Data Collection and Compilation on Environment and related issues in Eastern Nile Sub-Basin in Ethiopia

ENTRO
(Eastern Nile Technical Regional Office)

By Assefa Guchie –DELTA DMCS
Addis Ababa , 2006

Disclaimer

This Consultants report does not necessarily represent the views and opinions of Easter Nile technical Regional Office (ENTRO) or any institution of the Eastern Nile Countries. The designation employed in the maps and the presentation of the material in this document does not imply the expression of any opinion whatsoever on the part of the Eastern Nile Technical Office concerning the legal or constitutional status of any administrative region, state or Governorate ,country, or concerning the delimitation of any frontier.

TABLE OF CONTENTS

Introduction

This report deals with the environmental aspect of the three Nile Sub-basins in Ethiopia, namely: Abbay, Baro-Akobo and Tekeze. Its scope goes much beyond the draft outlines prepared during the inception meeting of the One-System Inventory. Despite the longer time required for its preparation, the consultant on his own believed in the necessity to incorporate as many data and information as possible in respect of the objectives of the consultancy assignments and the general framework of the inventory itself.

It is to be noted that the dominant part of the report has been based on the studies of the basins' master plans conducted in late 1990s, as they make the sole informative resource at the moment. Relevant parts of those studies (hardcopies) have been photocopied and submitted to ENTRO, including digital spatial data referring to individual basin, basin-consisting regions and the nation at large.

In general, the report and its accompanying data and information consist of:

- *This written report;*
- *Studies and reports on natural resources and environmental issues;*
- *Policies and legislations related to the environmental theme;*
- *Spatial environmental data in semi-processed, clipped and structured state;*
- *Regional and National spatial data as they were collected at the sources; and*
- *Statistical data computed based on known and important attributes of respective basins;*

The consultant has, accordingly, submitted:

- *Hardcopy references compiled into physical folders by basin;*
- *Softcopy (digital) data and information collected from various institutions- on 11 CDs; and*
- *The main report for the consultancy assignment.*

This report contains seven main parts. The first part summarizes major issues considered and collected in soft and hardcopy formats. Issues summarized in that part of the report are arranged in accordance with the content.

The second part provides invaluable points of environmental policy; legislations, guidelines, institutional frameworks and international agreements at work in Ethiopia.

The third, forth and fifth parts present basin-specific elements of environment especially as they were studied and documented by international consultants and the Federal Ministry of Water Resources Development of Ethiopia. These are informative parts, which have been considered important by the consultant of the Environment Theme in Ethiopia.

The sixth part dwells on general comments on the quality of data and recommendations on the tasks that might be necessary for consideration by ENTRO.

Last but not least are annexure on the list of computed datasets, softcopy spatial data, list of softcopy studies reports, policy, legislation and bibliography of the reference materials collected and identified by the consultant.

1. EXECUTIVE SUMMARY

1.1 Policy and Institutional Issues

The issue of environmental protection and management has got impetus in the Constitution of the Federal Democratic Republic of Ethiopia. The Constitution's provisions seems to have paved the way for the formulation of federal resources conservation strategy, the federal environmental policy, proclamations for the establishment of institutional organs for environmental protection, environmental impact assessment, environmental pollution control; and related environmental protection guidelines.

The conservation strategy of Ethiopia was prepared with joint consultations of the regional authorities in the country. The preparation of the strategy has been the major factor for the establishment of the Federal Environmental Authority and the formulation of the environmental policy. In line with the regional conservation efforts, it is said that the regions have prepared their own strategies in order to provide inputs to the federal-level conservation strategy.

The environmental policy was enacted after the approval by the Council of Ministers in 1997. Among others, the policy touches major sectoral issues of soil management and sustainable agriculture, forest and tree resources, genetic species and biodiversity, water, energy, mineral resources, the urban environment, industrial and atmospheric pollution and conservation of cultural resources.

The overall goal of the policy is to improve and enhance the health and quality of life of all Ethiopians through sound management and use of natural, cultural resources and the environment as a whole.

In specific terms, the policy focuses on sustaining the preservation of biological diversities, benefits from non-renewable resources by minimizing the negative impacts of exploitation; identifying and developing underutilized resources; incorporating the issues of environments in the national development plans; prevent all aspects of pollutions, enhance peoples' participation in environmental protection and environmental knowledge bases.

The environmental protection organs created by Proclamation No. 295/2002, have been instrumental for sustainable use of environmental resources and strengthening of coordinated efforts among environmental agencies at federal and regional levels. According to the proclamation, such organ consists of four hierarchies, namely: the Prime Minister's Office, Environmental Protection Authority, Environmental Protection Council, Sectoral Environmental Agencies and the Environmental units at district levels.

Following the creation of environmental protection organs, environmental impact assessment proclamation No. 299/2002 was issued with the objectives of bringing about thoughtful development by mitigating environmental impacts of development activities; assessing public documents before approvals; and prediction and management of adverse environmental impacts in the process of implementing environmental rights enshrined in the constitution.

Pollution control has been enacted by Proclamation 300/2002.The proclamation consisted pollution control, management of hazardous waste, chemicals and radioactive substances, environmental standards, the rights and duties of environmental inspectors and penalties.

Furthermore, sectoral guidelines designed to help in the implementation of environmental impact assessment processes have been prepared for the agricultural, transport and industrial sectors as well as for the leather processing plants and settlement programmes. The guidelines facilitate the inclusion of environmental issues in the development proposals. The guideline enables strategic environmental assessment, social impact assessment, and project environmental assessment.

Ethiopian has also entered into international agreements and conventions, some of which are: Convention on Biological Diversity; the United Nations Convention to Combat Desertification (CCD; the Vienna Convention for the Protection of the Ozone Layer; Framework Convention on Climate Change (FCCC); the Basel Convention on the control and regulate the trans-boundary movement of hazardous waste, the Stockholm Convention on banning the use of persistent organic pollutants, the Rotterdam Convention for prior consent in international trade causing specific hazardous chemicals and pesticides; and International Convention on Trade in Endangered Species, Fauna and Flora.

To date, there are no independent environmental studies of the three Nile sub-basins in Ethiopia, namely: Abbay, Baro-Akobo and Tekeze-Setit. However, available information of that sort solely refer to the sub-basin studies carried out during the last decade by the Federal Ministry of Water Resources Development. Those studies were carried out until late 1990s (between 1997 – 1999), having one to three separate phases.

The following information are provided based on the separate sub-basin studies.

1.2 Basin Situations

1.2.1 Abbay Basin
Abbay basin occupies an area of 199,812 km^2 in the eastern and central part of Ethiopia. The basin's location extends between 7^0 45' and 12^0 45' N longitude 34^0 05' to 39^0 45' E.

The basin's elevation varies from 490 m.a.s.l, where the Abbay crosses the Sudan border, to 4,247 m.a.s.l in the eastern highlands in Ethiopia. The part of the basin in Ethiopia falls within vast volcanically formed plateau situated between 2000 to 3000 m.a.s.l.

Abbay basin contains a mixed topography of high mountains, rolling ridges, flat grassland areas and meandering streams that can create spectacular waterfalls where they plunge over the escarpment to the lowland areas. Lake Tana is the largest lake in the basin and is located in the northeastern part of the basin, being the main source of Abbay River.

According to the FAO, the basin is classified in to three general topographic units: the plateau highlands of elevation between 2000 – 2700 m.a.s.l; the plateau valley in the eastern part; and the lower plains and eroded hill lands in the western part.

Influenced by the equatorial location and the altitude ranging above 500 m.a.s.l, the basin has rich local climate varying from hot and nearly desert along the Sudan border to temperate on the high plateau or even cold on the mountain peaks.

The rainy season (Kiremt) contributes from 50% up to nearly 90% of the annual rainfall. The mean annual rainfall within the basin varies from 800 – 2000 mm and generally increases with altitude. Rainfall in most of the basin is uni-modal with the majority of the rain falling in the wet season (June to September).

Temperature decreases with altitude at a general rate of about 0.7^0 C per 100 m elevation, while humidity increases with decreasing altitude.

According to the basin's study, there are five types of climate:

- ***Tropical Climate II:** with mean temperature of the coldest month above 18^0 C and mean annual rainfall between 1200 and 2800 mm;*

- *Tropical Climate III with mean temperature of the coldest month above 18^0 C and*
- ***Warm Temperate Climate** I: with dry months in winter, mean temperature of the coldest month below 18^0 C; the mean rainfall in the driest summer month at least one-third of the mean rainfall in the wettest winter month;*
- ***Warm Temperate Climate II**: with no clear dry season, mean temperature of the coldest month below 18^0 C, the mean rainfall in the driest summer month at least one-third of the mean rainfall in the wettest winter month;*
- ***Cool Highland Climate**: with dry months in winter, mean temperature of the warmest month below 10^0 C and a mean annual rainfall between 800 and 2000 mm.*

The dominant soil unit in the basin is Nitosol, which covers almost 36% of the basin's area. Soils formed in the eastern part of the basin form the basaltic rock, deep, productive, well-structured and inherently well-drained agricultural soils. They are intensively cultivated by the predominant household agriculture. The western part of the basin is less productive in which the soils are classified into varieties including the Nitosols and Vertisols.

The land cover study made in late 1990s showed that close to 34% of the basin's area has been cultivated, while the other 30% has been occupied by woodland, bush land and shrubs. The proportion of grassland has been relatively significant with 23% percent. In general, the basin could be divided into cultivated land in the east and woodland in the west.

Formerly undisturbed forest areas are rapidly being converted into agricultural land and settlements. Reports indicate that forests on a total 0f 2,276km^2 have been cleared and trees almost totally removed thus damaging about 1% of the basin. The standing volume for disturbed forests is in the order of 135 m^3/ha and for very disturbed forests this is reduced to 58 m^3/ha. In the highland areas, farming and grazing practices have significantly altered the original flora so that only remnant vegetation now exists in only a few places.

A west-east transect of the Abbay River basin would show a wide range of potential faunal habitats ranging from tropical dry land savana areas near the Sudanese border to montane vegetation in the eastern part of the basin. However, there has been severe reduction in wildlife habitats and numbers within the Abbay basin due to the conversion of large areas of land to agricultural use.

Abbay basin is one of the richest in the availabilityof water resources. Tana Lake with its area of 3,042 km^2 provides freshwater both to Abbay river and Bahir Dar Town in Amhara Region. The quality of water at the lake is said to be satisfactory for human uses. Apart from high sediment loads, the water quality of all rivers that are distant from urban centers, within the basin appears to be adequate for most uses (irrigation, livestock and with treatment suitable for human use).

Having a high fishery potential, Lake Tana is the most important source in the basin, while the tributaries of Abbay have low potential. Apart from Lake Tana, there is little information on fish species within the basin and no systematic fish identification has been done so far.

The main wetland areas within the basin occur around Lake Tana, the Finchaa and Chomen swamps and the large Dabus swamp which is located within west Wellega zone of Oromiya Region.

Regarding the wildlife habitats, there has been severe reduction in the Abbay basin due to the conversion of large areas of land for agricultural use. However, the lowland areas of the basin are less favored for human settlement due to the presence of tsetse fly and other climate related human health problems. In these lower western and northwestern areas of the basin, some of the large wildlife continue to survive at reasonable population levels.

Large areas of the basin have apparent land suitability for irrigation; however, water availability is seen to be generally constraining. In the highlands, the highest potential appears to be around Lake Tana, offering supplement irrigation and double cropping potential. In the lowlands, the lower Dabus valley and an area in East Wellega appear to offer the highest immediate potential. However, these comments refer to land potential only; they do not take into account water availability.

In the basin, livestock conditions are deteriorating. In part, the expansion of crop production in the face of increasing population and degrading resources has come at the expense of livestock. More and more traditional grazing areas are being cultivated and the growing livestock population is increasingly being relegated to marginal lands.

The major environmental threats identifies in Abbay basin are:

- *Land degradation;*
- *Deforestation;*
- *Loss of biodiversity; and*
- *Pollution and environmental health;*

1.2.2 Baro-Akob Basin

Baro-Akobo basin is an important watershed of the Whiter Nile with its drainage covering a total land area of 76,000 km^2. The basin includes all or part of four Regions: SNNRP in the south, Oromiya in NE, Gambela in the central western portion and Benshangul in the north western extreme.

The land comprises high plateaux elevation ranging from 1500 and 2000 m and mountains with peak exceeding 2500 meters easternmost and southern portion of the basin.

The size of population during the study was estimated at 2.2 Million with some 90% in the highland and the remaining part in the lowland. About 92% of the population is rural and the remaining 8% is classified as urban.

The temperature range in the area is from about 27^{0}C below 500 m.a.s.l on the flood plain to 17.5 ^{0}C at 2500 m.a.s.l in the highland. The range in mean maximum is 35 to 24 ^{0}C and mean minimum from 20 to 10^{0}C.

The mean annual rainfall distribution of the basin shows considerable spatial variation due to the variability in the nature of the topography. It has been reported that over the low land areas the mean annual rainfall is as low as 600 mm; and over the high land areas it reaches as high as 3000 mm. The basin is particularly well-watered region of Ethiopia. Most of the upper basin has an annual total rainfall over 1800 mm. Significant proportion of rain falling during the storms is lost by runoff and the occasional light rainfall out of season when soil and foliage are hot is lost by evaporation so the effective average rainfall of 750 mm annually in the low land raising to about 1250 mm in the high land.

The land use/land cover in the basin is extraordinarily unique in respect of situations in the country. Open woodland covers as high as 42% followed by cultivated area, which is 20% of the total area of the basin. Areas covered by forest also reach 18%, characterizing better ecology among the southwestern areas of the country. It is reported that the basin contains about 2.2 million ha of forests. The stock constitutes more than half of Ethiopian's remaining forests. In the area, however, loss by exploitation and uncontrolled burning exceeds the rate of forest growth.

The presence of natural vegetation, among other things has enabled the basin to be considered as one of the most important wild life reserve in Ethiopia. However, the present status hardly warrants a protected area of any kind as large part of the original park has been cleared for cultivation, grazing and other purposes.

Studies on the fish and fisheries of the Baro-Akobo basin are limited. No estimates of the number of fisheries operation in the region or an evaluation of their catch are available. But the Russian study in the upper catchment around Ale Wereda found some 40 fish species out of the 75 identified in the lower Baro-Akobo plain. In comparison to the lower catchment, there is little fishing in the upper catchment, but is purely on subsistence basis using traditional methods.

The traditional fishing practice is seasonal in the lower part of the basin. Flooding between June and October prevents most fishermen operating and thus the main fishing season is restricted to the drier periods between October and April.

In the basin, it is estimated that 1.2 million cattle, 0.4 million Sheep, 0.24 million goats, 0.09 million equines and 1.1million chicken exist. In the lower basin, the livestock are managed on a migratory system in response to the availability of grazing and water in the plain but the seasonal distribution of the feed is constrained. In the upper basin, feed resources are the main constraints to livestock production.

There are 18 irrigation potential areas identified in the scattered location in the upper part of Baro-Akobo basin. Of those identified, 17 of them were found to be unsuitable. In contrast with the upper basin, the lower basin, specifically the Gambela plain area offers many promising possibilities for the development of irrigation. The Ethiopian Government has decided to undertake the development of 10,400 ha at Alwero project that includes the Abobo dam. Based on water and land resources availability, the net area that can ultimately be developed is about 480,000 hectare.

Like in Abbay basin, soil erosion, land degradation and deforestation in Baro-Akobo basin are always expected to be environmental threats.

1.2.3 Tekeze Basin

Tekeze river basin is situated between latitudes 11^0 40' and 15^0 12' north and longitudes 36^0 30' and 39^0 50'. The area of the basin is about 86,510 km^2, of which a small part of the basin (4,160 km^2) is situated in Eritrea. Inside Ethiopia, the basin has an average elevation of 1,850 m.a.s.l and a catchment area of about 59,306 km^2. The area of land above 2,000 m elevation covers almost 40% of the total basin area. The river's slope is quite steep in the mountainous stretch (> 1.5 %), but decreases gradually to 0.3%, and then to less than 0.1% in the lowlands.

Tekeze river basin can be roughly divided into highlands at altitude of more than 1,500 m and lowlands at 500 to 1,500 m above sea level. The highlands have a mountainous to hilly topography, interspersed with flat to rolling plateaux and plains. The Tekeze basin as whole is characterized by the dominance of steep land and more than 50 % of the basin has slope gradient of over 30%.

Annual precipitation amounts show large variations over the basin. Humera in the lowland area has an average precipitation of 600 mm, while locations near the Simien Mountains have annual average above 1,300 mm.
In the lowland area (600 mm) average annual temperature are above 26^0C, while in the Simien Mountains the average temperatures falls below 10^0C. In the largest part of the highlands, the average temperature is around 22^0C.

In the study area, soils with well-developed profiles are rare. Soils developed in moderately deep-to-deep black clays (vertisols and vertic soils) are the main exception, having a fair real extent. Nearly all other soils are shallow, truncated or show very little profile development.

With high rate of increase in both human and animal populations in Tekeze basin, woodlands and bush lands have fallen under pressure. A number of factors have contributed to this, including population growth which induces increased demand for agricultural land and pasture and causes increased fuel wood harvesting exceeding both the woodland and bush lands regenerative capacity. The basin has an acute shortage of industrial wood, which is being imported from other parts of the country. There is no industrial plantation established in the basin for current and future consumption. Woodlands characterize the dominant vegetation cover of the basin and bush lands which occur mainly in the agro-pastoral zones along the northern and western part of the basin. They have been heavily used as a source of gum, incense, fuel wood and fodder for livestock.

Honey production is said to be better in Tekeze basin. Total production is estimated at 2,018 tons per annum, which makes for some 8.2 % of the national honey production.

It is reported that the basin has aquifers/formations with very low productivities except high and medium productive areas concentrated around Mekele and Hagere Selam areas. The water point inventory survey carried out on 720 points indicated that an average of 2.69 l/sec is extracted from each well in 8 hours per day, providing a total extraction per year of 28 Mm^3.

As to the ground water resources, a total of 8,191 Mm^3 has also been estimated to flow from Tekeze, Angereb and Goang, all of which make up the basin as a whole.

The hydropower potential of the basin is quite large. Rivers are quite steep and some have deep gorges, which make ideal dam sites. However, high dams and large reservoirs are required to produce sufficient power. The total potentially generable firm energy of the basin is 4117 GWh/yr.

Large scale irrigation potential created by impounding water in large dam in the lower reaches of the river has been calculated at 189,500 ha, on the bases of data on mean annual regulated flow from reservoirs in the Tekeze, Angereb and Goang/Gendua.

Tekeze river basin has been a focal point of the Ethiopian Wildlife Conservation due to the presence of Simien Mountains National Park. The ecosystem of the Simien Mountains national park is unique for its scenery, endemicity and genetic importance of the plants and animals that occupy the habitat. Among the numerous wildlife in the country, the Walia Ibex, "Key Kebero" (Ethiopian wolf)) and the Gelada Baboon are found in the Semien National Park, which is a distinctly known geographical area in the country.

There are important commercial fish species in Tekeze river basin. Most people living along the river courses do fish during the year. In the upper and mid reaches of the river basin, occasional and part-time fishermen produce 4 – 1,000 kg of fish per year. Fish catches with local fishing materials are between 20 and 60 kg/yr. Gill net catches are in order of 1,000 kg/yr. The fish catches are higher (up to 3,000 kg/yr) than those of the highland fishermen, but still insignificant due to the primitive nature of the fishing gear.

About 82% of the basin is not suitable for irrigation due mainly to high slope gradients in 73% of the basin. Rooting conditions limiting plant growth constrain about 69% of the area of the basin. Thus only about 5% of the basin is highly suitable for irrigated agriculture, most of which are found in the western lowlands.

If enough sites for micro-dams in the upper and middle catchments can be found, 1,500 dams each storing one million m^3, could be foreseen. These can provide supplementary irrigation on a small-scale basis to 450,000 ha of cropland in the wet season and to 112,500 ha in the dry season.

In Humera, Angereb and Metema, a total of 71,000 hectare has been proposed for large-scale irrigation, of which the lion's share is found in the former area. The existing irrigation practices are dominated by traditional and inefficient practices; and area coverage and productivity are at low levels. The current area coverage is not more than 10,000 ha virtually no external inputs and improved water management practices are adopted by the farmers.

Small-scale mixed farming system is dominant in the whole Tekeze river basin. Although the proportion of farmers in the whole basin is low, in the lowlands of the northwest of the basin there are farmers who own cattle and goats in large numbers and who depend totally on livestock production. The primary feed source in the Tekeze river basin is natural pasture. Crop aftermath is also extensively used.

Protection of lands from erosion has started to get full attention of the responsible line agencies. Awareness of erosion increases rapidly in the rural communities. The extent of areas with traced cropland, comprising both old and recently built terraces is considerable and still increases rapidly.

Malaria infestation, land degradation, erosion, deforestation, water-borne diseases and pests have been identified as the major environmental threats in Tekeze basin.

Regarding the impacts of major developments, malaria infestation, other waterborne and transmittable diseases are expected from dams and reservoirs.

2. PLICY, INSTITUTIONALFRAMEWORK AND LEGISLATIONS

2.1 Environmental Policy of Ethiopia

The supreme law of the land, the Constitution of the Federal Democratic Republic of Ethiopia, (Proclamation No.1/1995) contains provisions, which recognize the importance of the environment protection and the need for its proper management. These provisions are the major springboards for subsequent legislations in the environmental management, as well as for mainstreaming environmental sustainability in the political, social and economic development sectors.

2.1.1 The Policy Goal, Objectives and Guiding Principles

2.1.1.1 The Overall Policy Goal

The overall policy goal is to improve and enhance the health and quality of life of all Ethiopians and to promote sustainable social and economic development through sound management and use of natural, human-made and cultural resources and the environment as a whole so as to meet the needs of the present generation without compromising the ability of future generations to meet their own needs.

2.1.1.2 Specific Policy Objectives

The Policy seeks to:

a. Ensure that essential ecological processes and life support systems are sustained, biological diversity is preserved and renewable natural resources are used in such a way that their regenerative and productive capabilities are maintained and where possible enhanced so that the satisfaction of the needs of future generations is not compromised; where this capability is already impaired to seek through appropriate interventions a restoration of that capability;

b. Ensure that the benefits from the exploitation of non-renewable resources are extended as far into the future as can be managed, and minimize the negative impacts of their exploitation on the use and management of other natural resources and the environment;

c. Identify and develop natural resources that are currently under utilized by finding new technologies, and/or intensifying existing uses which are not widely applied;

d. Incorporate the full economic, social and environmental costs and benefits of natural resource development into the planning, implementation and accounting processes by a comprehensive valuation of the environment and the services it provides, and by considering the social and environmental costs and benefits which cannot currently be measured in monetary terms;

e. Improve the environment of human settlements to satisfy the physical, social, economic, cultural and other needs of their inhabitants on a sustainable basis;

f. Prevent the pollution of land, air and water in the most cost-effective way so that the cost of effective preventive intervention would not exceed the benefits;

g. Conserve, develop, manage and support Ethiopia's rich and diverse cultural heritage;

h. Ensure the empowerment and participation of the people and their organizations at all levels in environmental management activities; and

i. Raise public awareness and promote understanding of the essential linkages between environment and development.

2.1.1.3 Key Guiding Principles

Underlying these broad policy objectives are a number of key principles. Establishing and clearly defining these guiding principles is very important, as they will shape all subsequent policy, strategy and program formulations and their implementation. Sectoral and cross-sectoral policies and environmental elements of other macro policies will be checked against these principles to ensure consistency.

The Key Guiding Principles are:

a. Every person has the right to live in a healthy environment;

b. Sustainable environmental conditions and economic production systems are impossible in the absence of peace and personal security. This shall be assured through the acquisition of power by communities to make their own decisions on matters that affect their life and environment;

c. The development, use and management of renewable resources shall be based on sustainability;

d. The use of non-renewable resources shall be minimized and where possible their availability extended (e.g. through recycling);

e. Appropriate and affordable technologies which use renewable and non-renewable resources efficiently shall be adopted, adapted, developed and disseminated;

f. When a compromise between short-term economic growth and long-term environmental protection is necessary, then development activities shall minimize degrading and polluting impacts on ecological and life support systems. When working out a compromise, it is better to err on the side of caution to the extent possible as rehabilitating a degraded environment is very expensive, and bringing back a species that has gone extinct is impossible;

g. Full environmental and social costs (or benefits foregone or lost) that may result through damage to resources or the environment as a result of degradation or pollution shall be incorporated into public and private sector planning and accounting, and decisions shall be based on minimizing and covering these costs;

h. Market failures with regard to the pricing of natural, human-made and cultural resources, and failures in regulatory measures shall be corrected through the assessment and establishment of user fees, taxes, tax reductions or incentives;

i. Conditions shall be created that will support community and individual resource users to sustainably manage their own environment and resources;

j. As key actors in natural resource use and management, women shall be treated equally with men and empowered to be totally involved in policy, programme and project design, decision-making and implementation;

k. The existence of a system, which ensures uninterrupted continuing access to the same piece(s) of land and resource, creates conducive conditions for sustainable natural resource management;

l. Social equity shall be assured particularly in resource use;

m. Regular and accurate assessment and monitoring of environmental conditions shall be undertaken and the information widely disseminated within the population;

n. Increased awareness and understanding of environmental and resource issues shall be promoted by policy makers, by government officials and by the population, and the adoption of a "conservation culture" in environmental matters among all levels of society shall be encouraged;

o. Local, regional and international environmental interdependence shall be recognized;

p. Natural resource and environmental management activities shall be integrated laterally across all sectors and vertically among all levels of organization;

q. Species and their variants have the right to continue existing, and are, or may be, useful now and/or for generations to come;

r. The wealth of crop and domestic animal as well as micro-organism and wild plant and animal germplasm is an invaluable and inalienable asset that shall be cared for; and

s. The integrated implementation of cross-sectoral and sectoral federal, regional and local policies and strategies shall be seen as a prerequisite to achieving the objectives of this Policy on the Environment.

2.2 Sectoral and Cross-sectoral Environmental Policies

Sectoral and cross-sectoral policies and strategies that incorporate, directly or indirectly, environmental concerns have been formulated and are being implemented. The following are the major ones:

- **Cross-sectoral Policies and Strategies**: - These include polices and strategies on rural development, capacity building, poverty, disaster preparedness and prevention management, conservation and environment, science and technology, population, women, biotechnology, poverty reduction, food security etc. in addition such programmes as that of poverty reduction and food security are also in place.

- **Sectoral Policies and Strategies***:* - These include, policies and strategies on energy, water resources development and management, fertilizers, bio-diversity conservation and research, agricultural research, health, education and training etc.
- **The Conservation Strategy of Ethiopia and the Environmental Policy of Ethiopia**: - The Conservation Strategy of Ethiopia consists of 10 cross-sectoral and 10 sectoral issues pointing out the strategies for the sustainable development of the country. The preparation of the document has taken more than seven years. It was prepared through Federal and regional level joint consultations. The preparation of this document has been a major factor

leading to the establishment of the Ethiopian Environmental Protection Authority and the formulation of the Environmental Policy of Ethiopia. The regions have prepared region specific conservation strategies expected to promote regional conservation efforts. What is more, these regional conservation strategies have provided input to the similar federal level process.

2.3 Legal Enforcement of the Policy

The Council of Ministers approved the Ethiopian Environmental Policy in 1997. The following sectoral and cross-sectoral issues are included in the Environmental Policy: -

- Sectoral Environmental Policies
  - Improved soil management and sustainable agriculture,
  - Forest and tree resources management,
  - Genetic, species and ecosystem biodiversity conservation and management,
  - Water resources development,
  - Energy resources development,
  - Mineral resources development,
  - Urban Environment and environmental health,
  - Control and management of pollution from industrial waste and hazardous materials,
  - Control of atmospheric pollution and climate change,
  - Conservation and Protection of Cultural and Natural Resources,
- Cross-sectoral policies
  - Population growth and distribution, and its impact on natural resources
  - Peoples' participation and environment
  - Rural land and natural resource tenure and access
  - Land use planning
  - Social, cultural and gender issues
  - Environmental economics
  - Environmental information system
  - Environmental research
  - Environmental impact assessment
  - Environmental education and awareness

2.4 Policy Implementation

Although the Environmental Policy of Ethiopia consists of the above listed sectoral and cross-sectoral policies, no evaluation has been carried out regarding their implementation.

The activities undertaken to implement the conservation strategy and the environmental policy are not that much significant. However, the following major activities have been undertaken in connection:

- The Environmental Protection Authority has been established at the federal level;
- Three regional states have established their own environmental organs;
- Proclamations for pollution control, environmental impact assessment, and for the establishment of environmental protection organs have been enacted;
- The National Plan of Action to Combat Desertification has been prepared;
- The Environmentally Sustainable Industrial Development Strategy has been prepared; and
- The Environmental Protection Authority's organizational structure has been revised

2.5 Environmental Legislation, Guidelines and Standards

One of the objectives of the Ethiopian Federal Democratic Republic Constitution (Proclamation No, 1/1995) is to ensure the existence of a clean and healthy environment. It provides that all persons have the right to a clean and healthy environment.

2.5.1 Proclamations

Based on the Constitution, three different proclamations have been drafted by the Environmental Protection Authority and enacted by the Council of Representatives.

2.5.1.1 Proclamation for the Establishment of Environmental Protection Organs

The main objective of this Proclamation is assigning responsibilities to separate organizations for environmental development on the one hand, and environmental protection, regulation and monitoring on the other, avoiding possible conflicts of interests and duplication of efforts. The Proclamation has been enacted as Proclamation No. 295/2002 on 29th of October 2002. The proclamation is instrumental in the sustainable use of environmental resources and fosters a coordinated and yet distinct responsibility between and among environmental agencies at federal and regional levels.

This Proclamation provides for the Environmental Protection Authority, which is accountable to the Prime Minister. In addition it provides for the Establishment of Environmental Protection Council as well as sectoral agencies and Environmental units.

Pursuant to this proclamation each relevant government organisation shall establish under it environmental units with the responsibility to ensure that its activities are being carried out in a manner which is compatible with the environmental law and obligations emanating there from. In addition, the proclamation entrusts environmental organs to be established by the regions with extensive mandates that enables the coordination of environmental activities, avoids duplication and improves the dissemination of environmental information.

2.5.1.2 Environmental Pollution Control Proclamation

This Proclamation was enacted as Proclamation No. 300/2002 on 2nd of December 2002. It was enacted to help realize the effective implementation of the environmental objectives and goals incorporated in the Environmental Policy. In addition, the Proclamation was enacted because:

- Some of the social and economic development endeavours may be capable of causing environmental impacts that might be detrimental to the development process itself;
- The need to protect the environment in general and particularly safeguard human health and well-being, preserve the biota and maintain an untainted aesthetics is the duty and responsibility of all; and
- It had become essential to prevent or minimize the undesirable pollution resulting from economic development through appropriate measures.

The Proclamation consists a number of articles on different issues such as pollution control, management of hazardous wastes, chemicals and radioactive substances, environmental standards, the rights and duties of environmental inspectors and penalties etc.

2.5.1.3 Environmental Impact Assessment Proclamation

The main reasons for enacting this proclamation are the following:

- Environmental Impact Assessment serves to bring about thoughtful development by predicting and mitigating the adverse environmental impacts that a proposed development activity is likely to cause as a result of its design, location, construction, operation, modification and cessation.
- A careful assessment and consideration of the environmental impacts of public documents prior to their approval, provides an effective means of harmonizing and integrating environmental, economic, social and cultural considerations and aspirations into the decision-making process in a manner that promotes sustainable development.
- Implementation of the environmental rights and objectives enshrined in the Constitution requires the prediction and management of likely adverse environmental impacts, ways in which the benefits might be maximized, and the balancing of socio-economic benefits with environmental costs.
- Environmental impact assessment serves to bring about administrative transparency and accountability, as well as involve the public and, in particular, communities in development planning decisions which may affect them and their environment.

The Proclamation was enacted as Proclamation No. 299/2002 on 2nd of December 2002.

The enactment of these proclamations will help much in the effort to bring about sustainable development in the country. EPA is preparing procedures regulations, guidelines and standards to effectively implement and enforce the proclamations.

2.5.2 Other Laws

In addition to the above-mentioned proclamations, other environmental related proclamations and regulations prepared by sectoral agencies and approved by the pertinent body are being implemented. These are

- Forestry Proclamation No. 94/02
- Mining Works Council of Ministers' Regulation 82/98;
- Labour Proclamation No, 45/95;
- Investment Proclamation No 37/96;
- Commercial Registration and Business License Proclamation No. 67/97;
- Water Resources Management and Administration Proclamation No. 197/2000;
- Environmental Health Proclamation No. 200/2000;
- Mining Proclamation of 2001;
- Radiation Protection Authority Establishment Proclamation No. 79/1993; and
- Urban Zoning and Construction Permit Proclamation.

2.5.3 Environmental Guidelines

Environmental guidelines, among others, are tools that help the incorporation of environmental concerns and the concepts of sustainable development in development decision-making. In the past, such environmental guidelines did not exist in Ethiopia.
However, since the establishment of the Environmental Protection Authority in 1995, sectoral guidelines designed to help in the implementation of environmental impact assessment processes have been prepared for the agricultural, transport and industrial sectors as well as for the leather processing plants and settlement programmes.

Environmental guidelines are one of the tools for facilitating the inclusion of environmental issues and principles of sustainable development into development proposals. In Ethiopia there has not been any environmental guidelines in the past. However, following the establishment of the Environmental Protection Authority by virtue of Proclamation No. 9/95, sectoral Environmental

Impact Assessment guidelines focusing on agriculture, transport, industry, tannery and settlements have been prepared.

In addition to these, a general guideline for facilitating EIA in all sectors has been prepared. The fundamental purpose of this guideline is to ensure that proponents, the government and all other interested and affected parties have the opportunity to participate meaningfully in the EIA process. Since the guideline explicitly states the responsibilities of each party, it helps to eliminate problems that may arise form lack of understanding of the process, from acting beyond ones mandates and responsibilities as well as from sheer inadvertence.

The guideline indicates that EIA, strategic environmental assessment, social impact assessment, and project environmental assessment can be carried out in conjunction with each other. Moreover, it includes specific procedures for the identification of matters that should or should not be subject to EIA. Although an effort was made to introduce the guidelines in a workshop it is not sufficient from the point of view of enhancing the awareness of all those concerned about its contents.

In addition, EPA is preparing guidelines for the preparation of projects for the follow up and supervision of environmental matters to be submitted to the Global Environmental Facility as well as for waste disposal, for environmental education, gender and social impact assessment.

2.5.4 Environmental Management, Conservation and Regulatory Instruments

2.5.4.1. Environmental Impact Assessment and the State of the Art

In Ethiopia, national institutions such as the former Ethiopian Valleys Development Study Authority (EVDSA) and the Water Resources Commission were undertaking Environmental Impact Assessment of Projects at various degrees. However, there was no law requiring environmental impact assessments on projects, programs and policies likely to result in adverse environmental impacts. Hence, until recently, ***voluntary EIA was being undertaken only to comply with Article 4 of the Investment Proclamation No. 37/1996***. In addition, in line with the conditional ties and policy requirements of funding agencies, EIA has been undertaken on projects financed by loans and grants.

The Environmental Impact Assessment Proclamation of 1995 incorporates Project, Strategic and Social Impact Assessment. Therefore, the implementation of projects, programs or policies likely to have environmental impact shall not be allowed unless they include impact mitigation and contingency plans.

The Environmental Impact Assessment Guideline focuses on the implementation of the following principles:

- The application of the EIA process at an early stage investment planning;
- The participation of all interested and affected parties in the process;
- The consideration of all feasible alternatives (for example: - alternative sites or sources of raw materials as well as a "no-go" option) for the project; and
- The application of an operational system that ensures transparency and accountability.

The participation of interested or affected parties at all the critical stages of the EIA process is stated as a prerequisite. At the federal level, coordination of Environmental Impact Statement (EIS) is the mandate of the Environmental Protection Authority, and of regional environmental agencies at the regional level.

The federal Environmental Protection Authority is mandated to review the EISs of projects that may have an environmental impact of a trans-boundary nature, whether regional or international as well as of Federal Investment Authority licensed projects. Moreover the Environmental Protection Authority shall also be involved in the review of EISs where it is requested to do so by the regions in situations where the scale or the level and complexity of the impact of a project requires such involvement. In all other cases regional bodies with environmental mandates shall review project EISs.

The state of the Art

In Ethiopia, strategic environmental assessment has never been fully undertaken. However, the River Basin Master Plan Projects and assessments carried out by the Ministry of Economic Development and Cooperation had incorporated some strategic environmental assessments.

Until recently, there was no law or guideline that require formal strategic environmental impact assessment as part of the project cycle. Taking this fact into consideration, the Environmental Impact Assessment proclamation has been adopted. As the proclamation provides a framework for strategic environmental impact assessment, the problems that existed in this regard in the past are considered to have found a solution.

Accordingly, the law requires that environmental impact assessment be carried out on any policies, programs and international agreements. It is expected that carrying out such assessments will help decision makers at all levels in their effort to bring about sustainable development.

However, guidelines, which enable the application of this tool, are not yet prepared. Since the tools for impact assessment are still at the developmental stage, including in the developed countries, it will require a lot of effort to apply them to useful purpose. Lack of qualified and skilled manpower, and environmental information as well are additional constraints on the application of strategic environmental impact assessment.

2.6 International Agreements and their Implementation in Ethiopia

Ethiopia has adopted and ratified several international conventions and agreements related to the environment. The major ones are:

2.6.1 Convention on Biological Diversity

The Convention on Biological Diversity has three goals:

- The conservation of biodiversity;
- The sustainable use of the components of biodiversity; and
- The fair and equitable sharing of the benefits arising from the use of genetic resources.

The Convention was ratified by Ethiopia by Proclamation 98/94, on May 31, 1994.

Various activities are being carried out towards the implementation of this convention. The following are some of the exemplary activities:

- A project entitled, *"A Dynamic Farmers Approach to the Conservation of Plant Genetic Resources" has been implemented using financial support from Global Environmental Facility (GEF);*
- A National Biodiversity Protection and Research Policy has been prepared;
- Prior to 1998, the Institute of Biodiversity whose responsibility was to sample and conserve the country's plant genetic resources, has now transformed itself into the

Institute of Biodiversity Conservation and Research with additional duties regarding animal life and micro-organisms.

- Places for *in situ* conservation of coffee species has been identified in various parts of the country.
- A Forest Genetic Resources Conservation Project is being implemented. This project commenced in 1999 with financial support from GTZ. Its objectives include development of national forest genetic resources research strategy, registration of woody biomass, conducting socio-economic surveys in natural forest areas, establishing forest gene banks, compiling data on indigenous trees and shrubs, awareness creation and institutional capacity building.
- A Project for the Conservation and Sustainable use of Medicinal Plants is being implemented. The objective of this project is to promote the expansion of medicinal plants through *in situ* conservation in internationally recognized areas by encouraging their sustainable use. The Institute of Biodiversity Conservation and Research is implementing the project with financial support from the Global Environmental Facility. Through this project, efforts are being made to identify and gazette areas for *in situ* conservation and management of medicinal plants, undertake detailed socio-economic and biological survey, as well as draw up resource protection and management alternatives and guidelines.
- *National Biodiversity Strategy and Programme:* - The project aims at developing a national biodiversity strategy and programme in collaboration with the relevant federal and regional institutions.
- *Wildlife Protection Support Programme:* - This programme is being implemented with financial support from several international donors and the details of its activities are as follows:
    - Establishment of an endowment fund, rehabilitation of infrastructure, undertaking community and tourism development in 6 national parks as well as rehabilitating and enhancing the management of protected areas of prime importance is in progress with assistance from UNDP. The Ethiopian Wildlife Conservation and Development Organization with technical support from the World Wildlife Fund, East African Regional Programme is implementing this project.
    - Rehabilitation of three national parks (Omo, Mago and Nech Sar) is underway with financial support from the European Union.
    - A Programme for the conservation of priority forests is being undertaken with financial support from the Dutch Government.
    - An effort is being made to improve household security for pastoralists and undertake conservation and protection activities in the Awash National Park.
- A Project for the Conservation and Sustainable Use of Biodiversity in the East African Rift Valley Lakes is being considered for implementation by Ethiopia, Kenya and Tanzania with financial support from Global Environmental Facility. The objective of the project is to strengthen and enhance the conservation and sustainable use of the biodiversity resources in these lakes. The project particularly aims at developing and strengthening appropriate systems for the protection and conservation of threatened ecosystems.
- A Biodiversity Protection and Conservation Support Project in important bird areas is being implemented. The project has been operational since 1999 by the Ethiopian Wildlife Conservation and Development Organization with financial support from the Global Environmental Facility.

2.6.2 The United Nations Convention to Combat Desertification (CCD)

The objective of the Convention is to combat desertification and mitigate the effects of droughts in countries experiencing serious drought and/or desertification, particularly in Africa. Ethiopia has ratified the Convention by Proclamation No. 80/1997.

To implement the Convention the following activities are being carried out with the coordination of the Environmental Protection Authority and financial support provided by various donor agencies.

- Completion of the drafting of a national programme for combating and controlling desertification;
- Providing some capacity building support and implementing awareness raising programmes in the regions;
- Preparation by some of the regions of regional programmes for combating and controlling desertification.
- Using participatory approaches, pilot projects designed to demonstrate for communities how degraded land can be rehabilitated are underway in four regions.
- The drafting of a gender strategy designed to facilitate the incorporation of gender issues into the programme for combating desertification is in the process of preparation.
- A draft document with respect to the establishment of a fund for combating desertification has been finalized.

2.6.3 The Vienna Convention for the Protection of the Ozone Layer

The basic objective of this Convention is to combat the negative impact on the environment and human beings resulting from ozone depleting substances by reducing the amounts released and eventually banning their commercial use through internationally agreed measures. The Montreal Protocol entered into force in 1989 to facilitate the implementation of the Convention.

Ethiopia ratified and became party to the Vienna Convention and the Montreal Protocol in January 1996. The National Meteorological Services Agency has been mandated for the coordination and supervision of implementation of this convention in Ethiopia.

The following activities have so far been conducted towards implementing this convention:

- A programme for controlling ozone-depleting substances in Ethiopia is in place.
- A National Ozone Team has been established under the auspices of the National Meteorological Services Agency.
- A project for the repair and reuse as well as a programme with respect to the handling of CFC-based refrigerators have been developed;
- A draft legislation for the control substances that deplete the ozone layer has been prepared; and
- Training on awareness creation training has been conducted.

2.6.4 Framework Convention on Climate Change (FCCC)

Ethiopia has ratified this Convention by Proclamation No. 97/1994 on May 2/1994. This convention takes into account the fact that climate change has transboundary impacts. The basic objective of this Convention is to provide for agreed limits regarding the release of greenhouse gases into the atmosphere and prevents the occurrence or minimizes the impact of climate change.

The following major activities have been undertaken to implement the Convention at national level:

- Within the National Meteorological Services Agency, a Climate Change and Air Pollution Research Team has been established;

- Major sources of greenhouse gases in the country have been registered. A preliminary research has also been conducted to verify the effect of climatic change on the water flow of the Awash River as well as on wheat production and forest resources;
- Research has been undertaken on the best possible measures to minimize greenhouse gas emissions associated with energy utilization as well as from grazing and livestock production.
- A National Climate Change Report has been prepared for the first time in the country and submitted to the Secretariat of the Convention.

2.6.5 The Basel Convention

The objective of the Basel Convention is to control and regulate the trans-boundary movement of hazardous waste. The Bamako Convention of 1991 plays a similar role at the level of the African continent.

Ethiopia has ratified the Convention by Proclamation No. 192/2000. At present measures designed to amend the Basel Protocol is in progress. In addition, activities related to prior informed consent are being carried out. Furthermore, to implement the Convention within the country, draft policies and legislation have been prepared and submitted to the government.

2.6.6 The Stockholm Convention

In the year 2002, Ethiopia fully accepted and ratified the Stockholm Convention designed to ban the use *of persistent organic pollutants (POPS).* The Environmental Protection Authority has the full mandate to implement the Convention at the national level. A project to develop an appropriate system for the realization of the objectives of the Convention in Ethiopia is in progress.

2.6.7 The Rotterdam Convention

This Convention relates to prior informed consent in the context of international trade in specific hazardous chemicals and pesticides. The Environmental Authority is the organ responsible for the domestic implementation of this convention, which has been ratified by Ethiopia in 2003. The Environmental Protection Authority is preparing a framework for its implementation.

2.6.8 International Convention on Trade in Endangered Species, Fauna and Flora

The objectives of the Convention are:

- To control international trade in endangered species
- To ensure that international trade in non-endangered species is carried out in a manner which ensures stable markets and economic benefits for the exporting countries as well as to control and regulate illegal trade in such non-endangered species, fossils and/or their derivatives.

Ethiopia has ratified the Convention. The mandate to implement the Convention at the Federal level is bestowed upon the Ethiopian Wildlife Protection and Development Organization.

2.7 Environmental Projects and Programmes

The following projects have either been already implemented or are in the process of implementation:

- Project for the Control and Disposal of Expired Pesticides;
- Project for the Preparation of a National Chemical Handling and Registration guideline;
- The Ecologically Sustainable Industrial Development Project;

- The National Cleaner Production Centre Project;
- The Amhara Region Sustainable Development Project;
- The Energy and Woody Biomass Survey Project;
- The Addis Ababa Industrial Zone Cost Benefit Analysis Project;
- The Tannery Pollution Control Project;
- The Project for the Generation of Employment for Women Fuel-wood Carriers;
- The Project for the Environmental Auditing of 10 Factories; and
- The Federal and Regional Conservation Strategies.

2.8 Institutional Framework

2.8.1 Institutions

The introduction of the federal system has changed the balance of power in favour of the newly created regional states, which have legislative, executive and judicial powers within their jurisdiction. The goals of decentralization include increased administrative efficiency, local participation in development planning and management and the allocation of resources so that they reflect more closely the development priorities of local populations.

At federal level, EPA has been established with the objectives of co-ordinating and regulating activities in the environmental management field to ensure that all matters pertaining to the country's social and economic development activities are carried out in a manner that will protect the welfare of human beings. Its equally important objective is sustainable protecting, developing and utilising the resource bases on which they depend for survival.

In earlier days, natural resources development and environmental protection activities were carried out in a dispersed manner among sector institutions. In 1985, natural resources protection and development was attached to the Ministry of Agriculture as a distinct sector led by a vice minister. This lasted until 1993.

In 1993, the Ministry of Natural Resources Development and Environmental Protection was established. This new institution functioned until 1995, when it was replaced by the Environmental Protection Authority, by virtue of Proclamation No. 9/95.

In accordance with the duties and responsibilities entrusted upon it, the Authority has been undertaking various activities related to environmental protection until 1992. However this earlier enabling proclamation has now become repealed and replaced by the new proclamation which provides for the establishment of environmental organs because it was considered important:

- To facilitate the sustainable use of environmental resources by eliminating conflicts in mandates and duplication of work by allocating to separate institutions activities related to environmental development and management on the one hand and environmental regulation and supervision activities on the other hand; and
- To establish a mechanism which will strengthen the carrying out of the distinct organisational responsibilities of federal and regional environmental organs in a coordinated manner.

The Proclamation has also other articles that treat the conditions under which sectoral environmental units and regional environmental offices are to be established with full details of their duties and responsibilities.

This institutional set up is believed to facilitate the integration of environmental activities and information exchange hitherto scattered among diverse organizations.

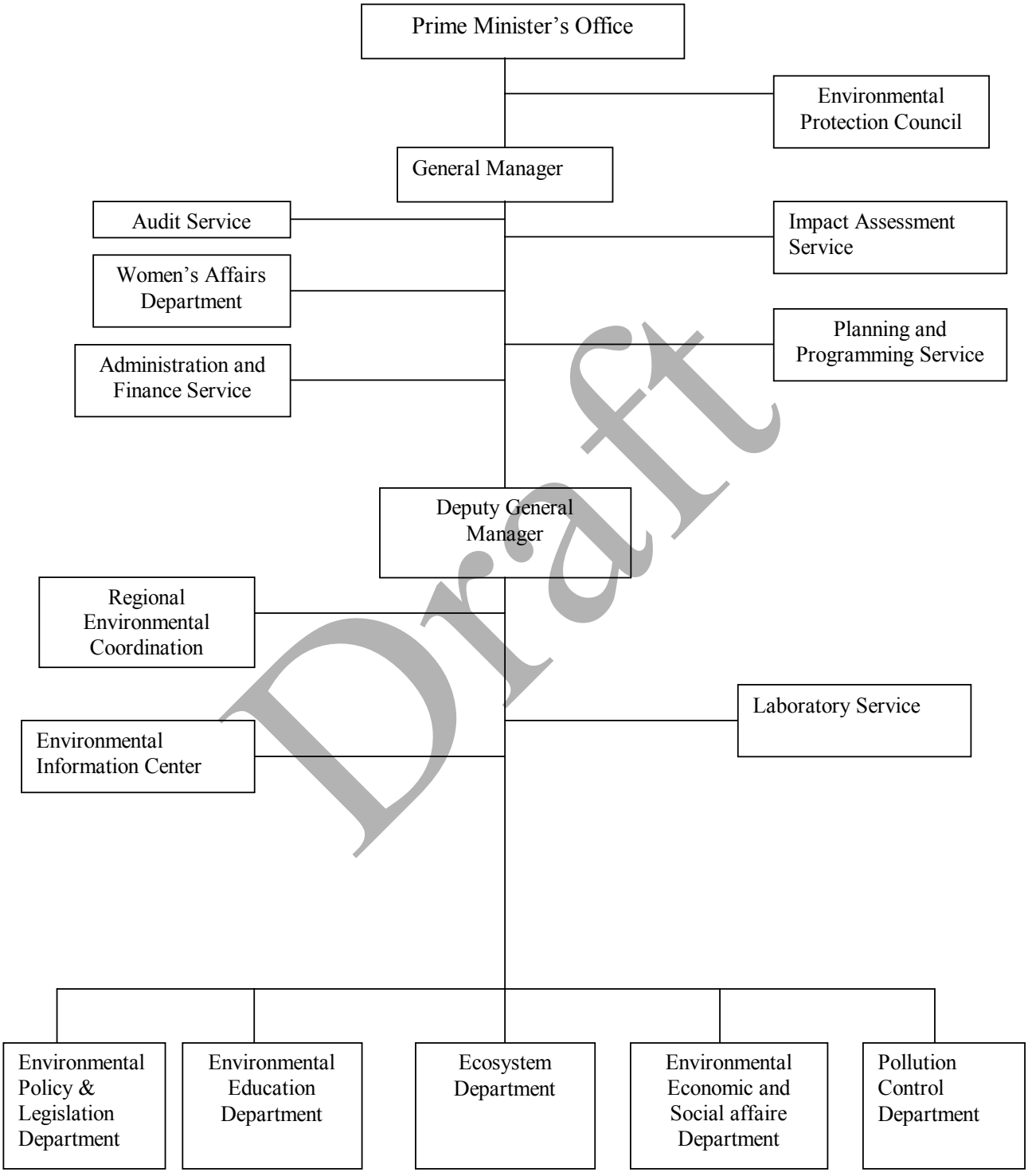
Until recently there were no legal bodies established in the regions with full responsibilities to undertake, supervise and execute environmental protection activities. Recently, however, offices legally mandated for environmental issues have been established and have commenced performing their duties in Addis Ababa, Afar, Oromiya and Amhara regions.

At the Federal and Regional levels there are several institutions engaged in natural resources protection, development and research. The following are the major ones:

- Ministry of Rural Development
- Ministry/Bureaux of Agriculture
- Ethiopian Wildlife Development and Protection Organization
- The Ethiopian Agricultural Research Organization as well as agricultural research institution in some regions;
- Ministry of Water Resources and regional Water and Energy Bureaus;
- Institute of Biodiversity Conservation and research;
- Ministry of Mines;
- Ethiopian Science and Technology Commission;
- Ministry of Labour and Social Affairs and regional Labour and Social Affairs Bureaux;
- Disaster Prevention and Preparedness Commission and regional Disaster Prevention and Preparedness Bureaux; and
- Rural Energy Development Promotion Centre

In addition, there are quite a number of non-governmental organizations, civil society institutions and trade associations that are involved in environmental protection, conservation and related activities.

Environmental Protection Authority Organizational Structure



2.9 Environmental Information System

Environmental information is very crucial for decision making on environmental issues and for the creation of awareness among various bodies. In view of the pivotal role that information plays the Ethiopian Environmental Policy has incorporated it as one of the cross-sectoral policy issues.

At present, it is difficult to say that there is an efficient and consistent environmental information system in the country. In the past, since different institutions collected environmental data from diverse sources at different times and for various purposes, they were not compatible and lacked consistency in time and space. Data captured earlier are scattered all over the place and there is fear that no one could locate where exactly they are. As a result, one could say that environmental control and monitoring activities are not conducted appropriately. Since the data collected at various levels are not properly kept centrally or otherwise, it is possible to say that they are not in a position to provide the necessary benefits in relation to the cost incurred to capture them.

Much effort is being made at present, in the area of the collection and storage of environmental data. Project work to establish a metadata environmental and natural resources database is in progress under the auspices of the Ministry of Water Resources with financial support from the Dutch Government. This project aims to create one central national metadata base in order to ensure consistency of data, avoid duplication of work among bodies engaged in this kind of activity and minimize financial and manpower wastages.

What is more, the Environmental Protection Authority has also started some initiatives in this area by setting up an environmental information centre.

3. BASIN SPECIFIC: Abbay River Basin

3.1 Location

The Abbay basin occupies an area of 199,812 km^2 and is located within the eastern and central part of Ethiopia between latitudes 7^0 45' and 12^0 45' N longitude 34^0 05' to 39^0 45' E. The basin drains towards Sudan on its western border and shares common boundaries with the Tekeze basin to the north, the Omo Gibe basin to the south, the Awash basin to the east and southeast and the Baro-Akobo to the southwest. The basin is located within part of each of the Amhara, Oromia and Benishangul-Gumuz Regions.

3.2 General Physiography of the Area

Abbay river basin has a diverse Physiography of various landforms and ranges in elevation from 490 m.a.s.l, where the Abbay crosses the Sudan border, to 4,247 m.a.s.l. in the eastern highlands. The highest named mountain is Mt. Guna at 4,231 m.as.l. The upper part of the basin is located within the Central Ethiopian Highlands, a vast volcanically formed plateau of temperate, rolling country situated between 2000 to 3000 m.a.s.l. elevations which slopes downwards in a westerly direction to the escarpment above the lowland plains and the valley of the Nile river. The basin contains a mixed topography of high mountains rolling ridges, flat grassland areas and meandering streams that can create spectacular waterfalls where they plunge over the escarpment to the lowland areas. Lake Tana is the largest lake in the basin and is located in the northeastern part of the basin and is the source of the Abbay River. Other lakes occur within the landscape in extinct volcanic craters. After leaving Lake Tana, Abbay River enters a deep canyon (the Abbay gorge) formed within the underlying Precambrian metamorphic and sedimentary rocks. The gorge directs the river south from its source at lake Tana and then west to the Sudanese border. During its passage, it progressively increases in depth downstream from Lake Tana to reach depths of up to 1300 m. the canyon forms a natural barrier to communication and together with numerous deeply entrenched tributary water course restricts the extension of groundwater reservoirs and their storage capacity.

The basin has been classified by the FAO (1983) into three general topographic units, which are characterized as follows:

- The plateau highlands: (also called the Central Ethiopia Highlands) the majority of this unit contains elevations between 2000 – 2700 m.a.s.l.. Within this unit are inclusions of higher mountains ascending to over 42000 m.a.s.l.. This is a vast fertile, volcanically derived plateau and is densely settled. The topography is dominated by volcanic remnants and broken by broad river valleys. Lake Tana, which is an important water resource and wetland area, is located within this unit. The plateau drops steeply to river gorges and the escarpment of the lower plains and hills. This unit dominates the eastern part of the basin and accounts for about 35 percent of the basin area.

- The plateau valley in the eastern part of the basin, which descends to the Abbay canyon and contains the main tributary rivers of the Abbay river. These include rivers such as the Beshelo, Welaka, Jemma, Muger, Guder, Chemoga and Fettam rivers. In many places these rivers occupy broad open valleys within the highlands and may then plunge via a series of spectacular waterfalls over the escarpment to the Abbay river gorge.

- The lower plains and eroded hill lands in the western part of the basin close to the Sudanese border. These contain the outlets to the Didessa, Dabus, and Beles rivers while in the north of the basin the middle and upper catchment of the semi perennial Rahad and

Dinder rivers are located within these areas. These areas account for about 40 percent of the basin

3.3 Climate

The climate in the Abbay River Basin is dominated by two main factors: the near-equatorial location, between latitude 7^0 45 ' N and 12^0 45' N, and altitude, from 500 m to more than 4200 m above sea level. The influence of these factors determine a rich variety of local climates, ranging from hot and nearly desert along the Sudan border to temperate on the high plateau or even cold on the mountain peaks.

The actual duration of the different reasons depends on the location. This seasonal pattern determines the annual variation of all climatic parameters. A few of them are given below.

- Maximum temperatures are observed in March-April while minima are recorded in July-August;
- The relative humidity get maximum daily sunshine duration from July to September while minima are usually observed from February to April;
- The maximum daily sunshine duration occurred in December-January while minima are observed in July-August;
- Through the variation from station to station is large the maximum mean wind while speed is usually recorded in the period from February to May.

The rainy season (Kiremt) contributes from 50% up to nearly 90% of the annual rainfall.

The small rains season (Belg) is only significant in the extreme east of the basin while it is practically not known around Lake Tana with less than 10% of annual rainfall during this season.

In the study area, rainfall varies with two essential parameters: (i) a basic trend of increase with altitude: the low-lying area are globally drier than the high plateau and most mountains are wetter than highlands around them; and (ii) a large interference in this first trend caused by local-and sometimes extensive 'shadow area' affects: the windward sides of the mountains are more subject to high rainfall than the leeward ones, for the dominant wind in each season. A clear case of 'shadow area' effect is the Lake Tana area, where the west side is quite dry (about 800 mm per year at Delgi or Kunzila) while Bahir Dar receives almost twice more rain (1450 mm per year).

Climatic elements

- Rainfall: mean annual rainfall within the basin varies from 800 – 2000 mm and generally increases with altitude. Rainfall in most of the basin is unimodal with the majority of the rain falling in the wet season (June to September) brought by the southwest monsoon originating from the Atlantic Ocean. The dry season extends from October to march while a period of short rains may sometimes occur from April to May from the penetration of the south east Indian Ocean monsoon into the basin area. The eastern fringe area of the basin can have a bimodal rainfall distribution, where the 'Belg' rains comprise nearly 50 percent of the 'Keremt' rains.

Rainfall tends to increase with altitude, but this may be affected by local rain shadow' effects that can be quite significant, for example the western side Lake Tana, which is quite dry with about 800 mm per year while Bahir Dar on the southern end of Lake Tana receives 1450 mm per year, twice this amount.

There are two areas of high rainfall (>2000 mm/yr) within the basin. The first is in the headwaters of the Gilgel Abbay, while the second area is south of Bedele in the headwaters of the Didessa River. This area has a longer wet season than the northern area. Rainfall is lowest in the north west part of the basin where the semi perennial Rahad and Dinder rivers are located.

- Temperature: temperature decreases with altitude at a general rate of about 0.7^0 C per 100 m elevation.
- Humidity: increases with decreasing altitude. There is little difference between the stations during the rainy season, when it may reach 88 percent.
- Wind speed: varies little throughout the year at either locality.
- Sunshine: is slightly lower at lower altitudes and is lower at both stations during the wet season.
- Evaporation: figures were unreliable for the basin stations and no figures are available. Potential evapo-tranispairation figures show that evaporation rates are highest in the northwest and eastern parts of the basin.

The combination of these various factors results in very substantial variations in climate. From this analysis and other climatic characteristics five types of climate can be found for the Abbay river basin:

Tropical Climate II: with dry months in winter, mean temperature of the coldest month above 18^0 C and a mean annual rainfall between 680 and 1200 mm; this type is prevailing in the north-west, the west and along the deep valleys.

Tropical Climate III: with mean temperature of the coldest month above 18^0 C and a mean annual rainfall between 1200 and 2800 mm; this type is found near Jimma and in a long fringe along the Abbay right bank up to the towns of Debre Zeiyt (Wembera) and Chagni.

Warm Temperate Climate I: with dry months in winter, mean temperature of the coldest month below 18^0 C. more than 4 months with average temperature above 10^0 C and a relation between mean annual rainfall Rf and mean annual temperature t: Rf>20(t=14); this type is prevailing in the highland plateau throughout the basin.

Warm Temperate Climate II: with no clear dry season, mean temperature of the coldest month below 18^0 C, the mean rainfall in the driest summer month at least one-third of the mean rainfall in the wettest winter month, the mean rainfall in the driest winter month at least one-tenth of the mean rainfall in the wettest summer month; this type is found in the upper catchments of Didessa and Dabana rivers.

Cool Highland Climate: with dry months in winter, mean temperature of the warmest month below 10^0 C and a mean annual rainfall between 800 and 2000 mm; this type is found around the main mountain peaks: Guna, Choke, Amba Farit and Abuye Meda.

3.4 Soils

Abbay River Basin Integrated Development Master Plan Project carried out reconnaissance soil survey throughout the basin. Accessible areas were surveyed by using 4WD vehicles while remote areas were accessed using helicopter. The mapping bases used in the reconnaissance field survey was Landsat TM images at a scale of 1:250,000, and topographic map of the same scale. Previous studies were also reviewed and incorporated in the soil analysis of the basin.

Summery of reconnaissance survey observations

Data Source	Number of Observations	Area (hectares)
Reconnaissance primary observation	910	
Selected (20%) semi-detailed observations	261	
Observations from previous studies integrated into reconnaissance soil survey	3,229	
Total observations integrated into reconnaissance soil survey	4,440	
Basin area		19,981,200
Inaccessible areas		4,995,300
Leptosols and rocks		4,083,626
Marshes and water		428,927
Effective basin area		10,473,347
Hectares per observation in reconnaissance survey	2,359	
Hectares per observations in previous studies	5,010	

3.5 Soils classification

The soils of the basin were classified based on the revised FAO-UNESCO-ISRIC legend to the Soil Map of the world (1988). The FAO-UNESCO-ISRIC legend contains 28 major soil groupings at the highest level and 153 soil units, which are subdivisions of the soil groupings, at the second level. The soil units are further differentiated into soil sub-units on the basis of differential criteria that relate to important soil properties at the third level.

The classification of soils within the basin was carried out based on observable and inferred characteristics of soils based on the field observations and from laboratory analytical data on the physical and chemical characteristics determined.

Soils formed in the eastern part of the basin form the basaltic rock cap are deep, productive, well structured and inherently well-drained agricultural soils. The basaltic derived soils are mostly classified by the FAO system (1988) as Luvisols and are intensively cultivated for peasant agriculture. Those soils formed in the western part of the basin form the underlying strata are somewhat less productive and are classified into a variety of major soils including Nitosols and Vertisols (black cracking clay soils). Other major soils found within the basin include Rendzinas (derived from calcareous deposits) and Lithosols (shallow rocky soils).

Major Soil Groups Identified within the Abbay River Basin

Major Soil Groupings	Area (km^2)	% of Basin Area
Fluvisols	799	0.4
Regosols	799	0.4
Vertisols	28,173	14.1
Arenosols	4,596	2.3
Cambisols	17,783	8.9
Phaeozems	1,399	0.7
Luvisols	24,177	12.1
Acrisols	12,988	6.5
Nitosols	71,333	35.7
Lithosols	26,775	13.4
Rendzinas	9,791	4.9

Marshes	1,199	0.6
Total	199,812	100

3.6 Land use / Land cover

Various land use and land cover categories found within the basin is shown on the table below. These have been mapped on Landsat imagery and verified by intensive ground checking, before being plotted on the GIS.

Major Land Cover of Abbay Basin

Land cover	Total area km^2	Total (%)
Cultivated	68150	34.1
Tree crops	260	0.1
Plantation	537	0.3
Afro-alpine	1103	0.6
Disturbed forest	2276	1.1
Bamboo	7326	3.7
Woodland, Bush land, Shrub land	60438	30.2
Grassland	46143	23.1
Wetland	2384	1.2
Water body	3415	1.6
Rock	7932	4
Urban areas	108	0.05
Total	199812	100

As it is easily discerned from the land cover map, the basin divides broadly into cultivated land in the east and woodland in the west.

3.7 Forests

No areas of undisturbed forest remains anywhere within the Abbay basin. All have been altered by some form of clearing or tree removal (2,276 km^2; 1 % of basin). Many of these areas are now occupied for human settlement and agricultural use. The original forest remains in a few places but the overall effect is one of a serious disturbed environment. The greatest conservation has occurred in the Amhara and then in the Oromia Region where areas of forest have been cleared for coffee planting. Disturbed forest area remain at; Gera, Setena, Jimma, Komto, Chato and Guangua. All of these areas have been classified as National Priority Forest Areas (NPFA's). The standing volume for disturbed forests is in the order of 135 m^3/ha and for very disturbed forests this is reduced to 58 m^3/ha.

3.8 Fauna and Flora

Ethiopia occupies a unique position in the world with regard to plant and animal diversity. The country is one of the centres for crop genetic diversity and accordingly on of the 12 Vavilov centers in the world. There are between 6,500 – 7,000 plants within Ethiopia of which 800 are endemic.
Ethiopian Fauna and Flora (source: adapted from BECOM, 1996)

Animals	Total	Believed Endemic
Mammals	240	22
Birds	845	16
Reptiles	201	6

Amphibians	63	33
Fresh water fish	150	4
Butterflies	324	7
Total Fauna	1,823	99
Plants		
Total Flora	6500 - 7000	800

In the highland areas farming and grazing practices have significantly altered the original flora so that only remnant vegetation now exists in only a few places. There have also been significant introduction of exotic species, which may be both useful to the farmers or they may be present as weeds. In the lower western area of the basin extensive agriculture is practiced and in these areas flora has not have been as significantly altered though like the highland areas there will also be complementary introductions of exotic species via the agricultural and pastoral systems.

A west-east transect of the Abbay River basin would show a wide range of potential faunal habitats ranging from tropical dry land savanna areas near the Sudanese border to montane vegetation in the eastern part of the basin. However, there has been severe reduction in wildlife habitats and numbers within the Abbay basin due to the conversion of large areas of land for agricultural use. This has particularly affected the more densely populated and human favored higher and cooler altitudes parts of the basin, where few large animal habitats remain intact. However, the lowland areas of the basin are less favoured for human settlement due to the presence of tsetse fly and other climate related human health problems. In these lower western and northwestern areas of the basin, some of the large wildlife continues to survive at reasonable population levels.

3.9 National Parks

Despite Ethiopia having a large national park network there are no national parks within the Abbay basin. The Amhara Regional has plans to make 9 km^2 national park area at the Tis Issat falls on the Abbay river, so that the area can be preserved for its scenic value and also for tourism

3.10 Water Resources

3.10.1 Surface water

There are two distinctly different hydrological components of the Abbay river basin. (i) The Abbay river and its tributaries and (ii) Lake Tana.

Abbay River Basin is the second largest basin in Ethiopia (the largest basin is the Wabi Shebelle basin which is in the drier eastern part of the country drains towards Somalia) but has the largest quantity of runoff estimated to be 51 X 10^9 m^3. The Abbay river basin drains to Sudan through three outlets.

Despite the lack of any basin data it can be postulated that apart from high sediment loads, the water quality of all rivers that are distant from urban centres, within the basin appears to be adequate for most uses (irrigation and livestock and with treatment suitable for human use).

Lake Tan, which is the 73 km long by 68 km wide is the largest freshwater lake in Ethiopia and has a surface area of 3,042 km^2 (at 1,786 m.a.s.l.).

Lake Tana water quality currently appears to be satisfactory and is used as a minor source of supply for Bahir Dar, capital city of Amhara Regional State. The reminder of the town's water supply being pumped from shallow (5 to 20 m deep) groundwater bores.

3.10.2 Ground Water

Groundwater is almost exclusively confined to consolidate rocks which include basalts, limestone and sandstone and the metamorphic basement rocks. The retention capacity of these rocks is low and any groundwater yield is linked to the occurrence of fracture within these rocks.

3.11 Aquatic Biodiversity

The Abbay basin has limited fish reserves in both lake and riverine systems. Lake Tana has a fisheries potential but is still the most important fish resource in the basin, the rivers have low potential. Apart from Lake Tana there is little information on fish species within the Abbay basin and no systematic fish identification has been done within the basin. However, studies have documented two separate fish faunal provinces, which are mainly determined by water temperature. These are (i) the Nilotic lowland fauna and (ii) the Ethioipian Highland fauna.

Fish Identified within Abbay and Tributary Rivers

Family Species	Abbay river	Tributary river	Family Species	Abbay river	Tributary river
Mormyridae			Schilbeidae		
Hyperopisus bebe	X		Schilbe spp.	X	
Mormyrops spp	X				
Mormyrus	X	X			
hasselquistii	X				
Mormyrus spp.					
Characidae			Mochokidae		
Micralestes spp.	X		Chiloglanis spp		X
			Synodontis spp.	X	
Cyprinidae			Cichlidae		
Barbus paludinosus		X	Oreochromis Niloticus	X	
Barbus trispilopeura			Cichlidae gen spp		X
Barbus intermedius		X			
Barbus spp		X			
Chelaethiops bibie	X	X			
Garra spp.	X	X			
Labeo coubie	X	X			
Labeo spp.	X				
Leptocypris spp.	X				
Raiamas spp.	X				
Varicorhinus beso	X	X			
Bagridae			Malapterurus Electricus	X	
Bagrus spp.	X		Eutropius niloticus	X	
			Heterobranchus spp	X	

Source JERBE, 1996

3.12 Wetlands

These areas can be either permanent swamps such as the Dabus swamp or, else they may seasonally recede as around Lake Tana. The main wetland areas within the basin, occur around Lake Tana, the Finchaa and Chomen swamps and the large Dabus swamp which is located within the W. Wellega zone of the Oromya Region.

Wetlands are important bird and wildlife areas and have significance for congregational bird species (Flamingos, cranes, ducks, geese, etc.) and over-wintering areas for a variety of migratory Palaearctic bird life.

Lakes

Lake Tana with 3,042 km^2 is the largest inland lake in Ethiopia and is an important regulating feature for Abbay River. Other small lakes occur throughout the basin as crater lakes within extinct volcanoes, e.g. Lakes Zengena and Dendi

Major Tributaries

Major Tributary Rivers	
Didessa	Jemma
Guder	Welaka
Angar	Wonbera
Dabus	Beles
Beshilo	Rahad
Finchaa	Dinder
Muger	Gilgel Abbay

3.13 Irrigation

Large areas of the basin have apparent land suitability for irrigation; however, water availability is seen to be generally constraining. In the highlands, the highest potential appears to be around Lake Tana, offering supplement irrigation and double cropping potential. In the lowlands, the lower Dabus valley and an area in East Wellega appear to offer the highest immediate potential. However, these comments refer to land potential only; they do not take into account water availability.

Identified irrigation schemes – Abbay basin

Name of Project	Selected area (ha)	Cumulated area (ha)
Seraba	4,854	
Robit	5,495	
Guramba	5,644	
Jarjr	8,517	24,510
Kola Diba	2576	
Jiwana	4,735	7,311
Bebaha Abo	2,388	
Gawarna	1,076	
Fentay	706	
Delgi	2,550	6,720
Guramba	1,542	
Mene Guzer	1,380	
Aba Kiro	424	
Bebeks	2,376	
Jigna	4,199	
Hod Gebeya	3855	13,776
Mitrha	1,632	

Gubay Mariam	1,868	
Kirnya	842	
Agid/kab	1,233	5,475

3.14 Livestock and Grazing

Despite many negatives, agricultural production is trending upwards, benefiting from the twin stimuli of positive policies and several years of good rains. By contrast livestock conditions are deteriorating. In part the expansion of crop production, in the face of increasing population and degrading resources, has come at the expense of livestock. More and more traditional grazing areas are being cultivated and the growing livestock population is increasingly being relegated to more marginal lands. Finding feed for the growing livestock population will become ever more difficult and the traditional option of grazing new areas is no longer available.

Abbay River Basin – Natural Resources Summary

Resources	**Indicator**	
Water Resources	River Flows	• Drainage area: 199,812 km^2 • Average annual discharge at the border:49.4 BCM 82% from July to October; 4% from February to May • Outlet Lake Tana: 3.5 BCM
	Sediments discharge	• 1700 t/ km^2/year • 335 Mt/year at the border
	Groundwater Flow	• Exclusively included in consolidated rocks • Mean borehole discharge: 3 to 4 l/s • Groundwater recharge: 250 to 300 m^3/s
Mineral Resources	Non-metallic minerals	• Potential in limestone, marble, gypsum, silica and clay is important
	Metallic minerals (sector is limited)	• Gold represents the main potential • Future exploration should be concentrated mainly in the west to investigate occurrences of Cu, Pb, Zn, Cr, Ni, Co
Land Resources	Land Suitability in km^2	• Rainfed: 165,680 • Smallholder rainfed: 95,150 • Mechanised rainfed: 105,280

		• Irrigated: 58,380 (5,838,000 ha)
Vegetation	Land cover %	• Cultivated: 34 • Forest+plantation: 1.5 • Bambou-woodland: 23.5 • Bush: 10 • Grassland: 24 • Wetland: 3 • Rock-urban: 4/100
Soil erosion and conservation	Rate	• At least 100t/ha/yr equivalent to 1 cm/yr from cropland
	Slopes (% of basin)	• 0-5%: 47 • 5-10%: 14 • 10-15%: 3 • >15 5: 36 100%
Energy	Hydropower potential	• 383 kWh (current energy consumption: 140 GWh
	Traditional Energy	• 98% of current energy consumption • Mainly fuel wood • 27% sustainable, 73% mining standing stock (annual deforestation rate of 230,000 ha)
Fisheries	Potential	• 18,200 tons/year (Lake Tana: 15,000; Fincha reservoir: 750; new reservoirs: 450)

3.15 Past and On-Going Environmental Related Activities, Projects and Programs

The following projects have either been already implemented or are in the process of implementation through out the country. (Environmental Protection Authority, 2003)

- Project for the Control and Disposal of Expired Pesticides;
- Project for the Preparation of a National Chemical Handling and Registration guideline;
- The Ecologically Sustainable Industrial Development Project;
- The National Cleaner Production Centre Project;

- The Amhara Region Sustainable Development Project;
- The Energy and Woody Biomass Survey Project;
- The Addis Ababa Industrial Zone Cost Benefit Analysis Project;
- The Tannery Pollution Control Project;
- The Project for the Generation of Employment for Women Fuel-wood Carriers;
- The Project for the Environmental Auditing of 10 Factories.

3.15 Environmental Threats

3.15.1 Land Degradation

Extensive land degradation has occurred as a result of deforestation and inappropriate agricultural practice in the basin. This in turn has resulted in both soil erosion and loss of fertility to a large area of the basin especially in the highlands (FAO, 1986). The Same study has showed that annual loss of some 681.5 Mt/year out of which 130Mt/year is carried out of the basin and erosion is resulting in a 2-3 %annual decline in crop yield.

The eastern area of the basin, where a combination of steep slope, erodible soils and highly erosive rainfall, are areas of soil erosion.

Similarly the transboundary environmental analysis () has indicated that the highlands of Abbay basin are characterized by land degradation (Severe deforestation, Severe soil erosion, moderate to severe riverbank and lakeshore degradation) and water quality degradation (pollution, Silitation)

3.15.2 Deforestation

No area of undisturbed forest remains in the basin and that only 1% (2300 km2) of disturbed forest remained. The assessment made by FAO 1n 1884 showed that at that time, 4% (8000 km2) of the basin was covered by forest. This represents a conversion of aboute 475km2 per year.

The main causes of deforestation is the need of a rapidly growing rural population for fuel wood (estimated at about 1.8 m3 /person/year), Building materials, agricultural land which is also responsible for the conversion of forests.

3.15.3 Loss of Biodiversity

Ethiopia occupies a unique position in the world with regard to plant and animal diversity; there is a high level of endemism within the country with 99 endemic animals and about 800 endemic plants. However the ability of Ethiopia to maintain this high degree of inherent biodiversity is now under threat as human use moves insatiably into the few remaining area that remain. EWNHS (1996) has identified that of the 16 endemic bird species with in Ethiopia, half of these are still found in Abbay basin, of these tow (the Ankober Serin and Harwood's Francolin) are categorized as Vulnerable in the list of globally threatened species. Wiled habitats are shrinking and apart from those savanna woodland areas in the northwest part of the basin, or those areas that have tsetse fly infestation few habitats remain intact. Urgent action is needed to address this problem of shrinking habitat and biodiversity loss before extinctions occur.

3.15.4 Pollution and Environmental Health Threats

Of the water related diseases, the major concern is malaria which is increasing, is difficult to control, has potential to infect a vary large population in epidemic outbreaks. The other water related diseases are Schistosomiasis, Typhoid, Diarrhea, Helminthiasis, Leshimaniasis, Onchocerchiasis.

3.16 Environmentally Sensitive Areas

The following table lists where these environmentally sensitive area are located and what the items that needs protection.

Type of Area and Name	**Location**	**Features**
Birds 1. Ankober-Debre Sina Escarpment 2. Awi Zone 3. Choke mountains 4. Jemma and Jara valles 5. Bahir Dar and Lake Tana 6. Fogera plains 7. Guassa (Menze) 8. Mid Abbay gorge 9. Yegof Forest 10. Fincha and Chomen Swamps 11. Dabus Swamp	$09^0$36'N/$39^0$46E $11^0$45'N/$37^0$00'E $10^0$42'N/37051'E $10^0$08'N/$38^0$56'E $11^0$37'N/$37^0$25'E $11^0$57'N/37045'E $10^0$21'N/$39^0$48'E $07^0$44'N/$12^0$46'E $11^0$06'N/$39^0$45'E $09^0$34'N/$37^0$21'E $10^0$36'N$34^0$54'E	Ankober Serin, Ruppell's Chat Various Habitats, Rouget's Rail, etc Forest; Abyssinian Longclaw Harwood's Francolin, Ruppell's Chat Wetland; Wattland Crane, Gr. Spotted Eag Wetland; Lesser Kestrel etc Rouget's Rail, Abyssinian Longclaw Harwood's Francolin Forest; Home to 18 highland biome Wetland; Wettled Crane, Roget's Rail
Wildlife 12. Dinder wildlife area 13. Didessa wiledlife area 14. Dabus Vally controlled hunting	$11^0$48'N/$35^0$24'E $08^0$12'N/$36^0$36'E $10^0$24'N/$34^0$54'E	Large animals; need further assessment Large animals, need further assessment EWCO to assess and allocate use
Fish 15. Lake Tana	Lake tana	Home of 13 isolated Barbus spp.hexaploi
Domestic Animals 16. Fogera plain	$11^0$54'N/$37^0$36'E	Home of indigenous Fogera Cattle
Afro-alpine Areas 17. Mt. Guna 18. Mt Amba Farit 19. Mt Choke	$11^0$42'N/$38^0$12'E $11^0$00'N/$39^0$00'E $10^0$42'N/$37^0$51'E	Area of rare fragile alpine vegetation Area of rare fragile alpine vegetation Area of rare fragile alpine vegetation
National Priority Forest protection Area 20. Gera 21. Setema 22. Gimma 23. Komto 24. Chato 25. Guangua	$08^0$00'N/$36^0$18'E $08^0$24'N/$36^0$06'E $08^0$00'N/$36^0$42'E $09^0$06'N/$36^0$36'E $09^0$30'N/$37^0$00'E $10^0$54'N/$36^0$30'E	Area of humid upland broadleaved Forest Area of humid upland broadleaved Forest Coffee shade forest Natural forest enclosed by exotic forest Possible watersheds/ wildlife protection area Disturbed Natural Albizia Spp. forest area
World Heritage Site 26. Faisal Gimb	Gonder	World heritage Site Gonder

National Park 27. Tis Abbay Waterfall	$11^0$30'N/$37^0$30'E	Scenic area; Tis Issat waterfall etc
Cultural and Heritage Areas	Numerous sites in all regions	

3.17 The Likely Impacts Of Possible Major Development

As the basin is endowed with rich water resources, it is one of the options of development in the basin. Among these, irrigation and hydropower development are that got attention. Both Hydropower and irrigation projects will create a range of direct and indirect impacts including disruption of settlement areas and loss of agricultural lands, Excessive watershed erosion, upstream deterioration in water quality, Downstream flow variation, Environmental and social enhancement (New reservoir fishing industries, draw-down Agricultural activates, Downstream community water supply, Forester and wildlife reserves and rural electrification), Inundation losses of primary forests, infrastructure loss, Impediments to movement of wiled life live stocks and people, Transmission line routes.

If the agricultural production is intensified by irrigation this will create greater use of agro-chemicals and machineries and increase health problems.

3.18 Critical Information Gap

This report is based on the information obtained from studies made by "Abbay River basin Integrated Development master Plan Project, 1998", The master plan study emphasizes on the water resource development only and relatively older than expected.

4. BASIN SPECIFIC: Baro-Akobo

4.1 Location

The Baro-Akobo river basin lies in south-western Ethiopia between latitudes $5^0$31N and $10^0$54N and longitude 33^0E and 36^0 E. It is made-up of numerous westerly flowing rivers and their contributing basins, the area is an important watershed of the White Nile. Its drainage covers about 76, 000 km2.(75876 km2) It includes all or part of four Regions: SNNRP in the south, Oromiya in NE, Gambela in the central western portion and Benshangul in the north western extreme.

The land comprises high plateaux elevation ranging from 1500 and 2000 m and mountains with peak exceeding 2500 meters easternmost and southern portion of the basin.

Present population in the basin is about 2.2 Million with some 90% in the highland and the remaining part in the lowland. About 92% of the population is rural and the remaining 8% is classified as urban.

Most of the agriculture is substance farming in the highlands, where mast of the animal population is also located and coffee is a major crop. The Urban population is growing with high rate of growth of the rural population. The area has moderately developed road system and several airfields. The major airport is at Gambela which includes a first class paved runway.

Different studies were made in the basin with the latest was the master plan study made an association of two firms: TAMS consultant, Inc of New York and ULG consultant, Ltd of Great Britain reported in 1997.The other two studies were made by Russian (western of the area basin) in 1990 and by ARDCO-GEOSERV (Eastern area of the basin) in 1995.

4.2 Climate

The temperature range in the area is from about 27^0C below 500 m on the flood plain to 17.5 ^{0}C at 2500 m in the high land. The range in mean maximum is 35 to 24 ^{0}C and mean minimum from 20 to 10^0C. The temperature peaks during February and March on the flood plain but high values extend in to April in the high lands. Below about 700m mean maximum value are in excess of 38^0C for two to three months. There are short periods of more than 40^0C, the critical value for anthesis of some crops, Notably Maize, but this not coincide with the cropping season. Daytime temperature in lowlands is very stable over the year with mean maximum not falling below 30^0C even during the rainy season. Maximum temperature is even more stable with a variation through the year of more than 2^0C about the yearly average of 19-21^0C.

In contrast, land above about 2000m is markedly cooler, with mean maximum in the hottest period not exceeding 28^0C and generally being in the range of 21-26^0C. Maximum daytime temperature at this altitude also is stable through the year ranging through only about 4^0C. Minimum temperature in the high land seems to be more variable and not so closely related to altitude. The annual mean minimum ranges from 15^0C at Atnago to 7^0C at 2320 m at fincha.

The annual mean value of sunshine is about 6hours daily and shows almost no variation with in the basin. Despite this uniformity, there is considerable seasonal variation. The most sunshine is recorded in the period march to May when skies are clearest and values are mostly 8 to 9 hours daily. The onset of the rainy season produces the dramatic fall in bright sunshine and average values of less than 2 hours daily in august are recorded.

The mean annual rainfall distribution of the basin shows considerable spatial variation due to the complicated nature of the topography. Over the low land areas the mean annual rainfall is as low as 600 mm and over the high land areas it reaches as high as 3000 mm. (Yeshanew, 1994)

The basin is particularly well-watered region of Ethiopia. Most of the upper basin has an annual total rain fall over 1800 mm. Significant proportion of rain falling during the storms is lost by runoff and the occasional light rain fall out of season when soil and foliage are hot is lost by evaporation so the effective average rainfall of 750 mm annually in the low land raising to about 1250 mm in the high land.

The seasonal variation in rainfalls follows the same pattern through out the basin with a peak precipitation during August. There are striking variation in annual distribution between the north and south of the basin. Te more even distribution of rainfall in the south is reflected in the greenness of the vegetation through out the dry season and contrasts with the parched landscape of the north.

The rainy period of the region is from February to November. The maximum rainfall over the southern portion of the Baro-Akobo river basin reaches as high as 300 mm in July and over the northern portion of region may reaches 250 mm in July. In the northern part of the area, the rainfall amount exceeds 200 mm during June and July.

According to the climatic zone of Ethiopia Map published by the NMSA in August1989, the rive basin is characterized by four climatic zone: Aw- Tropical climate II, Am-tropical Climate III, Cwb-Warm temperate Climate I and Xfb- warm temperate climate II.

The temporal rainfall pattern has a single peak in July. Over the basin, average rainfall grater than 100 mm occurs from May to October. Months with average rainfall grater than 200 mm are June, July, August, and September. On average, November, December, January, and February are the dry months over the Basin.

The Spatio-temporal mean of the minimum temperature and the maximum temperature for all stations in the bar-Akobo river basin shows that the mean maximum temperature grater than 30^0C occur from February to April while June and July have minimum temperature, value less than 250c.

4.3 Land Use/Land Cover

The following table show the different land cover units of the basin.

DADB	Legend	Hectares	%
BO	Open Woodland	110,981.94	1.46
C1	Cultivated Area (>60%)	139,5908.42	18.32
C2/FB3	Cultivated Area (<60%)	141,391.26	1.86
C2/GO	Cultivated Area (<60%)	154,93.95	0.20
C6	Perennial Crop	13,899.44	0.18
C6/FB3	Perennial Crop	25,713.33	0.34
C6/FP1	Perennial Crop	2,773.07	0.04
FB2	Disturbed Forest	336,292.17	4.41
FB3	Very Disturbed Forest	1,085,451.01	14.24
FB3/C6	Perennial Crop	136,488.10	1.79
FB3/GO	Very Disturbed Forest	10,501.11	0.14
FO/WO	Open Woodland	19,716.41	0.26

FR2	Disturbed Forest	90,875.98	1.19
SF	Perennial Crop	1861.92	0.02
WD	Dense Woodland	628,296.46	8.24
WD/WO	Dense Woodland	118,404.50	1.55
WO	Open Woodland	3,169,661.54	41.59
WO/GO	Open Woodland	256,885.08	3.37
WO/WD	Open Woodland	60,638.73	0.80
Total		7,621,234.432	100.00

Source: Ministry of Water Resource

4.4 Forest

The basin contains about 2.2 million ha of forests. Although isolated into small stands and seriously degraded, they constitute more than half of Ethiopian's remaining forests. Nonetheless, their situation is critical: Loss by exploitation and uncontrolled burning exceed the rate of forest growth. Few primary forests remain: those that remain occur on steep land that is unsuitable even for shifting agriculture.

There are 11 national priority Forestry Areas in the Basin: Gerjeda, Sigmo gaba, Sel Mesengo, gesha, Yeki, Sheko, Guraferda, saylem Wangus, Godere, Abobo Gog and gambela Park.

Based of reconnaissance observations rather than delineating of map units, the forest types delineated include Natural Forest (Afro-Alpine and Sub-alpine, Coniferous, Aningeria, Olea, Baphia, Evergreen Clump-shade, Mixed Deciduous, Combretum and acacia, Riparian) and Plantation Forest.

The Afro-alpine and sub-Alpine forests lie above 3200 m where they comprise small trees, herbs, and suffrutecents. Little human activity occurs in the zone other than grazing and barley cultivation. Coniferous forest , laying between 1800 and 2500m, occur principally on steep lands, where gravity dispersion of seeds assists their regeneration. Aningeria forestes lie between 1600 and 2000 m where the annual rainfall is about 1600-2400 mm. Olea forest lie between 1500 and 200m.their preference for gentle slops exposes them to disturbance and exploitation. They comprise a wide range of commercially desirable species. Bahpia forests often merge with riparian forest and are open forest type. The evergreen clump-shade forests occur throughout the highlands plateau. Remnants of the forest which once clothed Ethiopian's uplands, they are know made-up of island of trees whose under-story has been removed to provide space for coffee; there is no forest regeneration. The Mixed Deciduous extends along the southwestern edges of the plateau at about 1200m altitudes. The combretum and Acacia woodlands occupy the low and upper basin between 500 and 1500m altitude. Riparian forest extends through out the plateaux drainage pattern, dropping down to the flood plain. Like the woodland of savannah and upland basin, riparian forests are under enormous pressure from local and refugee population.

The natural vegetation of the basin reflects differences between the plain and uplands in landscape, soil, climate, and history of land use.

4.5 Biodiversity-Endanger Species

Gambela national Park has ostensibly received legal protection since 1974 and the region was at one time considered to be one of the most important wiled life areas in Ethiopia. Its present status hardly warrants designations a protected area of any kind. Large area of the original park has been cleared and is being used for cultivation and/or grazing.

High density of wiled life in the south and south west of the basin were reported on 30% of the area sampled from the air. Migration pattern of large mammals were inferred from air photographs, giving a general account of unglate movement (predictable dry season dispersal to the wetter grassland of the west, with rainy season movment to the higher levels of the watershed.

No data on wildlife in the montain tropical forests of the eastern part of the area was collected. Data on avifauna are too generalized to be of mach ornithological significance, and no ecological data is available beyond a pure presence/absence presentation. There is a marked paucity of information on herpetofauna and invertebrates.

The basin was once abundant with wildlife: At least 27 species of large mammal were recorded 25 years ago, atwell (1996), the basin has undergone such severe hunting, Civel unrest, and depletion oh habitat in recent years a that its population of significant mammals is mach reduced.

Important change to the habitat have occurred, most notably the occupation of large part of Gambela National park by a stat farm and Abobo Dam, part of whose upper reservoir also extends in to the Abobo Gog protected area.

4.6 National Parks

The lowland Basin is the site of Gambela National Park: three controlled hunting areas, Jikau, Alobo, and Tado, are also located in the basin. Despite efforts made to set aside habitat for the preservation of wildlife, the result hasn't matched expectation and Suitable habitat has become compressed. Important constraints are insufficient staff, insufficient awareness, insufficient finance, and absence of plans to manage priority areas, inadequate infrastructure, and no research capacity

4.7 Aquatic Biodiversity

Studies on the fish and fisheries of the Baro-Akobo basin are limited. The Russian Acadamy of science carried out a comprehensive study of the fish species of the lower basin in the late 1980s. This study examined the species composition, tropic status and parasitology of the fish populations but provided no information on the fisheries. No estimates of the number of fisheries operation in the region or an evaluation of their catch are available, and the fisheries department does not, as yet, collect such information. Similarly in the upper basin, ARDCO-GEOSERV study did not cover the fisheries sector in any detail, and with the exception of an ad hoc fish inventory survey around Wereda Ale by the Russian delegation of the science and technology commission, little information is available from other sources. No formal studies have been carried out in the upper basin region and no assessment of the status of the fisheries has been made.

4.8 Fish Species (Upper Basin - >800 m.a.s.l.)

The ad hoc Russian study in the upper catchment around the Ale Wereda found Some 40 fish species out of the 75 identified in the lower Baro-Akobo plain. On the upper plateau, Species with a preference for slower flows. As the river descends from the plateau to the lowland plain it cuts through steep gorges and is fast flowing. In this region rheophilic(fast water) species such as barbus and Labeo will be found.

4.9 Fishing (Upper basin)

In comparison to the Lowe catchment there is little fishing in the upper catchment. Fishing occurs on the Baro, Sur, Weber, Yabi, Dibo and Uka rivers, But is purely on a subsistence basis using traditional methods. The Dominant species caught are Oreochromis niloticus, oreochromis zillii and Barbus species. No data exist on the number of fishermen or intensity of fishing in different

parts of the catchment or at different times of the year. The reason for the lack of fishing include: the absence of any suitable size, slow-flowing water or lakes; inaccessibility of major rivers and tributaries for most of the course: and lack of a fishing tradition amongst the local ethnic groups. The majority of the groups (Oromes, Kefa and Amehara) are farmers and hunters and rely on livestock for their source of protein. Anuaks (the traditional fisherman) are only found in the Wellega region and in the Dale Awraja.

4.10 Fisheries Development (upper basin)

There has been some evidence of attempts to increase fish production. The fisheries department of the ministry of agriculture stocked Lake Bishan Waka Haye near Tepi with 11,000 tilapia fingerlings and Barta reservoir, west of Dembidolo, constructed by the world Lutheran federation for irrigation purposes, with 58,000 fingerlings. Unfortunately there has been no follow up of these activities.

4.11 Fish Species (lower Baro Akobo basin - <800 m.a.s.l.)

Species carried out by the Russian academy of Science as part of the overall Russian study (Selkhozpromexport, 1980) found 72 fish species in the lower basin. Nile perch (Lates niloticus) Nile tilapia (Oreochromis niloticus) , Catsish (Clarias sp), Bargrus, barbus and Labeo species were important both in ecological and commercial terms.

Fishing in the region is mainly on a subsistence basis, both in the main river channels and many of the floodplain lakes. Virtually every family that live near water fishes to supplement their diet. A dividers array of equipment is used. Clay pots with moistened flour bait and women and children to catch small-sized fish from the shallow riverbanks often use reed sieves. Active fishing is carried out by the men using spears, or modifications thereof, cones, various hook and line devices, traps made of reed used in a similar manner to a trawl, but from dugout canoes, and diama, which are similar to a beach seine but of sticks and ropes.

In addition to the subsistence fishermen, there are three fishing co-operatives at Pinudo (at Tata), Pinkew and Itang which were established by Lutheran World Federation and fish is both from the co-operative at 1.5 birr/Kg at Pinudo, 1.25 Birr/Kg at Pinkew and 1 Birr/KG at Itang. The Co-operative then buys the fish from the fishermen and sells it on in Gambela on the open market.

Fishing is highly seasonal in the lower Baro-Akobo basin. Flooding between June and October prevents most fishermen operating and thus the main fishing season is restricted to the drier periods between October and April.

No direct estimates of present fishing efforts and production are available because catch and effort data are not collected.

4.12 Cattle Grazing

The basin contains about 1.2 million cattle, 0.4 million Sheep, 0.24 million goats, 0.09 million equines and 1.1 million chickens. Cattle are of primary importance, representing about 90% of the total livestock unit. They are used for draught, milk, capital reserve, and resource of cash, cultural purposes such as status and bride price and subsistence.

In the lower basin, the livestock are managed on a migratory system in response to the availability of grazing and water in the plain but the seasonal distribution of the feed is constraint. In the upper basin, feed resources are the main constraints to livestock production.

4.13 Non-Renewable Resources

The basin contains primary and placer deposits of Gold and other important minerals.

4.13.1 Wetlands and Lake

If one takes the categorisation of wetlands under the Ramsar International Convention as a basis, Ethiopian wetlands would consist of fresh and brackish lakes, ponds, swamps/marshes, perennial and intermittent rivers and streams, riverine flood plains and manmade lakes. Wetlands in Ethiopia cover and estimated to cover an area of 18,587 km^2 amounting to 1.5 percent of the country's total area. (Environmental Protection Authority, 2003). According to the report on the 43 surveyed wetlands of Ethiopia; Cheffie Gebo, Ginina, Abol, Alwero and tata (thata) located in the Baro-Akobo river Basin descried in the following table.

No	Name	Size (ha)	Type	Limnology, Physical features	Use	Threats	Ownership	Management Measures
1	Alwero Reservoir	2210	-Man Made	-No rainfall and temperature data -No Limnology Data	-Water Supply, Fishing and Grazing, Forest area	-Deforestation -Malaria and Fascioliasis are Commen	State-Owend	-No known Conservation measures but found in good status
2	GININA	-Not Deline ated	-Seaso nal Flood Plain	-Belongs to the wet Kolla agro-ecological Zones near Gambela Town	-Dry season Grazing, Fire- wood collection site, settlement around the wet land	- Mimosa Pigra, an invasive plant becoming a problem by preventing fishing, grazing and farming	State-Owend	-No known Conservation measures
3	Tata /Thata	185	-Fresh water Lake	-Have no Temperature and Rainfall data	-Fishing -Water supply -Grazing -Canoe Transport -Farming	Current -Water hyacinth -Siltation Potential -Introduction of Alien species -Malaria and Fascioliasis	-Annuak People	-Traditional management but facing pressure of refugees

4	Cheffie Gebo	- No Not Delineated	-Wooded Wetland	-No Limnology Data -No rainfall and temperature data	-Forestry, Pasture, Religious Importance -Water supply - Farming	Current -Farming, Overgrazing and Siltation Potential -Introduction of Alien species, expansion of drainage farming	-Privet Framings - Mechara and Sigsega Farmer Associations	- Management measures to protect trees
5	-Abol	- No Not Delineated	-Seasonal Flood Plain	-No Limnology Data -No rainfall and temperature data	-Fishing (seasonal) -Grazing	Current -No threat Potential -Introduction of Alien species -Malaria and Fascioliasis and tse-tee flies	- Farmers of Abol Kebele farmers	-No management measures - The site is naturally Conserved

Source: Environmental Protection Authority

4.14 Rivers and Major Tributaries

The major rivers in the Baro-Akobo basin are Baro and its tributaries (Birbir, Geba, Sore), Gilo with its Tributaries (Gecheb, Bitum,Beg), and Akobo with its tributary Kashu and Alwero. The general direction of the rivers is from the east to west. The rivers rise in the high land (2000-3500m) situated in the east of the area and flow to the Gambela plain (500m) in the west.

4.15 Irrigation

ARDCO-GEOSERV identified 18 potential irrigation areas in scattered location in the upper basin and presented preliminary information on these areas. In contrast, under the Russian study, a comprehensive master plan was developed for the lower basin, which includes several areas located along a band of land above the flood prone zone.

Of those identified by ARDCO-GEOSERV in the upper basin, 17 of the candidate projects were found to be unsuitable for Irrigation.

In contrast with the Upper basin, the lower basin, specifically the Gambela plain area mostly above the seasonally flood areas, between elevation 425 and 550 meters above sea level, offer many promising possibilities for the development of irrigation. This was previously reorganized in the study made by TAMS (1970s) and more recently (1995) by Russian master plan. As the result of the latter, the Ethiopian Government decided to undertake the development of 10,400 ha Alwero project that includes the Abobo dam.

In addition, by Baro-Aokobo integrated master plan study (1997), 14 basic irrigation systems and 8 variant were identified, laid out, sized and costed. The area investigated comprises a gross surface area of about 631,000 hectares. Based on water and land resources, the net area that can ultimately be developed is about 480,000 hectare.

4.16 Projects that Enhance Biodiversity and Water Quality

- Forestry
  Forests are key components of the basin's environment. Improved forester provides suitable habitat many types of wildlife. Danes forest intercepts rainfall and helps protect the soil surface against soil erosion. The resulting betterment of hydrological condition will provide benefits to mach of the infrastructure such as roads, dams, bridges, and water supply that leads to improvement to human heath. Advance in the forest economy will offer alternatives to subsistence agriculture, and off-farm income will improve.
- West water collection, treatment, and disposal.
- Solid West collection and Disposal

4.17 Environmental Threats

4.17.1 Soil Erosion and degradation

In Ethiopia, up to 400 tons of fertile soil / hectare is lost annually from lands devoid of vegetative cover as well as from lands where no soil conservation has been carried out. The soil thus lost annually is from the farmlands, which make up 13 % of the total area. This kind of erosion is common at altitudes between 1,700 to 2, 600 m above sea level and where extensive farming activities are carried out.

Soil loss due to runoff, Loss of forest cover etc is increasing and the risk and consequences of soil erosion have been expanded. Soil loss due to removal of vegetation cover is an all too ubiquitous condition in the upland zones of the basin.

Cover	Slope (%)	Runoff (%)	Soil Loss ($T/Ha/Y^{-1}$)
Grass, percent	36	6.9	0.026
Grass, 20 percent	20	29.0	12.0
Forest	7.15	2.4	0.24
Cirrus + mulch	7	2.6	4.3
Citrus	7	9.2	18.9
Row crop + mulch	7	39	89.4
Fallow + Weed Grow	7	-	5.3

Source: Ministry of Water Resource

4.17.2 Land Degradation

According to the Nile river basin trans-boundary environmental analysis (2001), environmental threats observed in the Baro-Akobo Basin includes, Land Degradation (Severe deforestation in the high lands, Sever Soil erosion) water quality degradation (Moderate water Pollution-Point or not point source, sanitation concerns-water born diseases and environmental health).

Land degradation occurs in various forms throughout the basin: Water caused soil erosion, Chemical degradation, (leaching of bases), physical degradation (loss of porosity), and biological degradation (loss of humus)

4.17.3 Deforestation

As the result of combined action of civil unrest, land conversion to agriculture, fuel wood harvesting, burning and increase in population of refugees the basin is losing large amount of forest annually.

4.18 Environmentally Sensitive Areas

Sensitive areas are those areas that have significant importance with regard to biodiversity conservation or for the preservation of items that have cultural and heritage significance. Gambela national park, which is seriously affected by refugees from the Sudan and encroachment by people living near the park and wetland areas around Gambela national park, which still affected by refugees are more sensitive areas.

4.19 Likely and Possible Impacts of Major Developments

The following table indicates the possible positive and negative impacts of the proposed projects.

Project	Positive impact	Negative Impact
Soil Conservation		Water Quality, Production losses, soil losses and Gulling
Small-holder Agriculture	Better land husbandry, Reducing Soil Degradation, Increase Farm Productivity	Misuse of Agrochemicals, Coffee production
Forestry	Habitat for wild life, Protect Soil Erosion, Betterment of Hydrological conditions, betterment of infrastructures, and betterment of human health.	Need of Development of Roads, Increase of wildlife population etc
Wildlife	Developing Economy,	No foreseeable negative Impact
Tourism	Employment and Income, Expanding of Ethiopians natural Heritage	Polluting Lakes, Removing of Plantation
Livestock	Financial benefits, land and vegetation management, reducing flooding, Reduce agricultural pressure,	Degradation of Vegetation resource, Increased soil erosion, Habitat loss, Pollution and health hazard.
Fisheries	Increasing catch, Improve House holed income, Human nutrition Improve	Overexploitation, pollution from oil and fuel spill, use of explosive and poison
Apiculture	Increase income	Fire risk
Hydropower		

Source: Ministry of Water Resource

4.20 Critical Information Gap

This report is based on the information obtained from studies made by "Baro_Akobo River basin Integrated Development master Plan Project, 1998", The master plan study emphasis on the water resource development only. Therefore, all the information give on this report may lack recentness.

5. BASIN SPECIFIC: TEKEZE RIVER BASIN

5.1 Location

Tekeze River basin is situated in the northwest of Ethiopia, between latitudes 11^0 40' and 15^0 12' north and longitudes 36^0 30' and 39^0 50'. It is bordered by the Mereb river basin in Eriterea in the north, the Atbara river plains in Sudan in the west, the Abbay river basin in the south and the Danakil basin to the east. The area of Tekeze basin is about 86,510 km ^{2}. A relative small part of the basin (4,160 km ^{2}) is situated in Eritrea.

5.2 Elevation and Catchment Water Sources

Tekeze river basin (inside Ethiopia) has an average elevation of 1,850 m.a.s.l. and a catchment area of about 59,306 km $^{2.}$ About 70% of the basin lies in the highlands at an altitude of over 1,500 m. the upper reaches of the Tekeze are surrounded by mountain ranges, the elevation of which is over 2000m, attaining a maximum altitude (4,620 m) at the mountain of Ancua, part of the Ras Dashen system. The area of land above 2,000 m elevation covers almost 40% of the total basin area.

The length of Tekeze River, from its source at springs near lalibela down to the Sudanese border is more than 600 km. The major tributaries of the Tekeze, which originate in the highlands on the east side of the Simien Mountains, are the Zamra, Tserare, Geba and Worie. Large tributaries originating on the east side of the Simien Mountains are the Insia and Zarma. The river slope is quite steep in the mountainous strech (> 1.5 %), but decreases gradually to 0.3%, and then to less than 0.1% in the lowlands.

The Tekeze basin includes the smaller Angereb (area about 13,327 km ^{2}) and Goang (area about 6,694 km ^{2}) basins. The Angereb and Goang rivers cross the Sudanese border to the south of the Tekeze and join the Tekeze River downstream in Sudan. Together they form the Atbara River, which is an important tributary to the Nile. Basins of minor streams along the Sudanese border cover an area of 3, 023 km ^{2} .

Main Rivers and Basins of Tekeze River Basin

River Basin	Major River	Major Tributary River
Tekeze	Tekeze	Zamra, Tserare, Gheba and Worie, Insia and Zarema
Angereb	Angereb	Kaza
Goang	Goang	Gendua

5.3 General Physiography of the Area

The Tekeze river basin can be roughly divided into highlands at altitude of more than 1,500 m and lowlands at 500 to 1,500 m above sea level. About 70 % of the basin is occupied by highlands with almost 405 of the land being above 2,000 m altitude. The highlands have a mountainous to hilly topography, interspersed with flat to rolling plateaux and plains. Volcanic domes and cones form high-relief mountains in many areas. Plateaux usually terminate in steeply dissected escarpments, where resistant strata have been broken down by geological erosion. Extremely rugged topography exists in major fault zones. The highlands are cut into a number of blocks by the deeply incised gorges of the Tekeze River and tributaries. To the west of the highlands give way to flat and rolling lowlands along the Sudanese border.

A very general differentiation, based on Physiography and parent material, can be made as follows:

- Highlands on tertiary basalt and tuffs, south of the Tekeze river;
- Highlands on Precambrian and Palaeozoic volcanic, sedimentary and metamorphic rocks, north of the Tekeze river;
- Highlands on Mesozoic sandstone and Creataceous rocks around Mekele and bordering to the highlands with tertiary basalt
- Lowlands with undifferentiated alluvial and colluvial sediments along the Sudanese border.

5.4 Characteristics of the Major Landforms

Following the SOTER hierarchy of major landforms at the highest level of differentiation, four categories have been distinguished, viz. level, slopping and steep land and a composite landform. In the Tekeze river basin, level land includes landforms as plains, plateaux, flat valley floors and low gradient foot slopes; slopping land is all land classed as medium gradient hills; while steep lands are composed of high gradient hills, mountains, steep ridges, steep valleys and escarpment zones. The composite landforms consist of a combination of one or more of these single landforms in different classes, not separable at the scale of mapping.

Major landform	Area %
Level land	16
Sloping land	14
Steep land	52
Composite landforms	18

The Tekeze basin as whole is characterized by the dominance of steep land and more than 50 % of the basin has slope gradient of over 30%. The dominant landform in the basin is steep hilly land, with which one third of the basin is covered. Slopping land (gradients 8-30%) covers about 14% and level land (<8%) about 16%. The composite landforms, which combine two or more major landforms, cover 18% of the basin. Really flat land (<2% gradient) occurs in only 5 % of the basin.

5.5 Climate

The main influence of circulation in Ethiopia are the inter Tropical Convergence Zone (ITCZ), the northwestern trade winds and the southwestern monsoon. The trade winds are the dry air currents that flow from the high-pressure cells over the eastern Sahara and Arabia towards the low-pressure area over Central Africa. This system dominates from October to march (northern winter), causing the dry season. From mid-march onwards, the pressure system changes. Warm, moist and unstable air from the Indian Ocean moves in from the east and converges with stable continental air from the Sahara high-pressure cells. This produces precipitation in the eastern part of the basin, up to about 39^0 30' latitude. In the June-August period (northern summer), when the sun has moved to the northern hemisphere, the south-western monsoon winds become important. They are caused by the large difference between the heat retention capacity of soil and water.

The Tekeze basin can be divided in two regions, according to differences in climate seasons:
The region west of the Simien Mountains has two-season type climate: wet and dry. The wet season in this region last about four months from June to September included.

The region east of the Simien Mountains is characterized by three season, viz. a dry season from October to February (Bega), a small rainy season that covers the period from mid-February to mid-May (Belg) and the main rainy season that covers the period from June to September (Kiremt).

5.5.1 Rainfall

In Ethiopia, the variation of climate during the year is largely associated with the macro-scale pressure changes and the monsoon flows related to these changes. The movement of the Inter Tropical Convergence zone (ITCZ) and change in location of the subtropical high-pressure zones gives rise to two monsoons in eastern Africa. In summer (July-September) the large low-pressure area over the Indian Ocean and the Arabian Sea dominates the airflow and there is a strong movement of moist air from the southwest to the northeast, i.e from the high-pressure centre over the Gulf of Guinea (Atlantic Ocean) towards the low-pressure centre of Arabia. This movement carries warm, moist, unstable air mass from the Congo basin and is the largest source of rainwater for Ethiopia, including the Tekeze basin.

Indian ocean is another moisture source, especially for the south-eastern part of Ethiopia in march and April (in the Basin is this the region east of the Simien mountains or longitude 39^0 30'). Convective instability, due to intense heating of the high plateau land, is also the cause of some part of rainfall.

5.5.2 Precipitation

Annual precipitation amounts show large variations over the basin. Humera in the lowland area has an average precipitation of 600 mm, while locations near the Simien Mountains have annual average above 1,300 mm. In general precipitation decreases from south to north from 1,200 mm to 600 mm. However, the Simien mountains are an exception to this rule, they experience average annual amounts of precipitationsabove 1,300 mm, as mentioned above.

d.2 Temperature (^{0}C)

The temperature is mainly determined by altitude. In the lowland area (600 mm) average annual temperature are above 26^0C, while in the Simien mountains the average temperatures are below 10^0C. In the largest part of the highlands the average temperature is around 22^0C. Minimum monthly temperature occur in the December – February period and range in the basin between 3 and 21^0C, while maximum mean monthly values occur in march – April and range between 19 and 43^0C

5.5.3 Relative Humidity (%)

Minimum mean monthly relative humidity values occur in the dry period (October-March) and can be as low as 40 %. High values occur in the main rainy season (July-August) in which period mean monthly values for many stations are above 70%.

5.5.4 Sunshine (hrs/day)

Mean monthly sunshine hours for the different stations range between 6.5 and 8.5 hrs/day. Highest monthly values, up to 10hrs/day, occur during the dry period. Low values, to below 4 hrs/day, occur during the rainy season, and especially in the months of July and August.

5.5.5 Wind Speed (Km/Day)

For all stations monthly mean wind speeds, up to 300 km/day, occur during the rainy season (June-August). Low values occur during the dry season, sometimes below 100 km/day.

5.5.6 Evaporation (mm)

Evaporation is determined by a number of climatic elements as mentioned above. Evaporation occurs from open water surfaces or from plant cover. In the later case one speaks about evapo-transpiration. In this report reference is made to potential Evapo-Transpiration (PET), which is the water use of a standard crop experiencing no water shortages. The annual PET varies from 2,200 mm in the lowland (600 m.a.s.l.) in the west of the basin to less than 1,000 mm in the Simien

Mountains. In the east of the basin the PET is around 1,600 mm. On an annual basis PET is much higher than the precipitation, except in the Simien mountains.

5.6 Agro-climatic Zones

Based on the temperature, four basic climatic (thermal) zones can be recognized in the basin. They are presented in the table below. The kola zone is subdivided into three agro climatological zones, the Weyna Dega and the Dega thermal zone each into four and the Wurch in to two zones. In this way 14 agro climatological zones were created for Tekeze River basin. The temperature and the dependable length of growing period characterize the 14 zones.

Agro-climatological zones in Tekeze river basin

Agro-claimatological zone	Thermal zone	Rainfall (mm/yr)	Potential evapotranspiration (mm/yr)	Dependable length of growing period	% of basin
K1		500 800	1800 2300	3	9
K2	Kolla	600 1100	1500 1700	2.3	6
K3		700 1500	1500 2200	3.5	27
WD1		500 800	1500 1700	2	21
WD2	Weyna	700	1400 1900	3	8
WD3	Dega	1100	1300 1700	3	13
WD4		700	1400 1700	3.5	3
		1000		3	
		1000		3.5	
		1500		3.5	
				5	
D1		400 600	1400 1500	2	1
D2	Dega	500 700	1400 1500	3	1
D3		700	1600 1800	2	5
D4		1000	1300 1700	3	4
		1000		3	
		1400		3.5	
				3.5	
				5	
W1	Wurch	700	1400 1500	3	1
W2		1000	1000 1700	3.5	1
		800		3.5	
		1500		5	
HW	High Wurch	900 1300	1000 1500	3.5 5	0.1

In Ethiopia there is a system of altitude zonation as indicated in the table (after De Pauw). The thermal zonation is in fact an altitude zonation. Temperature can be readly estimated from altitude because the correlation between the two variables is generally very high in Ethiopia.

Thermal zonation (after DE Pauw, 1988)

No.	Traditional name of Zone	Temprature range	Altitude range
T1	Bereha when dry Lower Kolla	>27.5	<500
T2	(Upper) Kolla	27.5 - 21	500 - 1500
T3	Weyna Dega	21 - 16	1500 - 2300
T4	Dega	16 - 12	2300 - 3000

T5	Wurch	12 – 7.5	3000 - 3700
T6	High Wurch	<7.5	>3700

Further assessment has been made of the estimated Length of Growing Periods (LGP) in the basin, where a growing period is defined as that part of the year during which the moisture supply from precipitation and soil moisture and the temperature are adequate for crop growth.

Matching of crop growth duration with growing period is the key to consistent yields, in particular in areas with different rainfall. The calculated LGPs have been adjusted with field observations, where after they ranged between 2 and 5 months. The thermal zones have been combined with rainfall and LPG, which resulted in agro-climatological zones, which can be related with specific crops.

5.7 Agro Ecological Units

Agro ecological units, areas homogeneous in soil, terrain, and agro climate, are created by a combination of SOTER units and agro climatological zones. The descriptions of agro ecological units contain the soil and terrain data that are relevant for land evaluation. These are the so-called land characteristics, which are attributes of the land that can be measured or estimated. Examples are PH, effective soil depth, and soil texture. They described soil qualities.

5.8 Soils

Soils form an integrated part of each SOTER unit. At reconnaissance level, usually more than one soil unit (type) is present in SOTER unit. The soil units are the soil component of the SOTER database. Also non-mapable soil units can e stored in the database and can be given a percentage of occurrence (proportion) of the SOTER unit. The soil components of one SOTER unit are the soil associations or soil complexes in previous terminology. Mapable soil units will be indicated at SOTER unit level. Mostly SOTER units are composed of more than one soil component, but also SOTER unit with only one soil component occur. In both cases the dominant soil of the SOTER unit can be shown in a GIS environment.

In the basin, particularly semi-detail survey at 1:50000 scale have been related to irrigation development. The areas to be surveyed in semi-detail survey were identified from the regional maps prepared during reconnaissance survey, considering the quantity of water available for irrigation.

In the study area, soils with well-developed profiles are rare. Soils developed in moderately deep-to-deep black clays (vertisols and vertic soils), are the main exception, having a fair real extent. Nearly all other soils are shallow, truncated or show very little profile development.

5.9 Forestry

With the high rate of increase in both human and animal populations in the Tekeze basin, the remaining woodlands and bush lands continue to be under pressure. A number of factors have contributed to this, including population growth which induces increased demand for agricultural land and pasture and causes increased fuel wood harvesting exceeding both the woodland and bush lands regenerative capacity. As a result most of the vegetation of the basin has disappear and only little of the original vegetation is evident. It is only the lowland woodland and bush lands in the western and northern part of the basin which are nearer to climax.

From household survey conducted in the highland parts of the basin, 98 % of the farmers indicated that there is a shortage of forest product. This brought a corresponding reduction in the application of dung to enrich the soil organic content. The demand for wood to meet the basic needs exceeds

the available supply. The wood supply comes from trees around homestead and farmland, natural woodland and bush lands.

The basin has an acute shortage of industrial wood, which is being imported from other parts of the country. There is no industrial plantation established in the basin for current and future consumption.

Woodlands characterize the dominant vegetation cover of the basin and bush lands which occur mainly in the agro-pastoral zones along the northern and western part of the basin. They have been heavily used as a source of gum and incense and as sources of fuel wood and fodder for livestock.

The vegetation area covered by this study occupies much of the north western part of the basin with elevation below 1000 m.a.s.l.. The vegetation cover accounts for 1,052,617 hectares. Out of this, the woodland accounts for nearly 77% of the total area of the vegetation thus making woodland vegetation of major land cover.

5.10 Vegetation Formation of the Basin

Vegetation Type	Area in ha	Percentage (%)
Woodland		
Dense bushy woodland	276,510	
Dense woodland	245,857	77
Open woodland	288,807	
Total	811,174	
Bush land		
1.Dense bush land	71,230	10
2.Open bush land	36,293	
Total	170,523	
Wooded grassland	133,920	13
Total	1,052,617	100

The type of forests known to be present include:

- Afro-alpine and sub-afro-alpine heath vegetation
- Broad leaved deciduous woodland
- Acacia bush land

5.10.1 Non-Timber Forest Products

The collection and export of incense has been carried out for centuries. The lowland environment of has the best potential for producing naturally obtained gum exudates from Acacia Senegal and incense from Boswellia papyrifera. The Tekeze basin is one among the potential areas and has a long tradition of exploiting natural gum and incense. High potential of Acacia Senegal is evident around Humera and Sheraro. Boswellia papyrifera is also dominant in the welkait and Sheraro Woredas. The central part of the basin is virtually cleared of vegetation cover.

Apiculture or beekeeping is one of the sustainable agricultural sub-sector which many rural farming communities practise and from which they derive food security and income. Basic biotic resources indispensable for the development of apiculture are honey plants, honeybee colonies, climate and

water. As the basin has lost most of its bee keeping potential due to natural and human factors, it falls under moderate and low potential areas. However, some potential areas have been identified in relation to their surplus annual honey production.

The honey yield largely depends on the availability of surplus bee forage, prevailing weather conditions and type and size of the hives. When conditions are favourable, 2-20 kg of crude honey (honey mixed with beeswax, pollen, dead bees, etc.) has been reported to be harvest from a traditional hive and 12-31 kg from modern hives per annum. The total honey production of the basin is estimated at 2,018 tons per annum, which is some 8.2 % of the national honey production. Beeswax collection is unknown to all beekeepers in the basin. Honey is sold with out further processing and if consumed the beeswax is unused. As a result, data for beeswax production could not be obtained. But, 8-10 % of the total honey yield from a traditional hive is calculated to be beeswax. With modern hives the ratio is 1-2 %. At the minimum percentages, a total of 200 tons of beeswax could be produced in the basin per annum.

5.11 Water Related Resources

With construction of dams and reservoirs (with heights over 15 m), water resources of the basin may have a potential for irrigation, drinking water supply and hydropower generation. Less likely purposes in the Tekeze basin are fishing, tourism and navigation.

5.11.1 Groundwater

An extensive Water Point Inventory (WPI)has been carried out in the basin, during which discharge –draw down data have been collected. On the basis of this inventory it can be stated that the basin has aquifers/formations with very low productivities except high and medium productive areas concentrated around Mekele and Hagere Selam (Agula Shale, Antalo Limestone and Tertiary Dolerite formation). However, these areas have high TDS values (800 – 1000 mg/l); compared with Ethiopian Standards for Drinking water (highest desirable level 500 mg/l).

The WPI included 720 water points, out of an estimated total of around 1,000. it is assumed that on average of 2.69 l/sec is extracted from each well during 8 hours per day then the total extraction per year is 28 Mm^3 , a fraction of the total annual recharge from rainfall, estimated to be at least 2,500 Mm^3 . if a safe extraction factor of 15% is adopted, 375 Mm^3 can be extracted in the basin annually.

5.11.2 Surface Water

The Tekeze River Basin consists of three main basins:

- Tekeze (up to Humera) 63,376 km^2 of which 4,070 km^2 in Eritrea
- Angereb (up to Abderafi) 13,327 km^2
- Goang (up to Metema) 6,694 km^2
- Drainage in to Sudan 3,113 km^2 of which 90 km^2 in Eritrea
- Total 86,510 km^2
- **Total (without Eritrea) 82,350 km^2**

Estimated flows at the boundary:

- Tekeze (Humera) 5,875 Mm^3
- Angereb (Abderafi) 1,454 Mm^3
- Goang (Metema) 862 Mm^3
- **Total 8,191 Mm^3**

The basin contributes an estimated 6.5% of the nile river flow. The chemical quality of surface water is excellent, both for drinking and irrigation, except for a sample from the Ilala river, which had a rather high TDS.

5.11.3 Water Quality

The quality of ground water is usually better than surface water. Groundwater is to be found everywhere in the basin, but the art of locating a productive well site is to strike a groundwater bearing and conveying fracture system. Results of the water point inventory indicate that most wells (77 %) have only one water entry (fault or fracture) in the borehole from where water is pumped. Such entries are not easy to find. Exceptions are the limestone near Mekele, which have a well-developed system of fissures (dissolved pathways). The quality of this water is not very good. Other good locations are areas near large (dry) riverbeds (bank infiltration). If no groundwater can be found, surface water runoff is the only alternative

5.11.4 Hydropower Potential

The hydropower potential of the basin is quit large. Rivers are quit steep and some have deep gorges, which make ideal dam sites. However, high dams and large reservoirs are required to produce sufficient firm power. The total potentially generated firm energy of the basin is 4117 GWh/yr.

5.11.5 Irrigation

Large scale irrigation potential created by impounding water in large dam in the lower reaches of the river has been calculated on the bases of data on mean annual regulated flow from reservoirs in the Tekeze, Angereb and Goang/Gendua rivers.

- Tekeze 152,700 ha
- Angereb 23,200 ha
- Goang/Gendua 13,600 ha
- **Total 189,500 ha**

The large-scale irrigation potential is based on the water resources, at full utilization, suitable land, to use this water on, has to be identified.

5.11.6 Drinking Water Potential

In 1995 water demand in urban areas was estimated at 35 lcd and in rural areas at 20 lcd. With the improvement of the water supply infrastructure these figures have been estimated in the year 2030 to increase to 60 lcd in urban and30 lcd in rural areas. Total demand in 1995 is 37 Mm^3 (1.2 m^3/s) and in 2030 173 Mm^3 (5.5 m^3/s), figures that are small compared to the total outflow of the basin of 8,191 Mm^3 Mm^3 (260 m^3/s) also when an estimated 30% for non-domestic uses is added.

5.12 Biodiversity

As a result of its topography and diverse climatic conditions, Ethiopia is the home for various plant and animal species. There are no less than 7,000 different higher plant species out of which about 12 percent are endemic to Ethiopia. Ethiopia is the centre of origin for various crop species such as Coffee, Teff, Noug (Guizotia Abyssinica), Enset (Ensete Ventricosum), etc. Ethiopia is also home to crop species with useful genetic diversity such as sorghum, barley, wheat, horse beans, field peas, lentils etc.

5.13 Wildlife

The Tekeze river basin has been a focal point of the Ethiopian Wildlife Conservation Organization (EWCO) due to the presence of Simien Mountains National Park. The ecosystem of the Simien

Mountains national park is unique for its scenery, endemicity and genetic importance of the plants and animals that occupy the habitat. Sheraro – Kafta Wildlife Rreserve has a substantial potential for wildlife management in so far as the reserve is less utilized by livestock and because of the presence of elephants, one of the very species in the basin.

Lack of wildlife database for the basin covering such aspects as distribution, status and movement is identified as a basic problem of the basin. Such information requires time and manpower. As wildlife, particularly wild animals, are under constant change of distribution and status, the gathering of information requires at least two seasons. Without such a database, wildlife management proposals remain somewhat speculative.

However, according to available information at national level, out of 277 mammals 31 are endemic to Ethiopia. Out of 862 bird species 16 are endemic to Ethiopia while 14 are endemic to both Ethiopia and Eritrea. In addition, out of 201 reptiles 10, and out of 63 amphibians 34, are endemic to Ethiopia (National Meteorological Services, 2001). Among the 862 bird species recorded in Ethiopia 30.2 percent have been accorded international importance. In addition, about 31 of the species existing in Ethiopia are among the globally threatened. More over, there are 5 critically endangered, 12 endangered and 14 vulnerable species. Various migratory birds considered endangered at the international level also visit about fifty sites in Ethiopia every year. (National Meteorological Services, 2001)

Among the numerous wildlife in the country, the Walia Ibex, "*Key Kebero" (Ethiopian wolf)),* and the Gelada Baboon found in the Semien National Park, the Menelik's Bush Buck and "*Key Kebero"* (Ethiopian wolf) found in Northern Shoa, the Mountain Nyala, "*Key Kebero"* (Ethiopian wolf) found in the Bale Mountains National Park, are the major ones. The various bird species in the different parts of the country also have special attraction. However, due to the pressure they are encountering, the number of this wildlife is decreasing. There is evidence that the "*Key Kebero"* (Ethiopian wolf), is especially endangered, due to cross breeding with domestic animals (dogs) and infection by a disease that the dogs acquire through human contact. (UNEP, 2002) In addition, information acquired from the Ethiopian Wildlife Organisation and the Ethiopian Wildlife and Natural History Society indicate that there are 3 mammals that are seriously endangered as well as 2 mammals and 8 birds that are vulnerable.

5.14 Aquatic Bio-Diversity – Fishery

River fishery is not well developed in the basin. The rugged natures of the landscape together with the seasonal flow of many streams make it difficult to develop this sector in the highlands. In the lowlands some of the rivers and streams flow all year round and there is potential to increase fish production.

According the results of the livestock and fisheries survey conducted in the basin and the data gathered at the Bureaux of agriculture and Rural development in Mekele and Gonder the important commercial fish species in Tekeze River basin are: oreochromis niloticus; African catfish; Clarias gariepinus; Barbus; barbus intermedius; other Barbus species; and Bagrus docmac. Other species found in the basin presently have no economic value.

Most people living along the river courses do fish at some time during the year. The small catches of the basin fishermen are normally consumed or sold in fresh form. The preservation methods used are sun drying and some times salting. The types of fishing gear that are used in the basin are: rod and hook, poisons plant, cast nets and occasionally small gill nets.

In the upper and mid reaches of the river basin occasional and part-time fishermen produce 4 – 1,000 kg of fish per year (the lower figures are applying to the catches of occasional fishermen). Fish catches with local fishing materials are between 20 and 60 kg/yr. Gill net catches are in order of 1,000 kg/yr. In the lower catches of the river basin the fishing is a part-time and full-time occupation. The fish catches are higher (up to 3,000 kg/yr) than those of the highland fishermen, but still insignificant due to the primitive nature of the fishing gear.

Due to inadequate information on riverine fisheries the yield potential can only be obtained by extrapolation from systems of which the ecology has been studied more thoroughly. On that basis a production potential of 40 – 60 kg/ha/yr can be estimated for the lower reaches of the Tekeze river basin and about 200 kg/ha/yr for the upper course.

5.15 Irrigation

The major part, 82% of the basin, is not suitable for irrigation. In the first place because of a too high slope gradient (s), this is the most limiting factor for this land use, accounting for 73% of the basin. In the second place because of the rooting conditions, which are limiting for crop growth and for drainage of the irrigated lands. This limitation occurs for 68% of the basin.

About 5% of the basin is highly suitable for irrigated agriculture. Most of the suitable areas are found in the western lowlands, but also they occure around Shiraro and Arbaya. Moderately and marginally suitable lands covers 12% of the basin. Also here the availability of water is not taken into account. These moderate and marginally suitable lands can be found in the western lowlands, east of Adi Ramets, near Shiraro and north of Mekele. If water is available, some small-scale irrigated agriculture can be practised in these regions.

The Tekeze river basin has the potential to expand and develop irrigated agriculture. Small-scale schemes are appropriate for peasant farming, medium-and large-scale schemes for (commercial) agricultural undertakings and enterprising settlers. Large investment and high level of technical knowledge will be important inputs. Traditional irrigation needs to be expanded and supported to play its role in crop production.

5.15.1 Small Scale Irrigation

If enough sites for micro-dams in the upper and middle catchments can be found, 1,500 dams each storing one million m^3 have been foreseen. These can provide supplementary irrigation on a small-scale basis to 450,000 ha of crop land in the wet season and to 112,500 ha in the dry season. The reconnaissance soil survey cannot confirm whether suitable land in such amounts is available. However, estimate of the SAERT and SAERAR projects indicate that above figures are not out of range of reality.

On-going small-scale irrigation development schemes in Tigray Region

Zone	Wereda	Scheme	ha	Stage	Responsibility
South	Adi Gudom	Gum 30	100	Construction	SAERT
	Kuiha	Arato	100		SAERT
East	Wonberta	Era	100	Construction	SAERT
	Agula	Wukro	100		
Central	Lailay Maychew	Mai Neguse	100	Construction	SAERT
	Tembien	Adha	100	Operational	REST
	Worie-leke	Seguha	30	Construction	REST
	Abergelle	Agbe	30		
West	Adi daero	Enda Mariam	30	Construction	SAERT

Source: Agronomy survey 1995

On-going small-scale irrigation development schemes in Amhara Region

Zone	Wereda	Scheme	ha	Stage	Responsibility
Wag Hemra	Sekota	May Lomi Mahabere Genet	50 60	Construction	SAERT SAERT
North Gonder	Belesa	Zana Atelkaina	65 50	Feasibility	SAERT

Source: Agronomy survey 1995

5.15.2 Large-scale Irrigation

Three large-scale irrigation projects have been proposed:

- Humera, with a gross (net) irrigable area of 50,500 (42,965) ha;
- Angereb, with a gross (net) irrigable area of 13,592 (11,561) ha;
- Metema, with a gross (net) irrigable area of 19,276 (16,385) ha;

Priority crops for irrigation are potato, lentil, bean, onion and vegetables in the highlands; chick pea, vegetables and fruit trees in mid-altitudes; sesame, cotton, groundnut, sugar cane and vegetables in the lowlands. Cereals as barely, wheat, maiz and sorghum may be grown, prefereably under supplementary irrigation, but they may not give large enough returns to be economical.

Currently, irrigated agriculture in the basin has not yet been developed. The existing practice is entirely dependent on traditional irrigation (diversion and spate) systems, which have both limited area coverage and low yield levels.

The existing irrigation practices are dominated by traditional and inefficient practices and both area coverage and productivity are at low levels. The current area coverage is not more than 10,000 ha virtually no external inputs and improved water management practices are adopted by the farmers. Recently, encouraging efforts on irrigation development have been made in both regions. However, due to inadequate planning and inefficient implementation. Irrigation has hardly been started even in several completed irrigation schemes.

5.16 Livestock and Animal Feed

The small-scale mixed farming system is dominant in the whole Tekeze river basin area. It accounts more than 97% of the farm households. Although the proportion of farmers in the whole basin is low, in the lowlands of the northwest of the basin there are farmers who own cattle and goats in large numbers and who depend totally on livestock production.

The tekeze river basin cattle are predominantly of zebu type. Five breeds have been identified: Barka (locally called Begait); Arado; Fogera; The Raya-Azebo (locally called Harmo); Abyssinian shorthorned zebu. There are also crosses of Holstein-Friesian and locals used for milk production in peri-urban areas.

The proportion of oxen (bulls plus castrates) and cows in the total herd is 27% and 31%, respectively.

The primary feed source in the Tekeze river basin is natural pasture. Crop aftermath is also extensively used. The farmers in many parts of the Dega and Weyna Dega areas collect crop residues to feed primarily to oxen and lacting cows during the dry period. Opuntia ficus (prickly pear cactus), locally called belese, serves in the eastern and Southern Zones of Tigray both as human food and livestock feed during normal crop seasons and in case of feed deficits. Since it contains about 90% moisture, it is also utilized as source of water for animals during the dry period. The feed supply from all sources declines in quantity, nutritive value and palatability starting October and remains very low until the rains start.

The total dry matter supply in the basin is 20% above the annual maintenance requirement of the grazing animals. The nutrient requirement in terms of energy and portion components, however, shows a deficit of 31% and 3%, respectively.

5.17 Non-Renewable Resources-Mineral Resources

Placer gold is being recovered from numerous small panning sites. It is estimated that several hundred kilograms of gold are recover annually using this labour intensive method. Resources of gold, which could be exploited by mechanized mining very probably, exist; exploration is needed to indicate which of the known gold occurrences could be profitable mined. Marble and limestone is being quarried from localities south of Adwa and north of Mekele

5.17 Tourism

Ethiopia is a relatively newcomer in the international tourist market. Tourist arrivals in Ethiopia have shown a steady increase. There is a significant expatriate population that travels throughout the country, both on missions and for leisure.

The main international tourist attraction in the Tekeze basin is the so-called historic route, a circuit which includes Lake tana and Gonder (Just outside the basin), lalibela, Mekele and Axsum. This is, the best-known and most visited part of Ethiopia by international tourists. The Simien Mountain National Park is another major asset.

5.18 Past and On-Going Environmental Related Activities

Environmental issues are multi dimensional, and hence multi-sectoral. Environmental related proclamations and regulations prepared by sectoral agencies and approved by the pertinent body are being implemented. According to these proclamations and regulations, sectoral agencies have to prepare environmental assessment plan prior to the implementation of development activities and programs. However, with low awareness and due attention given to the environmental issues, sectoral agencies are giving more focus and priority on specific and short-term targeted plan implementation rather than long term environmental problems.

Mitigation of the enormous problem of land degradation in the Tekeze basin could only be achieved by joint action of all stakeholders including the local population. Protection of lands from erosion has started to get full attention of the responsible line agencies. Awareness of erosion increases rapidly in the rural communities. The extent of areas with traced cropland, comprising both old and recently built terraces is considerable and still increases rapidly. Terraced lands are concentrated mainly in the eastern, southeastern and northern part of the basin. Major concentrations of old terraces can be found in the eastern part of the basin.

Large tracts of recently terraced land were observed around and the west of the town of Mekele, and on the north-eastern plateaux areas between Adwa and Indasilase. Remarkable is the virtual lacking of terraces around the town of Gonder, despite the high pressure on land resources there, and in the vast very steep escarpment zones north and west of the Gonder- to – Debark plateaux areas, where cultivation is randomly spreading beyond the edges of the plateaux.

5.19 Environmental Treats

Most of the Tekeze river basin can be classified as an environmentally sensitive area comprising arid and semi arid land. This includes areas of environmental degradation, habitats of rare or endangered wildlife and cultural heritage sites and where development has reached high intensity and threatens to become unsustainable (eg in areas of high density urban or industrial development where water shortage and sanitation problems exist). Deforestation and soil degradation and erosion are key issues to be addressed in all EIAs for development in the basin. This degradation has a knock-on effect on biodiversity conservation, public health and socio-economic conditions. Population pressures, (i.e tree felling for fuel and to clear land for crop cultivation) destroy wildlife habitats and are a key factor in environmental degradation. The Tekeze river basin is also rich in cultural heritage sites. Which need to be safeguarded from any negative environmental impacts of development.

Since most of Tekeze river basin area can be classified as environmentally sensitive then Environmental impact assessment (EIA) should be extensively used for screening most types of sectoral development proposals (eg livestock, apiculture, fisheries, crop cultivation, dams, hydropower and irrigation, industry, mining, energy development and tourism. However the primary objective of some of the proposed projects can be viewed as mitigation (eg sectors of soil conservation, water supply and sanitation, wildlife conservation and some aspects of energy development). Most development projects may result in unsustainable levels of water extraction, crop cultivation can result in changes in soil fertility and development of pests. Irrigation projects, while raising fertility and providing extra food, can result in fluctuations in water table and increase in **malaria infestation**. Mismanaged tourism development, while generating income can result in degradation of cultural heritage site, and wildlife. Proposed industrial activities and mining development are not yet widespread enough to have a national impact, yet they can have grave negative environmental impacts at local level if they are not monitored and regulated as part of environmental management programmes.

Land degradation and erosion: the most extensive and pervasive environmental problem in the Tekeze river basin, in particular in the highlands, is clearly land degradation and soil erosion. Awareness of erosion as an environmental issue exists only since a few decades. Of the natural conditions, two general features have caused high erosion hazards since ages: the erosive character of the rainfall pattern and the predominantly steep relief in most of the study area. Erosion hazard turns into actual erosion if the protective vegetation cover is depleted.

Soil degradation in terms of fertility loss and erosion must have started gradually, but decreased productivity could long be compensated for by expansion of the cultivated area. In general, population increases during the latest 50 to 100 years have entailed the dramatic increases in land degradation and erosion rates, but around the old habitation centres, this must have started earlier. Limits of natural regeneration of resources were passed when increasing demands for land has forced peasants to expand cultivation onto steeper land being much more susceptible to erosion. Increasing demand for fuel and timber has caused large-scale deforestation.

Water erosion, in the form of sheet, rill and gully erosion obviously in the most intensive and widespread form of land degradation. Of the water erosion phenomena, sheet erosion or inter rill erosion, including also soil transport by rain splash, is probably contributing most of the total impact of erosion. Rill and Gully erosion are more spectacular because more evident features are formed during much shorter periods. Stream bank erosion was one of the striking features observed throughout the basin during the present study. By far the greatest majority of natural drainage ways in the area are actively eroding.

Deforestation: is a key issue in Ethiopia and in the basin in particular. Population pressure and unsustainable agricultural practices have resulted in distraction of forests for use as fuel wood and to make way for cultivation. This leads to erosion and soil depletion, which in turn leads farmers to deforest and cultivate further areas. Deforestation of steep slopes has led to severe erosion and loss of soil fertility.

The fuel demand in the Tekeze river basin, using a developed model, is given below. The fuel demand, expressed in Peta Joules (PJ) is given by fuel type for the year 1995, 2000, 2010, and 2045.

Fuel Demand by Fuel Types

Fuel	1995	2000	2010	2025	2045
Electricity	0.26	0.40	0.97	3.04	7.66
Kerosine	0.41	0.40	3.75	6.41	9.89
Diesel	2.84	2.69	6.56	15.49	50.94
LPG	0.00	3.77	0.17	0.82	2.13
Gasoline	0.24	0.02	0.66	1.97	7..03
Firewood	48.48	0.34	45.16	57.80	86.53
Wax	0.02	41.65	0.00	0.00	0.00
Charcol	8.08	0.00	19.30	24.53	34.38
Dung	12.42	19.77	9.07	11.33	15.55
Agri Residues	3.69	8.42	2.23	2.83	3.80
Batteries	0.00	2.06	0.03	0.11	0.16
Total	76.54	0.00	79.12	124.33	218.13

From the table, the following should be noted. The fuel wood, agricultural residues and dung demand willl decrease between 1995 and 2000 as a result of expected improvements in the energy efficiency of the Cooking devices (Enjera and charcoal stoves) and through fuel switching. After the year 2000 the demand will increase again a result of population growth. Charcoal demand shows somewhat similar trend. The demand will first, however, increase sharply. Between 2000 and 2010 the demand will be command will be constant. After 2010 the demand will increase again because of population growth.

Encroachment and destruction of wildlife habitats (In Simien mountains, Shiraro-Qafta Wildlife reserve and wildlife habitats around Humera): Encroachment of Simien Mountains is likely to accelerate now that the access road through the conservation area has been constructed. The current gold prospecting activities around Sheraro-Qafta may identify suitable extraction sites in or close to the reserve. Labour camps are likely to fell trees for fuel and hunt game for food. Deforestation to make way for irrigation is being carries out by numerous small farmers around the Humera area around which elephants and other large mammals migrate.
Industrial and agricultural input Pollution: air pollution in Mekele from the recently approved cement factory, water pollution from the newly constructed Sheba Tannery and the dyeing factories of Tigray.

The existing agricultural practices are characterized by low utilization of external agro-inputs. While the average fertilizer use in the basin is less than 2 kg/ha, the fertilizer use in Tigray, North Gonder, South Gonder, North Wollo and Wag Hemra was 2.5, 4.5, 4.0, 0.3 and 0.2 kg/ha, respectively in 1994. Teff and Wheat respectively account for 63.0 and 37.0% of the fertilizer use in the basin. DAP, at 86% of the fertilizer consumption, is by far the most used.

Commercial, large-scale crop production is conducted in the western lowlands, by individual investors and private share companies. The area under commercial farming is 108,000 ha in Tigray and 20,000 ha in Amhara. The present commercial farming system is characterized by (i) a certain amount of mechanized farm operations; (ii) limited use of fertilizers and improved seeds; (iii) crops are sorghum, cotton and sesame; (iv) selective use of pesticides (during periods of pest outbreaks); (v) low yield; (vi) shortages of labour; and (vii) lack of adequate machinery maintenance services.

Water-borne diseases: four major vector-borne diseases, notably malaria, intestinal schistosomiasis, visceral leishmaniasis (VL) and onchocerciasis are confirmed as being endemic and pose a major challenge to socio-economic development effort. The incidence of malaria and schistosomiasis will increase in areas of ongoing micro-dam construction. Most major settlements in the basin have non-extent or inadequate drinking water supply systems. Sanitation is also inadequate, piped drinking water should be boiled.

Mekele already has a water quality problem due to the chemical composition of the aquifer rocks. At present Lalibela has sever water shortage with daily water cuts. The existing residential areas have few latrines. People defaecate on the hills surrounding the town. This has resulted in the pollution of the land underneath the rock-hewn churches in the valley. Sample taken from the churches foundations show evidence of erosion due to urine concentrations.

Pests and Weeds: Regular crop yield loss caused by various pests such as weeds, diseases, insects, rodents and birds are common. The existing weed control measures are limited to hand weeding, commonly performed quite late after crop emergence. Farmers do not use herbicides. Single weeding is the common practice in all cereals, except Teff, which gets more attention. Diseases such as rust, smut, scald and blotch are reported to cause damage to various crops, virtually no measures are taken by peasant farmers to control these diseases. Insects are the major pests in the area. They cause a substantial damage in different crops. However, only a very limited number of farmers use malathion in order to control insect pests like army worm and grass hopers. Due to inadequate and/or delayed supply and poor technical know-how of farmers the present efficiency of pesticide use by peasant farmers is quit low.

Loss and decay of cultural heritage sites: As the number of visitors to Lalibela increases due to the opening of the airstrip and new road, the pressure on the already non-extent sanitation grows. The foundations of the rock-hewn churches are being eroded by urine. Historic relics are largely unprotected from visiting tourists. Some items in Lalibela and other rock-hewn churches and museums in Axum have been stolen. There is a risk that current proposals for new industries, mines and dam sites may be constructed close to cultural heritage sites, and may cause their deterioration (Tigray region).

Mining: there are project proposals for exploration activities to be undertaken in the north east of the basin near Hawzen. Similar activities are currently being undertaken in the northwest prospecting area. The environmental impacts of mining will depend on the type of mining, the chemical processes used and the characteristics of the location. In addition land taken by the mine, potential negative impacts include depletion of water resources due to over extraction, pollution of water and soil, degradation of landscape, subsidence, dust and noise.

5.20 Resource Conflicts

Food production, livestock feed and fuel requirements put competing demands on scarce and vegetation resources. The Tekeze basin area has been a process of gradual degradation of land and vegetation under population pressure and inadequate management of natural resources. An analysis of scarcity and degradation of resources in the 42 PAs studied showed that pressure on

resource is strong or critical in 31 PAs and low or moderate in 11 PAs. Most of the later are situated in the western lowlands of the basin.

5.21 Environmentally Sensitive Areas (Hotspots)

5.21.1 Encroachment and destruction of wildlife

Encroachment and destruction of wildlife habitats (In Simien mountains, Shiraro-Qafta Wildlife reserve and wildlife habitats around Humera): Encroachment of Simien M000000000ountains is likely to accelerate now that the access road through the conservation area has been constructed. The current gold prospecting activities around Sheraro-Qafta may identify suitable extraction sites in or close to the reserve. Labour camps are likely to fell trees for fuel and hunt game for food. Deforestation to make way for irrigation is being carries out by numerous small farmers around the Humera area around which elephants and other large mammals migrate.

5.21.2 Industrial Pollution

Pollution problems in this case are air pollution in Mekele from the recently approved cement factory, water pollution from the newly constructed Sheba Tannery and the dyeing factories of Tigray.

5.21.3 Water-Borne Diseases

The incidence of malaria and schistosomiasis will increase in areas of ongoing micro-dam construction.

5.21.4 Cultural Heritage Sites

As the number of visitors to Lalibela increases due to the opening of the airstrip and new road, the pressure on the already non-extent sanitation grows. The foundations of the rock-hewn churches are being eroded by urine.

Historic relics are largely unprotected from visiting tourists. Some items in Lalibela and other rock-hewn churches and museums in Axum have been stolen. There is a risk that current proposals for new industries, mines and dam sites may be constructed close to cultural heritage sites, and may cause their deterioration (Tigray region).

5.22 Likely Impacts of Possible Major Developments

5.22.1 Dams and Reservoirs

Screening the preliminary environmental impact of dams has covered the dam site, its reservoir plus a five-kilometre radius “buffer zone” representing the area where malaria infection is most pronounced. The wider catchment area of the reservoir was screened for its erosion potential. Potential negative effects of the dams are related mainly to water born and transmittable diseases, changing water regimes. Interaction with surrounding catchments is dominated by soil erosion and siltation of the reservoir (s).

Micro-dams and prevalence of parasitic infections: In a survey involving 2,271 people of 410 households around 41 micro-dams, malaria, schistosomiasis and other geohelminthic infections were found to be prevalent with prevalence rates of 1.2%, 7.2%, 8.9%, 2.4%, 2.3% for malaria, schistosomiasis, hookworm, trichuriasis and ascariasis respectively. Prevalence rates reached as high as 20% for trichuriasis and 78% for hookworm around some micro-dams.

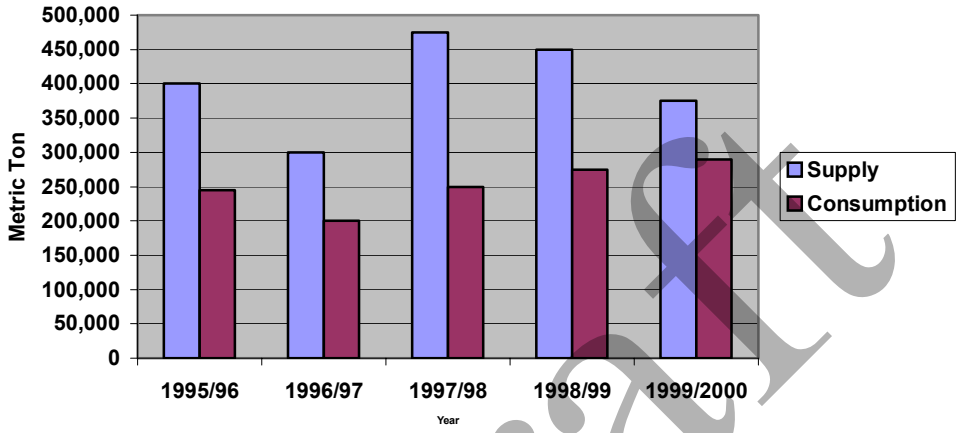
5.22.2 Irrigation Projects

The key environmental issues for irrigation projects include the land allocation conflicts, population resettlement, habitat destruction, erosion and changes in water table, water quality, malaria, and other water borne diseases. The majority of these potential negative impacts can be mitigated through best management practices and good project design.

The chemical inputs that are used in Ethiopia to increase production are fertilizers, pesticides and herbicides.

***Chemical Fertilizers**:* The use of chemical fertilizers in Ethiopia commenced in the late 1960ies along with the commencement of integrated agricultural programmes and projects. Ever since then, chemical fertilizers have been popularised and the expansion of their use promoted through the Agricultural Extension Program. The chemical fertilizers that are in use in the country are DAP and UREA.

National Fertilizer Supply and Consumption



Information from the Ministry of Agriculture indicates that, in addition to government, private sector firms also import pesticides and herbicides into the country. The amount of pesticides distributed to the regions in 1995/96 was 168, 700 litres while in 1999/ 2000 it was only 138, 510 litres.

The amount of pesticides and herbicides that were imported by the Ministry of Agriculture for application in the agricultural sector is indicated in Table 26. It was not possible to get information regarding the amount imported and distributed by the private importers. As can be surmised form the table, 927.7 tons of chemicals have been imported into the country in 1995/96 while in 1999/2000, the amount has increased to 1,081.9 tons. This indicates a 16.6 percent increase over the amount imported in 1995/96.

Imported Herbicides and Pesticides (in tons)

No	Type of Chemical	1995/96	1996/97	1997/98	1998/99	1999/2000
1	Insecticides	327.21	517.657	505.019	303.34	207.64
2	Herbicides	554.00	467.45	328.15	794.22	826.76
3	Fungicides	45.79	16.06	7.89	117.30	41.61
4	Rodenticides	-	-	-	2.00	2.00
5	Avicides	-	5	10	-	-
6	Plant Growth Regulators	-	-	20	-	4
Total		**926.9**	**1,028.94**	**998.88**	**1230.86**	**1,081.939**

Source: Ministry of Agriculture, 2001

5.22.3 Urbanisation

Major concern with consequence of urbanization are related first and foremost to urban housing conditions, notably to the level of domestic and municipal sanitary facilities and services and, secondly, to the state of waste disposal, sanitation and safety of working environments. The latter stands for essential characteristics of occupational diseases. In the coming 20-50 years, agro-processing is expected to lead the industrial sector or at least to provide the basis for its development. A survey of major health problems of industries by an expert group of ministry of labour and Social Affairs in the years 1993/94 identified 11 top diseases of manufacturing and large scale agricultural schemes. These includes: bronchial asthma, parasitic infections, pneumonia and upper respiratory infections, haemorrhoids, anaemia, tuberculosis, depression, malaria, schistosomiasis, skin diseases and rheumatism in that order of morbidity. For the large scale agricultural enterprises, the order of importance is malaria, anaemia, gastro-enteritis, malnutrition, pneumonia, tuberculosis, bronchial asthma, skin diseases and accidents. These diseases are related either to poor sanitary facilities in the work environment, to poor waste and sewerage disposal, and to excessive air-borne wastes such as dust in addition to work related stress.

There are no data describing impacts of chemical hazards such as pesticides in agriculture, agro-industrial development endeavours need to cater for basic requirements of safe working environments, notably acceptable sanitary facilities including a potable water supply, proper waste and sewer disposal, and additional measures to reduce excessive dust, heat, noise, glare, etc. Agricultural development activities also need to include safe pesticide management strategies.

5.22.4 Road Infrastructure

Road construction usually causes increased erosion leading to increased land degradation and loss of land. Once roads are constructed they attract increasing amounts of vehicles, causing pollution with their exhaust fumes. In addition there is a serious risk of traffic accidents, livestock and wildlife movements may be disturbed, etc.

5.22.5 Tourism

The management of tourism activities is critical in determining the impact of the industry on its environment: tourism attraction is typically sensitive natural and man-made environments. In the basin the sensitive attractions include:

- Simien National Park
- Sheraro Qufta Wildlife Reserve
- Lalibela Rock Hewn Churches
- Gonder Castles
- Monuments at Axum
- Rock Hewn Churches of Tigray

The impact of tourism on the habitats of endangered species such as the Ibex and Simien Fox needs to be carefully controlled. Negative impacts can occur when visitors disturb sensitive habitats during the breeding seasons of endangered species.

Hotels in national parks pollute animal drinking water by releasing untreated sewage into watercourses and vehicle emission from tourist vehicles pollute the air. Uncontrolled hunting will reduce endangered and rare species below sustainable levels.

Large numbers of tourists visiting churches and monuments can damage wall paintings and carvings by walking on or rubbing against them and create erosion by walking over grassed areas. When high concentration of tourist vehicle and airplane emission is reached (eg where vehicles

park or airplanes fly near monuments) acid rain can form which can corrode rock surfaces of historic monuments.

In the basin the volume of tourism has not yet reached a critical level to cause these impacts. However tourism concentrations speak over three months and the thresholds of sustainability could be reached in the foreseeable future.

5.22.6 Industry

Industrial development in the basin would provide a valuable alternative to livelihoods derived from agriculture. It would have a positive impact in that it would decrease the demand for agricultural land and enable steep slopes to be taken out of cultivation. Where improved agricultural methods are successful it may be possible to start agro-processing industry, creating added value to local products. The development of tanneries to process hides and skins is likely to be one of the more viable industries.

So far the emphasis has been on attracting industry. Almost no controls exist on the regulation of industrial process and waste products. The general view among government officials is that industry activity is of insufficient scale to pose any pollution problems. This may be true in national term but the local level impacts can be severe.

Industrial environmental impacts include:

- Water pollution
- Land contamination
- Air pollution
- Noise
- Visual pollution
- Socio-economic impacts
- Public health impacts

5.23 Critical Information Gap

Most of the information and data presented are based on the study and reports of “Tekeze River basin Integrated Development master Plan Project”, which aims at combining approaches of river basin planning and integrated regional development plans. River basin planning emphasizes on water resource development while integrated regional planning deals with multi sectoral development in a spatial planning framework. On the other hand since all data refer back to the situations in 1994-1996, up-to-date data and information may be necessary for better explanation of current realities of the basin in consideration.

6. COMMENTS ON DATA QUALITY AND RECOMMENDATIONS

The following comments are provided on the data and information collected on the Environment Theme.

The environmental policy of Ethiopia seems to be relatively older in view of the structural and institutional changes that have taken place since the issuance of the policy. In spite of the constitutional considerations for environmental protection, the strength of legal backing and institutional functionalities within the environmental protection activities seems to be less clear in the documents collected so far. The status of environmental protection endeavours in the regions involving the sub-basins has not been adequately described and there is hardly any information on the effectiveness and functionality of the environmental structures probably established according

to the Proclamation for the Establishment of Environmental Protection Organs.

The basin master plan studies form the most important and relevant components of the datasets collected and compiled during the consultancy services. The natural resources aspect of the physical environment has been treated well and information collected in those regards are invaluable in respect of the data poverty in the country. In the three Nile sub-basins in Ethiopia (Abbay, Baro-Akobo and Tekeze) the studies categorically considered the different Physiography and tried to differentiate the magnitudes of phenomenal processes accordingly.

However, in light of the needs arising from ENTRO, the consultant feels that most of those important data sets and information are relatively older to explain current and short-term realities in the sub-basins. The doubts on the effectiveness of those datasets may worsen if the pressing issues like land degradation, erosion hazards, soil loss, deforestation, flooding, environmental threats, etc. are considered. Many of such information are available almost entirely in the highland reclamation studies and documents produced when the Soil Conservation Research Projects were prepared. The durations of those information and accompanying data date back to mid 1980's and early 1990s.

The consultant expects that the highland parts of the Nile sub-basins in Ethiopia are likely characterized by high population densities and consequent greater human pressure on natural resources, including land. In highland areas of the sub-basins, extensive cultivation and encroachments into areas of natural vegetation may most probably result in further deforestation, severe erosion hazards and continued loss of soils. Thus in such tendencies, available old datasets may hardly enable to measure the magnitudes of different environmental process in the three sub-basins.

It might, therefore, be necessary to carryout land use/land cover surveys; soil erosion hazard assessments and land use/land cover change analysis in order to identify areas of severity and environmentally sensitive zones in the sub-basins.

No study and report in the sub-basins adequately disclosed the potentials for aquatic resources, the state of wetlands and wild life habitants in the sub-basins. The absence of information in these areas of concern seems to have limited identification of hot spots in the context of environmental conservation.

In spite of their importance and relevance, some of the datasets availed by the Ministry of Water resources happened to be incomplete particularly for Tekeze River basin. None of the spatial data provided for the basin contain descriptions at least for important attributes. The GIS ad RS section of the Ministry could not provide complete data, as there has been inadequate building of the databases during the Master Plan study of the basin. In lesser degree, the problem of data incompleteness has also been the case for the remaining basins, too. The following datasets have been found incomplete in attribute description:

- Main roads, Lakes, Farming System, Forest Resources and Main rivers (for Abbay basin);
- Forest, soil and Roads, Isohyets, soil geomorphology, and Roads data (Baro-Akobo basin);
- Thermal zones, Towns, soil, road, land cover, roads and others (Tekeze basin).

ENTRO would, therefore, be required to remind the GIS and RS section of the Ministry to provide complete datasets of the basins, as the effort of the consultant could not bring any result from the section.

Despite their common sources, the spatial data from the Ministry of Water Resources seldom provide spatial consistencies. The boundaries of the three basins do not match and similar

thematic layers happen to show differences across respective boundaries. Worth mentioning in this connection is the attribute inconsistencies observed in the classifications of land cover/land use and related Physiographic variables. Such inconsistencies may pose some level of technical problems upon integrating the sub-basins into one dataset, either across the countries or within Ethiopia itself.

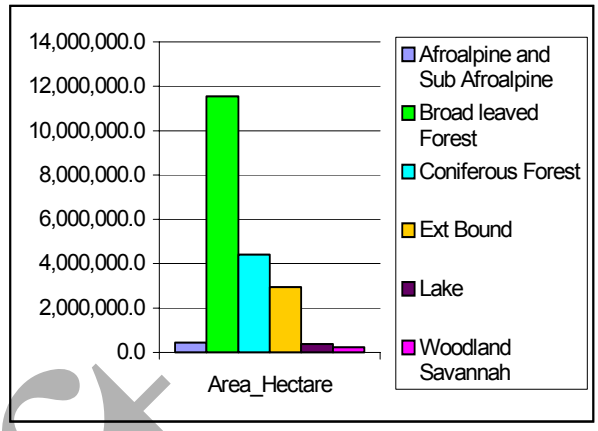
Differences in sources, modelling and generation techniques may also cause limited technical problems also in further processing of some datasets. Some data are software specific and need relevant software for conversion. The naming conventions for some files have been found vague in terms of their thematic issues; the duration of acquisition, method of generation and sources of the base data are not known at all. Therefore, there a need to use skilled GIS experts for resolving related technical problems.

APPENDIX ONE: SUB-BASINS COMPUTED DATA (SELECTED)

1.1 ABBAY BASIN: COMPUTATIONS FROM SELECTED DATASETS

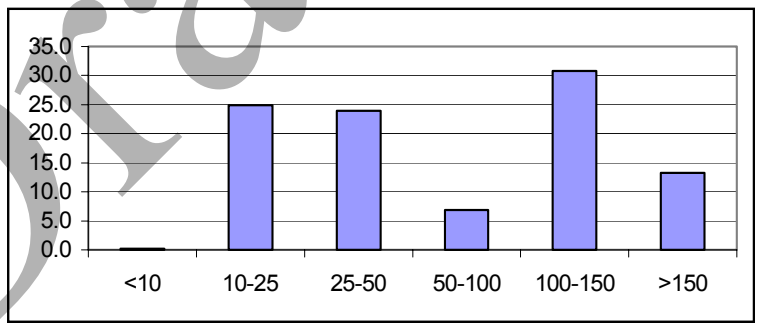
Abbay: Major Natural Vegetation

VEGETATION	Area_Hectare	%
Afroalpine and Sub Afroalpine	448,387.8	2.2
Broad leaved Forest	11,544,960.8	57.9
Coniferous Forest	4,408,922.2	22.1
Ext Bound	2,937,038.9	14.7
Lake	366,635.0	1.8
Woodland Savannah	225,002.0	1.1
Total	**19,930,946.8**	**100.0**



Abbay:Soil Depth

DEPTH (mm)	Area_hectare	%
<10	67,388.5	0.2
10-25	8,590,975.6	24.9
25-50	8,288,057.7	24.0
50-100	2,384,039.8	6.9
100-150	10,656,561.8	30.8
>150	4,573,359.1	13.2
Total	34,560,382.5	100.0



Mean Monthly Rainfall

No.	Month	Abbay	Baro	Tekeze
1	January	18	26	32
2	February	26	43	11
3	March	48	81	14
4	April	59	101	33
5	May	121	190	32
6	June	194	206	59
7	July	307	237	99
8	August	308	231	256
9	September	205	206	91
10	October	81	95	27
11	November	25	60	14
12	December	13	33	10

Maximum and Minimum Temperature of All Basins

No.	Month	Maximum	Minimum
1	January	26	10
2	February	27	11
3	March	28	12
4	April	28	12
5	May	27	13
6	June	26	12
7	July	23	12
8	August	23	12
9	September	24	11
10	October	25	10
11	November	25	9
12	December	25	9

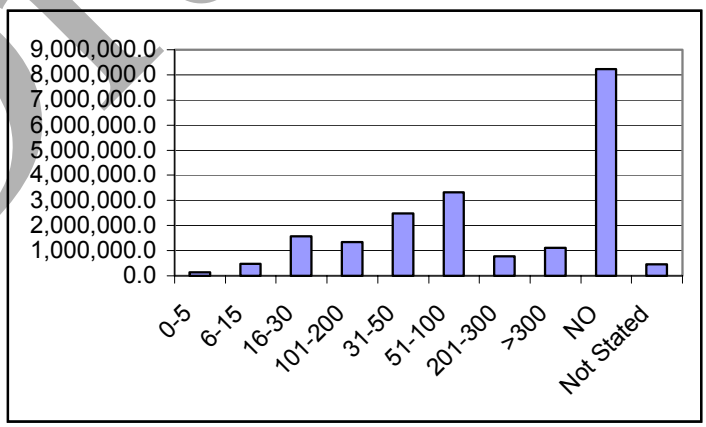
Reference year not known

Mean Annual Rainfall:

1 Abbay = 1320 mm
2 Baro-Akobo = 1365 mm
3 Tekeze - Setit = 822 mm.

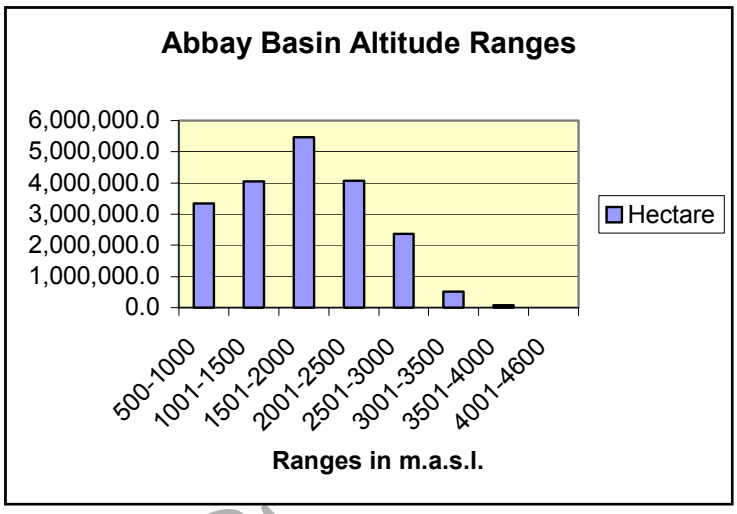
Abbay: Soil Loss

TONS_HA_YR	Area_Hectare	%
0-5	139,168.0	0.7
6-15	486,935.3	2.4
16-30	1,581,640.6	7.9
101-200	1,354,706.1	6.8
31-50	2,474,303.3	12.4
51-100	3,321,457.5	16.7
201-300	771,612.2	3.9
>300	1,124,228.4	5.6
NO	8,221,624.9	41.2
Not Stated	462,017.3	2.3
	19,937,693.6	100.0



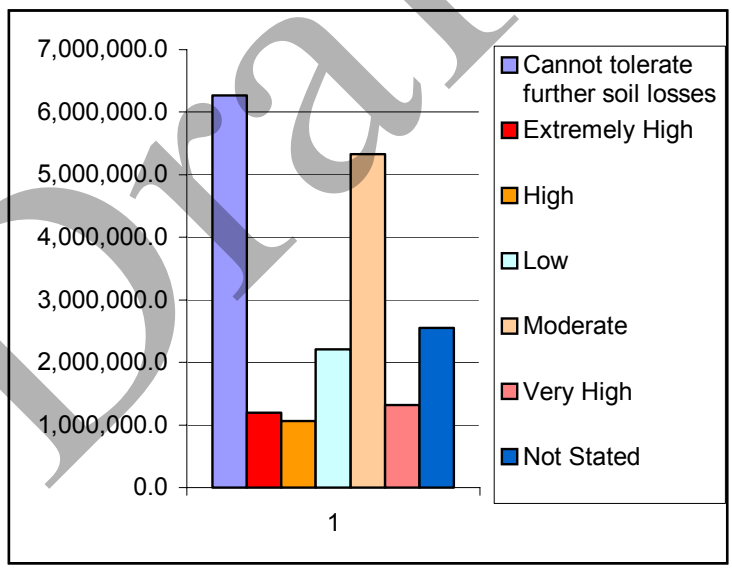
Abbay Basin: Altitude Ranges

Alt Range	Hectare	%
500-1000	3,350,749.8	16.8
1001-1500	4,058,277.1	20.4
1501-2000	5,471,767.9	27.5
2001-2500	4,061,661.8	20.4
2501-3000	2,377,152.4	11.9
3001-3500	521,416.1	2.6
3501-4000	70,218.5	0.4
4001-4600	577.8	0.0
Total	**19,911,821.4**	**100.0**



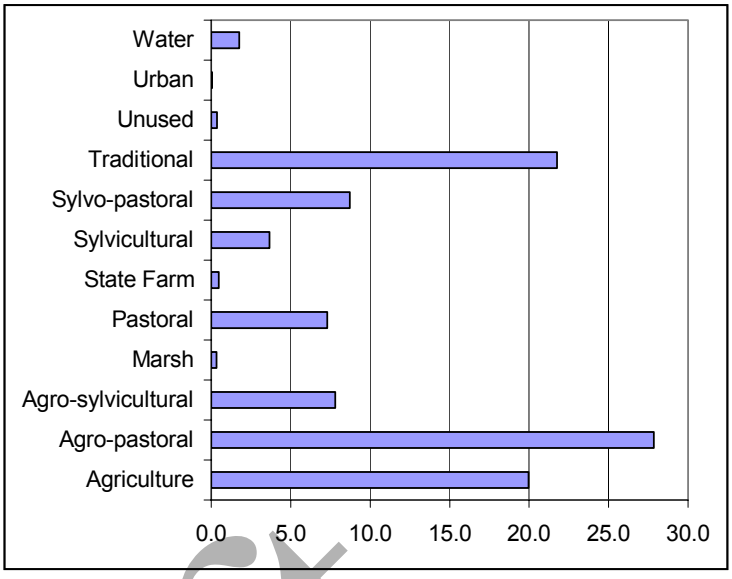
Abbay: Erosion Hazard

Area_Hectare	%
6,266,483.5	31.4
1,192,278.7	6.0
1,063,634.7	5.3
2,212,925.2	11.1
5,329,438.3	26.7
1,318,646.9	6.6
2,553,777.9	12.8
19,937,185.2	**100.0**



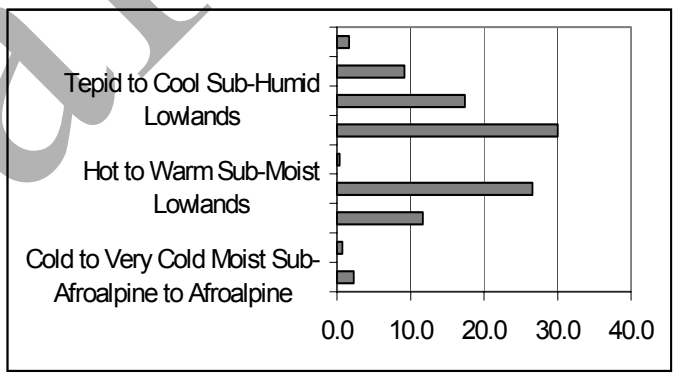
Abbay Basin: Land Use

Use Type	Area_Hectare	%
Agriculture	3,987,842.8	20.0
Agro-pastoral	5,564,169.0	27.8
Agro-sylvicultural	1,559,741.3	7.8
Marsh	64,829.3	0.3
Pastoral	1,458,922.7	7.3
State Farm	96,833.0	0.5
Sylvicultural	729,763.2	3.7
Sylvo-pastoral	1,741,791.7	8.7
Traditional	4,349,205.0	21.8
Unused	70,083.5	0.4
Urban	10,410.6	0.1
Water	350,266.4	1.8
	19,983,858.7	100.0



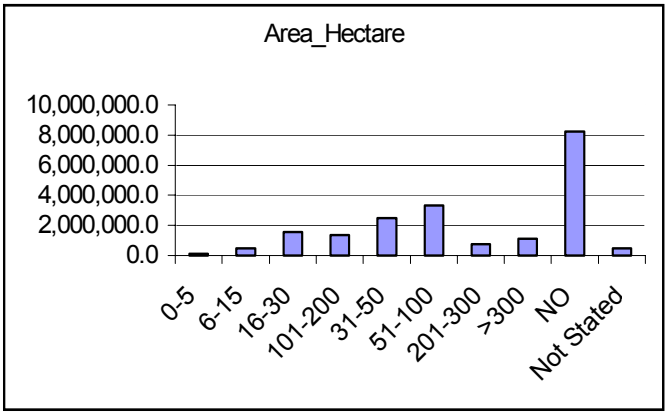
Abbay Basin: Major Agro-ecological Zones

Major Zones	Area_Hectare	%
Cold to Very Cold Moist Sub-Afroalpine to Afroalpine	457,858.3	2.3
Cold to Very Cold Sub-Moist Sub-Afroalpine to Afroalpine	150,463.3	0.8
Hot to Warm Sub-Humid Lowlands	2,332,105.0	11.7
Hot to Warm Sub-Moist Lowlands	5,297,284.2	26.6
Tepid to Cool Humid Mid Highlands	76,458.5	0.4
Tepid to Cool Moist Mid Highlands	5,980,304.0	30.0
Tepid to Cool Sub-Humid Lowlands	3,464,941.7	17.4
Tepid to Cool Sub-Moist Mid-Highlands	1,833,293.7	9.2
Water Bodies	334,996.4	1.7
	19,927,705.2	100.0



Abbay: Soil Loss

TONS_HA_YR	Area_Hectare	%
0-5	139,168.0	0.7
6-15	486,935.3	2.4
16-30	1,581,640.6	7.9
101-200	1,354,706.1	6.8
31-50	2,474,303.3	12.4
51-100	3,321,457.5	16.7
201-300	771,612.2	3.9
>300	1,124,228.4	5.6
NO	8,221,624.9	41.2
Not Stated	462,017.3	2.3
	19,937,693.6	100.0

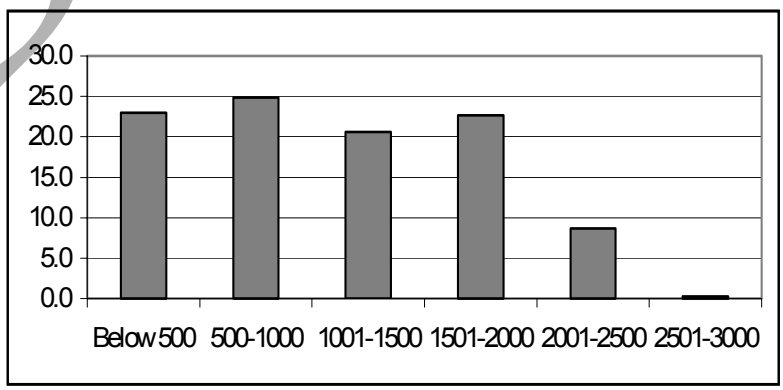


Abbay Basin: Major Soil Units

Major Units	Area_Hectare	%
Calcic Vertisols	229,071.3	1.1
Cambic Arenosols	60,473.4	0.3
Chromic Luvisols	980,825.3	4.9
Dystric Cambisols	74,505.8	0.4
Dystric Leptosols	242,727.4	1.2
Eutric Cambisols	1,709,509.1	8.6
Eutric Fluvisols	1,143,165.3	5.7
Eutric Leptosols	3,446,371.6	17.2
Eutric Regosols	141,031.3	0.7
Eutric Vertisols	1,722,899.1	8.6
Haplic Nitisols	73,781.5	0.4
Haplic Acrisols	891,911.0	4.5
Haplic Alisols	4,138,074.2	20.7
Haplic Arenosols	72,183.5	0.4
Haplic Luvisols	826,553.8	4.1
Haplic Nitisols	1,782,885.7	8.9
Haplic Phaeozems	9,010.1	0.0
Lithic Leptosols	60,610.2	0.3
Marsh	78,281.2	0.4
Rendzic Leptosols	538,773.6	2.7
Rhodic Nitisols	1,323,379.4	6.6
Urban	5,473.5	0.0
Vertic Cambisols	106,335.4	0.5
Water	323,355.6	1.6
Total	**19,981,188.2**	**100.0**

Baro: Altitude Ranges

Alt. Range (m.a.s.l.)	Area_Hectare	%
Below 500	1,732,699.32	23.0
500-1000	1,874,454.38	24.9
1001-1500	1,553,155.89	20.6
1501-2000	1,707,037.81	22.6
2001-2500	653,349.49	8.7
2501-3000	20,535.08	0.3
Total	**7,541,231.95**	**100.0**



1.2 BARO-AKOBO: COMPUTATIONS FROM SELECTED DATASETS

Baro: Mean Annual Rainfall

Milimeter	Area_Hectare	%
800-900	341,160.5	4.5
901-1000	903,633.2	12.0
1001-1100	861,101.2	11.4
1101-1200	885,560.1	11.7
1201-1300	1,020,939.3	13.5
1301-1400	873,314.9	11.6
1401-1500	391,297.5	5.2
1501-1600	384,506.8	5.1
1601-1700	468,794.2	6.2
1701-1800	485,384.7	6.4
1801-1900	456,546.9	6.0
1901-2000	476,717.5	6.3
2001-2100	10,131.0	0.1
	7,559,087.8	100.0

Baro: Farming Systems

Systems	Area_hectare	%
(Anuak)	2,269,552.1	29.8
(Berta) Shifting cultivation (sorghum dominant)	408,643.4	5.4
Enset root complex (cereals are dominant, tubers only minor and enset present)	1,729,832.1	22.7
Enset root complex (tubers are dominant, cereals only minor and enset present)	819,646.9	10.8
Grain plough complex of Welega (cereal farming type)	749,436.2	9.8
Pastoral complex (system almost wholly dependant on livestock)	1,645,521.5	21.6
	7,622,632.2	100.0

Baro: Forest Resources

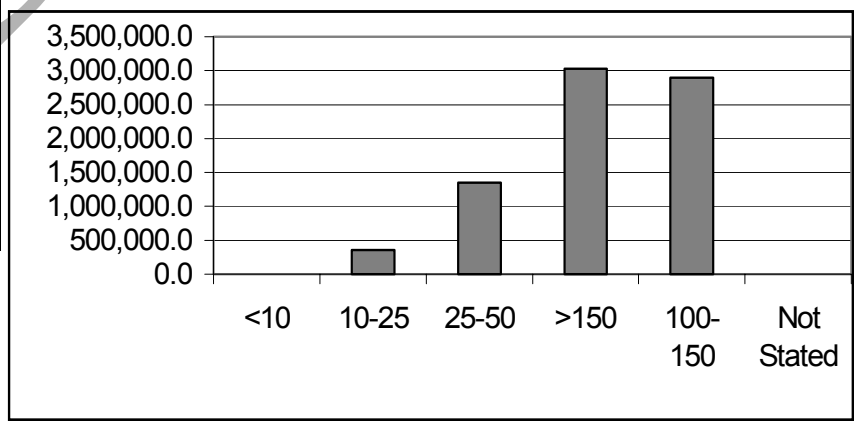
NAME	Area_hectare	%
ABOBO GOG	362,505.9	4.8
GAMBELA PARK	586,160.9	7.7
GERJEDA	121,198.5	1.6
GESHA	55,389.6	0.7
GODERE	126,897.1	1.7
GURAFERDA	40,973.4	0.5
JORGOWATTA	17,132.1	0.2
SAYLEM WANGUS	186,153.4	2.4
SELE MESENGO	365,140.6	4.8
SHEKO	89,144.3	1.2
SIGMO GEBA	228,024.2	3.0
YEKI	65,450.2	0.9
Other	5,378,835.2	70.6
	7,623,005.2	100.0

Baro: Land Cover

Cover Type	Area_Hectare	%
Cultivated Area (<60%)	156,885.1	2.1
Cultivated Area (>60%)	1,395,907.6	18.3
Dense Woodland	746,700.5	9.8
Disturbed Forest	427,167.9	5.6
Open Woodland	3,617,881.7	47.5
Perennial Crop	180,735.8	2.4
Very Disturbed Forest	1,095,951.5	14.4
NS.	0.6	0.0
Total	**7,621,230.7**	**100.0**

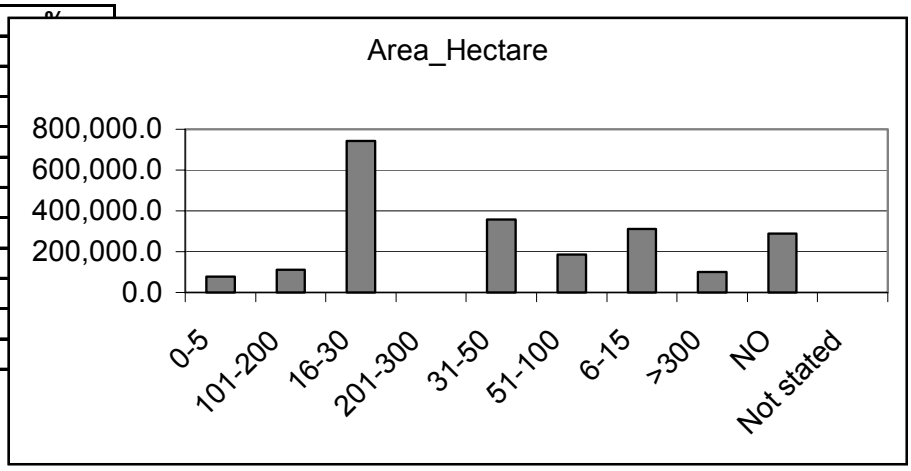
Baro: Soil Depth

DEPTH	Area_Hectare	%
<10	53.6	0.0
10-25	356,025.8	4.7
25-50	1,353,469.6	17.7
>150	3,031,938.3	39.7
100-150	2,897,216.0	37.9
Not Stated	115.0	0.0
Total	**7,638,764.7**	**100.0**



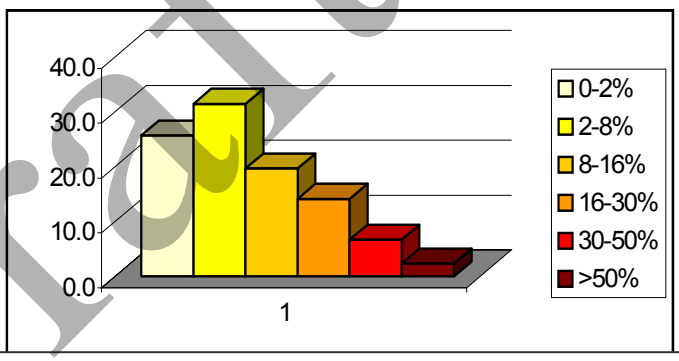
Baro: Soil Loss

TONS_HA_YR	Area_Hectare	%
0-5	78,440.0	
101-200	111,682.7	
16-30	743,151.3	
201-300	792.9	
31-50	356,015.0	
51-100	186,587.7	
6-15	310,293.2	
>300	100,908.7	
NO	288,843.1	
Not stated	3.7	
	2,176,718.3	



Baro: Slope Gradient

Gradient	Area_hectare	%
0-2%	1,952,462.0	25.7
2-8%	2,390,319.4	31.5
8-16%	1,490,899.5	19.6
16-30%	1,071,734.7	14.1
30-50%	506,892.9	6.7
>50%	179,329.1	2.4
Total	**7,591,637.7**	**100.0**



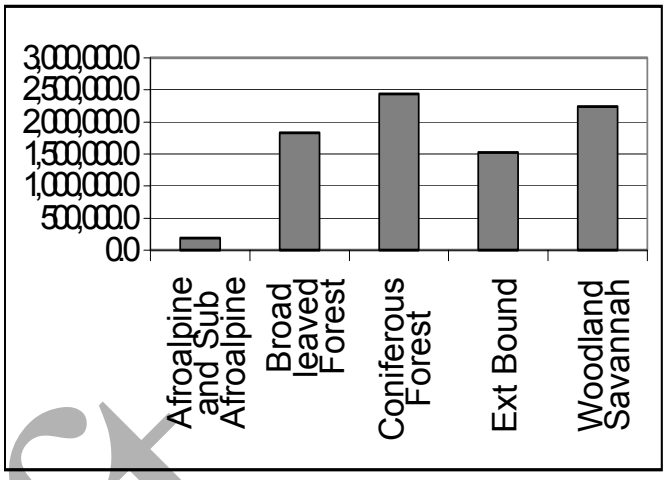
Baro: Soil Geomorphology

Description	COUNT	SUM_HECTAR	%
Chromic and Haplic Luvisols,weathered soils. Erosion hazard. 3531 km2, 5% of basin	51.0	356,276.4	4.7
Dystric and Chromic Cambisols weathered and often shallow with coarse top soils, 8164 km2, 11% of basin	140.0	833,159.7	10.9
Dystric and Eutric Fluvisols, variable textures, usually deep. Slight erosion hazard 10 086 km2, 13% of basin	83.0	1,027,366.2	13.5
Dystric and Eutric Plinthosols, variable depth over laterite/gravels. Erosion hazard. 2237 km2, 3% of basin	31.0	229,983.0	3.0
Eutric Gleysols, seasonally waterlogged. Low erosion hazard. 6857 km2, 9% of basin	74.0	689,990.4	9.1
Eutric Vertisols seasonally waterlogged, generally fertile, often flooded in lower basin, risk of sodic conditions. Gi	56.0	726,592.7	9.5
Haphic Lixisols, often shallow over gravels and strongly weathered. Erosion hazard. 2195 km2, 3% of basin	24.0	221,987.2	2.9
Haplic Nitisols, usually deep, fine textured over basalt, Red Forest solis. Slight erosion hazard 10710 km2, 14%	144.0	1,079,598.4	14.2
Lithic and stony Dystric, Eutric and Chromic Cambisols. Haphic Acrisols shallow stony. High and very high erosic	136.0	854,561.7	11.2
Planosols associated with drainage lines and swamps, waterlogged for part or all year. Coarse profiles on shallov	13.0	207,470.6	2.7
Rhodic Nitisols, usually deep, fine textured over basalt Forest Soils, strong red colour. Slight erosion hazard 608	105.0	612,323.1	8.0
Rock Scree, Lithic and Eutric Leptosols Very high erosion hazard 6935 km2, 9% of basin	227.0	704,129.2	9.2
Not Stated	20.0	79,510.3	1.0
		7,622,948.8	100.0

1.3 TEKEZE-SETIT: COMPUTATIONS FROM SELECTED DATASETS

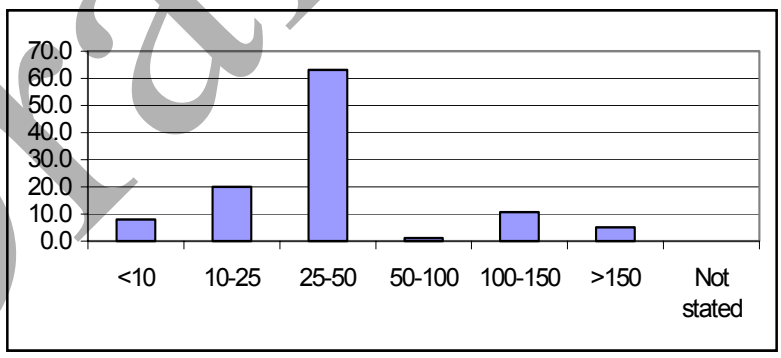
Tekeze: Major Natural Vegetation

VEGETATION	Area_Hectare	%
Afroalpine and Sub Afroalpine	185,065.2	2.3
Broad leaved Forest	1,833,343.7	22.3
Coniferous Forest	2,436,905.2	29.6
Ext Bound	1,525,463.7	18.6
Woodland Savannah	2,238,600.8	27.2
	8,219,398.7	100.0



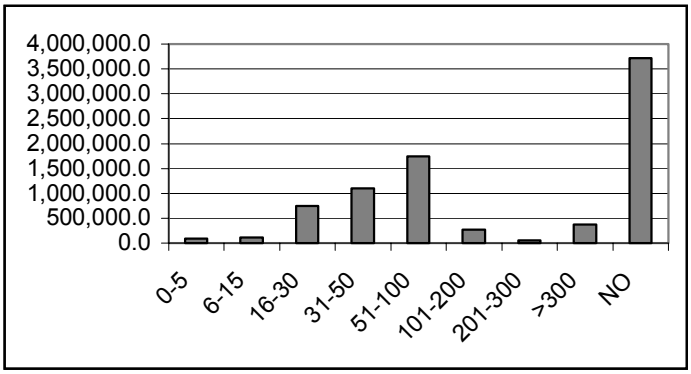
Tekeze: Soil Depth

DEPTH	Area_Hectare	%
<10	900,855.5	8.0
10-25	2,244,124.9	20.0
25-50	7,095,210.7	63.2
50-100	115,754.4	1.0
100-150	1,201,563.1	10.7
>150	572,628.4	5.1
Not stated	14.6	0.0
Total	**11,229,296.3**	**100.0**



Tekeze: Soil Loss

TONS_HA_YR	SUM_HECTAR	%
0-5	89,368.5	1.1
6-15	110,257.4	1.3
16-30	748,744.2	9.1
31-50	1,097,503.0	13.4
51-100	1,740,601.2	21.2
101-200	267,156.0	3.3
201-300	61,398.1	0.7
>300	376,173.7	4.6
NO	3,721,106.4	45.3
Total	**8,212,308.4**	**100.0**



ANNEX TWO: LIST OF SOFTCOPY SPATIAL DATA – COLLECTED AND COMPILED

No.	File Name	Theme	Source	Thematic level				Remark
				National	Abbay	Baro-Akobo	Tekeze-Setit	
1	Agroecology_abbay	Agro-ecological zones	EDRI		✓			Converted to GIS Shape File format
2	Annualrain_abbay	Annual rainfall	EDRI		✓			Converted to GIS Shape File format
3	Dtm_abbay	Height above see level	EDRI		✓			Converted to GIS Shape File format
4	Faosoilsoter_abbay	Terrain based soil data	EDRI		✓			Converted to GIS Shape File format
5	Rainapr_abbay	April rainfall	EDRI		✓			Converted to GIS Shape File format
6	Rainaug_abbay	August rainfall	EDRI		✓			Converted to GIS Shape File format
7	Raindec_abbay	December rainfall	EDRI		✓			Converted to GIS Shape File format
8	Rainfeb_abbay	February rainfall	EDRI		✓			Converted to GIS Shape File format
9	Rainjan_abbay	January rainfall	EDRI		✓			Converted to GIS Shape File format
10	Rainjul_abbay	July rainfall	EDRI		✓			Converted to GIS Shape File format
11	Rainjun_abbay	June rainfall	EDRI		✓			Converted to GIS Shape File format
12	Rainmay_abbay	May rainfall	EDRI		✓			Converted to GIS Shape File format
13	Rainnov_abbay	November rainfall	EDRI		✓			Converted to GIS Shape File format
14	Rainoct_abbay	October rainfall	EDRI		✓			Converted to GIS Shape File format
15	Rainsep_abbay	September rainfall	EDRI		✓			Converted to GIS Shape File format
16	Shade-abbay	Analytical hillshades	EDRI		✓			Converted to GIS Shape File format
17	Agroecology_baro	Agro-ecological zones	EDRI			✓		Converted to GIS Shape File format
18	Anualrainbaro	Annual rainfall	EDRI			✓		Converted to GIS Shape File format
19	Dtm_baroakobo	Height above see level	EDRI			✓		Converted to GIS Shape File format
20	Faosoilsotter_baro	Terrain based soil data	EDRI			✓		Converted to GIS Shape File format
21	Rainapr_baroakobo	April rainfall	EDRI			✓		Converted to GIS Shape File format
22	Raiaug_baro	August rainfall	EDRI			✓		Converted to GIS Shape File format
23	Raindec_baro	December rainfall	EDRI			✓		Converted to GIS Shape File format
24	Rainfeb_baro	February rainfall	EDRI			✓		Converted to GIS Shape File format
25	Rainjan_baro	January rainfall	EDRI			✓		Converted to GIS Shape File format
26	Rainjul_baro	July rainfall	EDRI			✓		Converted to GIS Shape File format

27	Rainjun_baro	June rainfall	EDRI			✓		Converted to GIS Shape File format
28	Rainmar_baro	March rainfall	EDRI			✓		Converted to GIS Shape File format
29	Rainmay_baro	May rainfall	EDRI			✓		Converted to GIS Shape File format
30	Rainnov_baro	November rainfall	EDRI			✓		Converted to GIS Shape File format
31	Rainsep_baro	September rainfall	EDRI			✓		Converted to GIS Shape File format
32	Shade_baroakobo	Analytical hillshades	EDRI			✓		Converted to GIS Shape File format
33	Agroecology-tekeze	Agro-ecological zones	EDRI				✓	Converted to GIS Shape File format
34	Anualraintekeze	Annual rainfall	EDRI				✓	Converted to GIS Shape File format
35	Dtm_Tekeze	Height above see level	EDRI				✓	Converted to GIS Shape File format
36	Faosoilsoter	Terrain based soil data	EDRI				✓	Converted to GIS Shape File format
37	Rainapr	April rainfall	EDRI				✓	Converted to GIS Shape File format
38	Rainaug_tekz	August rainfall	EDRI				✓	Converted to GIS Shape File format
39	Rainfeb_tekeze	February rainfall	EDRI				✓	Converted to GIS Shape File format
40	Rainjan_tekeze	January rainfall	EDRI				✓	Converted to GIS Shape File format
41	Rainjul_tekeze	July rainfall	EDRI				✓	Converted to GIS Shape File format
42	Rainjun_tekeze	June rainfall	EDRI				✓	Converted to GIS Shape File format
43	Rainmar_tekeze	March rainfall	EDRI				✓	Converted to GIS Shape File format
44	Rainmay_tekeze	May rainfall	EDRI				✓	Converted to GIS Shape File format
45	Rainnov_tekeze	November rainfall	EDRI				✓	Converted to GIS Shape File format
46	Rainoct_tekeze	October rainfall	EDRI				✓	Converted to GIS Shape File format
47	Rainsep_tekeze	September rainfall	EDRI				✓	Converted to GIS Shape File format
48	Shade-tekeze	Analytical hillshades	EDRI				✓	Converted to GIS Shape File format
49	Ecoforest	Forest cover	ILRI		✓			Converted to GIS Shape File format
50	Hydlakes	Lakes	ILRI		✓			Converted to GIS Shape File format
51	Hydriver	Rivers	ILRI		✓			Converted to GIS Shape File format

52	Natparkpy	National park parks	ILRI		✓			Converted to GIS Shape File format
53	Natwetlands	Wetlands	ILRI		✓			Converted to GIS Shape File format
54	Roads	Road network	ILRI		✓			Converted to GIS Shape File format
55	Ecoforest	Forest cover	ILRI			✓		Converted to GIS Shape File format
56	Hydlakes	Lakes	ILRI			✓		Converted to GIS Shape File format
57	Hydriver	Rivers	ILRI			✓		Converted to GIS Shape File format
58	Natparkpy	National park parks	ILRI			✓		Converted to GIS Shape File format
59	Natwetlands	Wetlands	ILRI			✓		Converted to GIS Shape File format
60	Infroads	Roads	ILRI			✓		Converted to GIS Shape File format
61	Hydriver	Rivers	ILRI				✓	Converted to GIS Shape File format
62	Natparkpy	National park parks	ILRI				✓	Converted to GIS Shape File format
63	Roads	Roads	ILRI				✓	Converted to GIS Shape File format
64	Agroecologyabbay	Agro-ecological zones	MoA		✓			Converted to GIS Shape File format
65	Isohyets	Rainfall regimes	MoA		✓			Converted to GIS Shape File format
66	Lgp_abbay	Length of Growing Period	MoA		✓			Converted to GIS Shape File format
67	Agroecology_baro	Agro-ecological zones	MoA			✓		Converted to GIS Shape File format
68	Isohyets	Rainfall regimes	MoA			✓		Converted to GIS Shape File format
69	Lgp_baroakobo	Length of Growing Period	MoA			✓		Converted to GIS Shape File format
70	Agroecology_tekeze	Agro-ecological zones	MoA				✓	Converted to GIS Shape File format
71	Isohyets	Rainfall regimes	MoA				✓	Converted to GIS Shape File format

72	Lgp_tekeze	Length of Growing Period	MoA				✓	Converted to GIS Shape File format
73	Allriver	All rivers	MoWRD		✓			Already provided in Shape File format
74	Climaxv	Vegetation types	MoWRD		✓			Already provided in Shape File format
75	Dvpzone	Development zones	MoWRD		✓			Already provided in Shape File format
76	Farming	Farming systems	MoWRD		✓			Already provided in Shape File format
77	Lake-bnd	Lakes	MoWRD		✓			Already provided in Shape File format
78	Landcov	Land cover	MoWRD		✓			Already provided in Shape File format
79	Landuse	Land Use	MoWRD		✓			Already provided in Shape File format
80	Mainrivers	Main rivers	MoWRD		✓			Already provided in Shape File format
81	Mroads	Main Roads	MoWRD		✓			Already provided in Shape File format
82	Roads	Roads	MoWRD		✓			Already provided in Shape File format
83	Soil	Soil Units (major)	MoWRD		✓			Already provided in Shape File format
84	Wetland	Wetlands in the country	EPA	✓				Generated from coordinates compiled in hard copy formats
85	150-240 lgp	Length of growing period	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
86	1985soil depth	Soil depth in 1985	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
87	Aez line	Agro ecological zones with line boundaries	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
88	Aez pol	Agro ecological zones with polygon boundaries	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
89	Alt zones	Altitude ranges	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers

	Erosion hazard	Erosion hazard	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
90	Esoilwat hold	Soils water holding capacities	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
91	Geology	Geology	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
92	Gp majcrops	Growing periods for major soils	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
93	Irrig pot	Irrigation potential areas	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
94	Lakes	Lakes	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
95	Maj nat veg	Major natural vegetation	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
96	Maj soils	Major soil units	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
97	Mai towns	Main towns	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
98	Lgp	Length of growing periods	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
99	Marf	Rainfall patterns	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
100	Physio	Physiographiy	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
101	Pop2000	Population size in 2000	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers

102	Popden83	Population densities in 1983	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
103	Present sev ero	Severity levels of soil erosion	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
104	River basin	Main river basins	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
105	Roads	Roads	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
106	Soil loss annual	Annual soil loss	ESARPP, HoA Coordination Office	Ethiopian Highland (only)				Attribute values have been calculated for the major data layers
107	Allw	All-weather roads	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				The Region touches Abbay and Tekeze basin
108	Alt	Altitude ranges	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
109	Amalake	Lakes in Amhara Region	Woody Biomass Inventory and 110Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
111	Contours	Contours	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
112	Eco	Agro ecology	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
113	Fsys	Farming systems	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
114	Geomor	Geomorphology	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region

115	Isohyet	Isohyets	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
116	LGP	Length of growing period	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
117	Maj riv	Major rivers	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
118	Rain	Mean annual rainfall	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
119	Soil	Major soil units	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
120	Sempzon	Thermal zones	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
121	Tir riv	Tributary rivers	Woody Biomass Inventory and Strategic Planning Project	Amhara Region				Abbay and Tekeze basins are found in the region
122	Allw	All-weather roads	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
123	Alt	Altitude ranges	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
124	Amalake	Lakes in Amhara Region	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
125	Contours	Contours	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
126	Eco	Agro ecology	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
127	Fsys	Farming systems	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin

128	Geomor	Geomorphology	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
129	Isohyet	Isohyets	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
130	LGP	Length of growing period	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
131	Maj riv	Major rivers	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
132	Rain	Mean annual rainfall	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
133	Soil	Major soil units	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
134	Tempzon	Thermal zones	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
135	Tir riv	Tributary rivers	Woody Biomass Inventory and Strategic Planning Project	Tigray Region				The region involves Tekeze Basin
136	Allw	All-weather roads	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region Gumuz				The region involves Abbay and Baro-Akobo basins
137	Alt	Altitude ranges	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
138	Amalake	Lakes in Amhara Region	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
139	Contours	Contours	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins

140	Eco	Agro ecology	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
141	Fsys	Farming systems	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
142	Geomor	Geomorphology	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
143	Isohyet	Isohyets	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
144	LGP	Length of growing period	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
145	Maj riv	Major rivers	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
146	Rain	Mean annual rainfall	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
147	Soil	Major soil units	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
148	Sempzon	Thermal zones	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
149	Tir riv	Tributary rivers	Woody Biomass Inventory and Strategic Planning Project	Benishangul Gumuz Region				The region involves Abbay and Baro-Akobo basins
150	Allw	All-weather roads	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
151	Alt	Altitude ranges	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
152	Amalake	Lakes in Amhara Region	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin

153	Contours	Contours	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
154	Eco	Agro ecology	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
155	Fsys	Farming systems	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
156	Geomor	Geomorphology	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
157	Isohyet	Isohyets	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
158	LGP	Length of growing period	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
159	Maj riv	Major rivers	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
160	Rain	Mean annual rainfall	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
161	Soil	Major soil units	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
162	Sempzon	Thermal zones	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
163	Tir riv	Tributary rivers	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
164	Allw	All-weather roads	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
165	Alt	Altitude ranges	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin

166	Amalake	Lakes in Amhara Region	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
167	Contours	Contours	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
168	Eco	Agro ecology	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
169	Fsys	Farming systems	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
170	Geomor	Geomorphology	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
171	Isohyet	Isohyets	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
172	LGP	Length of growing period	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
173	Maj riv	Major rivers	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
174	Rain	Mean annual rainfall	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
175	Soil	Major soil units	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
176	Sempzon	Thermal zones	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin
177	Tir riv	Tributary rivers	Woody Biomass Inventory and Strategic Planning Project	Gambella Region				The region involves Baro-Akobo basin

178	Allw	All-weather roads	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro- Akobo Basin
179	Alt	Altitude ranges	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro- Akobo Basin
180	Amalake	Lakes in Amhara Region	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro- Akobo Basin
181	Contours	Contours	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro- Akobo Basin
182	Eco	Agro ecology	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro- Akobo Basin
183	Fsys	Farming systems	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro- Akobo Basin
184	Geomor	Geomorphology	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro- Akobo Basin

185	Isohyet	Isohyets	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro-Akobo Basin
186	LGP	Length of growing period	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro-Akobo Basin
187	Maj riv	Major rivers	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro-Akobo Basin
188	Rain	Mean annual rainfall	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro-Akobo Basin
189	Soil	Major soil units	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro-Akobo Basin
190	Sempzon	Thermal zones	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro-Akobo Basin
191	Tir riv	Tributary rivers	Woody Biomass Inventory and Strategic Planning Project	Southern Nations, Nationalities and Peoples Region				The region involves Baro-Akobo Basin

192	Allw	All-weather roads	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
193	Alt	Altitude ranges	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
194	Amalake	Lakes in Amhara Region	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
195	Contours	Contours	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
196	Eco	Agro ecology	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
197	Fsys	Farming systems	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
198	Geomor	Geomorphology	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
199	Isohyet	Isohyets	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
200	LGP	Length of growing period	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
201	Maj riv	Major rivers	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins

202	Rain	Mean annual rainfall	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
203	Soil	Major soil units	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
204	Sempzon	Thermal zones	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins
205	Tir riv	Tributary rivers	Woody Biomass Inventory and Strategic Planning Project	Oromia Region				The region involves Abbay and Baro-Akobo Basins

ANNEX THREE: POLICIES, LEGISLATIONS, STUDIES AND REPORTS

No.	File Name	Theme	Location on CD	*Thematic level*				*Remark*
				Basin/Region/National	**Abbay**	**Baro-Akobo**	**Tekeze**	
1	Environment Policy of Ethiopia	Federal Environmental Policy of Ethiopian	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
2	Executive summary of NAPCD	Executive summary of National \Action Plan to combat Desertification	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
3	Gap Analysis to Combat Desertification	Desertification	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
4	National Action Program to Combat Desertification, Vol. I	Action Plan on Desertification	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
5	National Action Program to Combat Desertification, Vol. II	Action Plan on Desertification	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
6	National Action Program to Combat Desertification, Vol. III	Action Plan on Desertification	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
7	EXE.SUM.WPD	Natural Resources Development and Environmental Protection	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-

		Strategy and Major Programs						basins in Ethiopia
8	National Conservation Strategy Volume I	Federal Conservation Strategy	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
9	National Conservation Strategy Volume II	Federal Conservation Strategy	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
10	National Conservation Strategy Volume III	Federal Conservation Strategy	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
11	National Conservation Strategy Volume IV	Federal Conservation Strategy	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
12	EIA Proclamation	Environmental Impact Assessment Proclamation	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
13	Pollution Control Proclamation	Pollution Control Proclamation	Environmental Policies and Legislations	National/Federal				There are parts relevant to the three sub-basins in Ethiopia
14	Benshangul Gumuz RCSA	Benishangul Gumuz Regional Capacity Needs Self-Assessment and Action Plan	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
15	Gambella NCSA-Phase III	Gambella Region Capacity Building Action Plan	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia

16	Tigray-RCNA2	Regional Capacity Need Self -Assessment	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
17	Tigray-RCNA3	Regional Capacity Need Self -Assessment	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
18	Tigray-RCSA1	Regional Capacity Need Self -Assessment	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
19	State of Environment	State of Environment Report of Ethiopia	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
20	UNCCD 3rd country report-final	The 3rd National Report on the Implementation of the UNCCD/Nap in Ethiopia	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
21	Amhara Region WBISPP Reports	• Livestock; • WB Strategic Plan; • Energy balance; Socio-economic Studies on Strategic Plan for the sustainable development, conservation and management of the Woody Biomass Resources, Volume 2 • Report On Natural Grazing Lands And Livestock Feed Resources.	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia

22	Benishangul Gumuz Region WBISPP Reports	• Livestock; • WB Strategic Plan; • Energy balance; Socio-economic Studies on Strategic Plan for the sustainable development, conservation and management of the Woody Biomass Resources, Volume 2 • Report On Natural Grazing Lands And Livestock Feed Resources.	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
23	Gambella Region WBISPP Reports	• Livestock; • WB Strategic Plan; • Energy balance; Socio-economic Studies on Strategic Plan for the sustainable development, conservation and management of the Woody Biomass Resources, Volume 2 • Report On Natural Grazing Lands And Livestock Feed Resources.	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
24	Tigray Region WBISPP Reports	• Livestock; • WB Strategic Plan; • Energy balance; Socio-economic Studies on Strategic Plan for the sustainable	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia

		development, conservation and management of the Woody Biomass Resources, Volume 2 • Report On Natural Grazing Lands And Livestock Feed Resources.						
25	Southern Nations, Nationalities and Peoples Region	• Livestock; • WB Strategic Plan; • Energy balance; Socio-economic Studies on Strategic Plan for the sustainable development, conservation and management of the Woody Biomass Resources, Volume 2 • Report On Natural Grazing Lands And Livestock Feed Resources.	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia
26	Oromia Region WBISPP	• Livestock; • WB Strategic Plan; • Energy balance; Socio-economic Studies on Strategic Plan for the sustainable development, conservation and management of the Woody Biomass Resources, Volume 2 • Report On Natural Grazing Lands And Livestock Feed	Woody Biomass Reports	Regional				There are parts relevant to the three sub-basins in Ethiopia

		Resources.						
	Agricultural Strategies	Agricultural Strategies (Proposals)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Agricultural Situation	Agricultural Situation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Agriculture	Agriculture Review		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Cost-Benefit Analysis for Reclamation	Cost-Benefit Analysis for Reclamation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Degradation	Land Degradation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Degradation_(Resources_3)	Land Degradation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Degradation_land2	Land Degradation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Development Strategy	Development Strategy (proposal)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	EHRS-Final Report_Volume1	Highland Reclamation		National/Highlan				There are parts

		Study Final Study		d Ethiopia				relevant to the three sub-basins in Ethiopia
	EHRS-Final Report_Volume2	Highland Reclamation Study Final Study		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Forest Development Strategy	Forest Development Strategy (Proposal)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Forestry & Grassland Strategy	Forestry & Grassland Strategy (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Grassland and Forest Land	Grassland and Forest Land (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Irrigation Development	Irrigation Development (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Irrigation Potential	Irrigation Potential (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Livestock Development	Livestock Development (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Livestock Situation	Livestock Situation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-

								basins in Ethiopia
	Macro-Economic Review	Macro-Economic Review		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Population	Population (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Preamble and acknowledgement	Preamble		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Resettlement Program Evaluation	Resettlement Program Evaluation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Resettlement Strategy (Proposal)	Resettlement Program Evaluation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Rural Development (Resources for)	Rural Development (Resources for) - study		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Sirinka Catchment Rehabilitation	Catchment Rehabilitation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Sociological Survey	Sociological Survey (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia

	Soil and Water Conservation Strategy	Soil and Water Conservation Strategy (proposal)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Soil and Water Conservation	Soil and Water Conservation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Soil Conservation (Arjo Awuraja)	Soil and Water Conservation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Soil Degradation (Dominant)	Soil Degradation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Soil Formation	Soil Formation (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia
	Transport & Communication Development Strategy	Transport & Communication Development Strategy (study)		National/Highland Ethiopia				There are parts relevant to the three sub-basins in Ethiopia

ANNEX FOUR: BIBLIOGRAPHY OF HARDCOPY DOCUMENTS

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume II- Natural Resource.

MWR, (1999). Abbay River Basin Integrated Development Master Plan Project, Phase2,Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume III-Water Resource

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume V- Water Recourse Development.

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume VI- Water Resource Development Scheme.

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project. Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume VIII- Land Resource Development

MWR, (1999). Abbay River Basin Integrated Development Master Plan Project, Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume IX- Land Resource Development- Agriculture

MWR, (1998). Abbay River Basin Integrated Development master plan project. Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume X –Land resource Development –Agriculture

MOWR, (1998). Abbay River Basin Integrated Development Master Plan Project. Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume XI Land Resource Development

MOWR, (1998). Abbay River Basin Integrated Development Master Plan Project. Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II,Sectoral Studies, Volume XII- Land Resource Development

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume XIII- Environment,

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Phase2,Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies,Volume XVI- Infrastructure,

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Phase2, Data Collection- Site Investigation, Survey and Analysis, Section II, Sectoral Studies, Volume XVIII-Infrastructure.

MWR, (1999). Abbay River Basin Integrated Development Master Plan Project, Phase3, Volume 1- Main Report

MWR, (1998). Abbay River Basin Integrated Development master plan project, Phase3, Appendixes to the main Report, Part 1.

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Phase3, Appendixes to the Main Report, Part 2.

MWR, Abbay River Basin Integrated Development Master Plan Project, Phase 3, Appendices to the Main Report, Description of Land Management Zones, Part 3

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Phase3, Volume IV Pre-Feasibility Study, Part 4, Irrigation and Drainage –North East Lake Tana.

MWR, (1999). Abbay River Basin Integrated Development Master Plan Project, Phase3, Part 1, Volume IV Pre-Feasibility Study, Irrigation and Drainage – Gilgel.

MWR, (1999). Abbay River Basin Integrated Development master plan project, Phase3, Volume IV Pre-feasibility Study, Irrigation and Drainage –Lower Birr

MWR, (1999). Abbay River Basin Integrated Development master plan project, Phase3,Volume IV Pre-feasibility Study, Irrigation and Drainage – Megech.

MWR, (1999). Abbay River Basin Integrated Development Master Plan Project, Phase 3, Volume IV Pre-Feasibility Study, Irrigation and Drainage – Ribb

MWR, (1998). Abbay River Basin Integrated Development master plan project, Phase3, Pre-feasibility Study, Hydropower Schemes,Pre-feasibility Study on Fettam hydroelectric Project.

MWR, (1997). Abbay River Basin Integrated Development Master Plan Project, Phase 1 Reconnaissance, Section III, Volume II (B) Water Resource.

MWR, (1997). Abbay River Basin Integrated Development Master Plan Project, Phase2, Data Collection –Site Investigation, Survey and Analysis, Section II Sectoral Studies, Volume III (A) Water Resource Development.

MWR, (1997). Abbay River Basin Integrated Development Master Plan Project, Phase2, Data Collection –Site Investigation, Survey and Analysis, Section II Sectoral Studies,Volume V-Environment.

MWR, (1997). Abbay River Basin Integrated Development Master Plan Project, Phase2, Data Collection –Site Investigation, Survey and Analysis, Section II Sectoral Studies, Volume VII- Infrastructure.

MWR, (1998), Abbay River Basin Integrated Development Master Plan Project, Phase3, Pre-Feasibility Study, Arrigation And Drainage – Ribb, Part II.

MWR, (1998). Abbay River Basin Integrated Development Master Plan Project, Phase3,Volume IV Pre-Feasibility Study, Arrigation And Drainage – Ribb, Part I.

Tis Joint Venture, (1997). Tis Abbay II Hydropower Project, Final design Report Ethiopian Valleys

Development Studies Authority Master Plan Study for Abbay (Blue Nile) River Basin, Expression of Interest and Statement of Capability Sep. 1993

MWR, (1998). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Volume IV, Map Album.

MWR, (1997). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Volume II Resources Base and Development Options

MWR, (1997). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Volume V Pre-Feasibility Study.

MWR, (1997). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Water Resource , Part 1

MWR, (1998). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Part 3.

MWR, (1997). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Annex 1 Water Resource ,Part 4

MWR, (1997). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Annex 2, Part 1 Natural Resource.

MWR, (1997). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Annex 2, Part 2, Natural Resources

MWR, (1997). Baro-Akobo River Basin Integrated Development Master Plan Study, Final Report, Annex 4, Environment

MWR, (1998). Medium Scale Hydropower Study Project, Baro Hydropower Study, Pre-Feasibility Study, Volume 5 Internal Environmental Assessment.

MWR, (1998). Tekeze River Basin Integrated Development Master Plan Project Master Plan, Volume I , Main Report.

MWR, (1998). Tekeze River Basin Integrated Development Master Plan Project, Master Plan,Volume III, Reconnaissance and Pre-Feasibility Study

MWR, (1998).Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Volume IV Water Allocation and Utilization.

MWR, (1998). Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume VI Climatology.

MWR, (1998).Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume IX Water Resources ,Water Point Inventory Assessment of Ground Water Quality,Hydrological Target Areas.

MWR, (1998), Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume X Water Resources, Dams, Reservoirs and Hydropower Development.

MWR, Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume XI Water Resource, Drinking Water Supply and Sanitation.

MWR, (1998). Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume XIII Natural Resoursce, Soil and Terraiin, Part1.

MWR, (1998). Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume XIV Natural Resource, Soil and Terrain, Part 2 And 3.

MWR, (1998), Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume XV Natural Resources, Land Use and Land Cover.

MWR, (1998). Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume XVI Natural Resources,

MWR, (1998), Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume XIX, Environment, Land Degradation and Soil Conservation, Environmental Impact Assessment and Environmental Monitoring System.

MWR, (1998). Tekeze River Basin Integrated Development Master Plan Project, Master Plan, Sectoral Report, Volume XX -Physical Planning,, Road Infrastructure, Tourism, Electric Power Planning, Industrial Planning.

BDCRI, National policy on Biodiversity Conservation and Research.

BDCR, Convention on Biological Diversity

MWR, Excerpts from Nile River Basin Trans-boundary Environmental Analysis

BSPP, Federal Negerit Gazeta Environmental Protection Organs Establishment proclamation

MoA, Ethiopian Forestry Actions Program (EFAP) Final Report Vol. III: Issues and Options.

MoA, Ethiopian Forestry Action program. (EFAP Final Report Vol..III: The Challenges for Development

EPA, Proceedings of the National Consultative Worksop on the Ramsar Convention and Ethiopia The Environmental Protection Authority in Collaboration with the Ramar Bureau March 18-19,2004 Addis Ababa

BDCRI, Forest Genetic Resources Conservation Strategy of Ethiopia

BDCRI, Socio- economic (PAR) Report of Tiro Boter-Becho Forest (Technical report series No.19), forest (Genetic Resource Conservation Project Institute of Diversity Conservation GTZ, May 2004

BDCRI, Inventory of Woody Species in Masha-Anderacha Forest Report NO.3 (Forest Genetic Resources Conservation Project Institute of Biodiversity conservation Propjet Research, GTZ- Feb. 2002;

UNDP, GIF,UNDP; Nile River Basin: Trans-Boundary Environmental Analysis, May 2001.