes to Q5.1, for what purposes?

[ ] 1. Irrigation
[ ] 2. Fishing
[ ] 3. Other edible animals from the lake
[ ] 4. Edible plants from the lake
[ ] 5. Livestock watering
[ ] 6. Drinking water
[ ] 7. Household use/washing, cooking, etc)
[ ] 8. Transport (using boats)
[ ] 9. Others (specify) _____

5.3. If you or a member of the household harvested edible animals from the lake, how much did you get during 1999 EC? Estimate also the value.

Sr. No.	Type of food harvested from the lake (Fish and others)	No. harvested in 1999 EC	Price of one (Birr)*	Utilization (1=Consumed; 2=Sold)
1	Fish			
2				
3				

* Estimate the value taking the market price (if the item can be sold in the market)

5.4. What is your observation of the fish population in lake Tana?

[ ] 1. Increasing over time
[ ] 2. Declining over time
[ ] 3. The same as before
[ ] 4. I don't know

5.5. What is your opinion on water pollution of the Lake Tana?

[ ] 1. Highly polluted
[ ] 2. Not much polluted
[ ] 3. No pollution
[ ] 4. I don't know

5.6. If you observed a sort of pollution, what do you think is the reason?

[ ] 1. Waste disposal from Bahir Dar
[ ] 2. Agricultural chemicals (pesticides and fertilizer)
[ ] 3. Others (specify) _____
[ ] 4. I don't know

5.7. Have you ever confronted any conflict on the use of irrigable or marshy area?

[ ] 1. Yes [ ] 2. No

5.8. Is the conflict on wetlands more severe than on drylands? [ ] 1. Yes [ ] 2. No

5.9. How do you resolve the conflict on natural resources?

[ ] 1. Bring the case to kebele administration
[ ] 2. Bringing the case to traditional leaders who apply traditional laws
[ ] 3. Individual agreements
[ ] 4. Court case
[ ] 5. Others (specify) _____

6. Other Means of Livelihood

6.1 If you were involved in income generation activities other than agriculture (crop and livestock), how much did you/your household earned during the 1999 EC from the following activities?

1. Petty trade: _____ Birr
2. Hand craft: _____ Birr
3. Remittance: _____ Birr
4. Brokering: _____ Birr
5. Fishing: _____ Birr
6. Transport service: _____ Birr
7. Employment (wage/salary): _____ Birr
8. Tourist guide: _____Birr

9. Selling of wood/charcoal/firewood: _____Birr

10. Others (specify) _____

6.2 How is the direction of change in the income from different sources compared to before 10 years (1= increased; 2= decreased; 3= the same/no change)

No.	Income source	Direction of change relative to 10 years ago(1= increased; 2= decreased; 3= the same/no change)
1	Annual crop production	
2	Perennial crop production	
3	Livestock production	
4	Fishing	
5	Hand crafts	
6	Petty trade	
7	Tourist guide	
8	Brokering	
9	Selling of wood/charcoal/firewood	
10	Employment (wage/salary)	
11	Remittance	
12	Transport service	

6.3 For how many months could you feed your family?

In 1999 EC: _____ Months

10 years ago: _____ Months.

6.4 If there is a change, what are the reasons? _____

6.5 What are the coping strategies when the household faces food shortage? Rank them

[ ] 1. Sell livestock [ ] 2. Sell household assets

[ ] 3. Cut trees and sell fire wood/charcoal [ ] 4. Hunt wild animals including birds

[ ] 5. Fishing [ ] 6. Ask for food aid

[ ] 7. Others (specify) _____

6.6 Sources of animal protein for your family:

[ ] 1. Own livestock [ ] 2. Meat/mutton purchased

[ ] 3. Fish [ ] 4. Hunt wild animals including birds

[ ] 5. Others (specify) _____

6.7 How often is fish consumed in your household? _____Meals per week

6.8. Are there fish types not allowed by the tradition to eat? [ ] 1. Yes [ ] 2. No

6.9. If Yes, to Q6.8, what are they? _____

6.10. Do you eat aquatic plants from the lake? [ ] 1. Yes [ ] 2. No

6.11. If Yes to Q6.10, which ones?

_____

Thank you so much for your cooperation

Appendix 9.2: Checklist for Focus Group Discussions and Key Informants Interview

Land use system:

1. Identify list of crops grown in the area (annual and perennial)?
2. What are the production systems? Irrigated, Marshy, Non-irrigated?
3. What is the share of wetland (irrigable and marshy areas) in the total land holding of an average household? Do women have equal access to wetlands?
4. Do women and female headed households have equal access to land as men do? Explain the situation.
5. What are the means used by the people to increase access to land? (Land sharing among relatives, renting, share cropping, purchasing, etc.)
6. Discuss land availability and changes in land size over time? If there is a sense of land shortage, what are the reasons? Prioritize the reasons. What is the implication for sustainable utilization of the wetland resources?
7. How does the value of wetland differ from the other land type? (Get comparative value of the rent of wetland (irrigable and marshy land of 1 timad) and non-irrigable land of the same size.
8. Compare productivity of irrigated, marshy and non-irrigated land under similar input level (take similar and most common crop suitable for comparison per Timad)
9. How is the land quality changing over time and reasons?
10. What are land conservation practices employed (indigenous and introduced)? Which ones are widely used? Which ones are more effective?
11. Compare yield of crop on conserved and non-conserved area (under the same technology)
12. What are the best ways of conserving trees? What should be done?
13. Is there conflict on land use? How is it resolved?

Forest/trees:

14. What type of trees grow in your area? Where are they kept (garden, farmland, communal land, church compound, etc.)
15. What are the purposes of these trees (direct use value, indirect use values such as conservation and option values such as inheriting to children, recreation, biodiversity, etc.).
    a. Direct value: Take two specific trees and try to estimate the number of such trees pre HH, the market value of trees (honey production-description), construction, fire wood,
    b. Indirect value: Take one of the above trees and estimate the damage avoided by the presence of the trees in the field. Discuss the environmental protection

values of these trees e.g. wind break, erosion control, shade for coffee production and estimate the loss avoided. Discuss and estimate the following.

c. Take area closure, if any. Describe the perception of the community on the satisfaction they get in terms of shade trees, weather/climate improvement, qualitative assessment of how big value they would attach the environmental benefits. What is the yield of coffee with and without shade tree? Consider same management.

d. Option value: What are the social and cultural values of trees? Are trees kept to inherit to children? Are trees kept for prestige? Do trees have role after death of the owner? Discuss these and try to get estimate of these values in terms of what a person think it deserves: What number of trees could be equivalent to inheriting 1 ox to children?

16. How is the forest tree population changing and why?
17. What is the role of women in tree planting and conserving?
18. Do people view trees as opportunity or threat?
19. What are the best ways of conserving trees? What should be done?

Animals

20. Type of animals in the area:
    a. Livestock in the area
    b. Type of wild animals
    c. Type of Birds
    d. Type of aquatic life they know
21. Purposes of these animals (food-hunted or trapped-,
22. The animals whose population is declining and purposes
23. Wild animals being hunted by the people
    a. Which ones
    b. Purpose of hunting? (for food, sales, entertainment, culture, etc)
    c. Value of just one animal compared to purchasing meat of similar weight
    d. Estimated number of such animals hunted per year/month?
    e. What type of social group/people involved in hunting the animals? (rich, medium, poor, the unemployed, the marginalized, etc)
24. Are wild animals threats or opportunities for your livelihood?
25. What are the opinions of the community on the best ways of conserving wild animals

Culture and tradition:

26. What are the indigenous institutions responsible for natural resources management? How do the functions of the traditional institutions differ from the functions of the government institutions?
    a. Consider land management (land allocation, erosion prevention, etc)
    b. Forest/tree preservation?
    c. Wildlife conservation and use?
    d. Fishery?
27. What are the culture governing the land use? Is there traditional law governing land use? What are these laws and how are they applied? Is there any contradiction with the existing land use law of the government?
28. What are the traditions/culture that promote natural resources protection?
    a. Culture/practices of prevention of soil erosion
    b. Traditional ways of promoting tree planting
29. Are all fish types edible? Identify those not edible and why?
30. Do the people make discriminatory protection of the edible and non-edible fish types? Explain how the difference occurs?
31. There are different plant species. Are there spp not permitted by the tradition/culture to grow on farmers land? If yes, why? Where should such spp grow?
32. Are there plant spp. not allowed by the tradition/culture/religion to cut? Which ones and why?
33. Ask similar questions for:
    a. Birds
    b. Other wild animals
34. What are the indigenous institutions that can enhance sustainable use of land, forest, water resources and wild animals?

Appendix 9.3: List of Participants of Focus Group Discussions

No	Zone	District	FA (Kebele)	Name of participant	Sex
1.	S/Gonder	Fogara	Qora Abo	Kassahun Shibabaw	Male
2.				Asnaku Getnet	Female
3.				Janbare Yirdaw	Male
4.				Tadesse Alemu	Male
5.				Teshager Yazen	Male
6.				Yekabe Agizez	Female
7.			Woreta Zuria	Hailu Asmare	Male
8.				Misganaw Dagnew	Male
9.				Gudu Takele	Male
10.				Nigist Turu	Female
11.				Yeshi Maru	Female
12.				Abebe Tafa	Male
13.				Bilata Muchadegn	Male
14.				Bilata Berad Jagni	Male
15.			Nabega	Babu Abebe	Male
16.				Kes Niguse Yirdawa	Male
17.				Bilata Abebe Sebdek	Male
18.				Bilata Sew Ayalew	Male
19.				Abeje Belachew	Male
20.				Kasanesh Tegeng	Female
21.			Wogtera	Demoz Tsegu	Male
22.				Tsegaw Muchbelew	Male
23.				Wase Getaw	Male
24.				Mintamr Yimer	Female
25.	W/Gojam	Bahir Dar Zuria	Debre Tsehion	Kes Mare Endale	Male
26.				Eshet Admas	Male
27.				Amare Deresse	Male
28.				Yekabe Agizez	Female
29.				Kes Mulate Endale	Male
30.				Ayele Mengessha	Male
31.			Zeghe	Tadesse Emiru	Male
32.				Tadesse Gedo	Male
33.				Getnet Getu	Male
34.				Tibebu Abebe	Male
35.				Hunegnew Tsegaye	Male
36.				Tesfaye Eneyew	Male
37.			Wogelsa	Belay Yimem	Male
38.				Kerebish Gebre	Female
39.				Meseret Wubayehu	Male
40.				Atnikut Gebeyehu	Male
41.				Misganaw Kebede	Male
42.				Abe Atnikut	Male

No	Zone	District	FA (Kebele)	Name of participant	Sex
43.			Robit	Adugna Mokonen	Male
44.				Wide Mekonen	Female
45.				Misganaw Alem	Male
46.				Hunachew Tegene	Male
47.				Maru Alemu	Male
48.				Tilahun Tegegn	Male
49.				Misganaw Nega	Male
50.				Berhanu	Male
51.		North Achefer	Sankira	Gebru Abiye	Male
52.				Genetu Alemu	Male
53.				Demelesh Alemu	Male
54.				Nigatu Sinsew	Male
55.				Yihun Asmare	Male
56.				Adina Shiferaw	Female
57.			Qunzila	Gebre Terefe	Male
58.				Mulugeta Addis	Male
59.				Nlitesh Semi	Female
60.				Habtamu Adir	Male
61.				Mulugeta Chane	Male
62.				Wube Takele	Female
63.				Atnikut Aregaw	Male
				Total	**63**