FDRE Abbay Basin Authority

Environmental Assessment Report of Abbay River Basin

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ACRONYMS

ABA	Abbay Basin Authority
ALNP	Alatish National Park
BGNRS	Benishangul Gumuz National Regional State
CSA	Central Statistics Agency
DNP	Dander National Park
ENTRO	Eastern Nile Technical Regional Office
EOSA	Ethio-Organic Seed Action
ESSP	Ethiopia Strategy Support Program
EWCA	Ethiopian Wildlife Conservation Authority
FAO	Food and Agricultural Organisation
GDP	Gross Domestic Product
GERD	Grand Ethiopian Renaissance Dam
GiZ	Deutsche Gesellschaft Für International Zusammenarbeit
HIS/BIS	Hydrologic Information System/ Basin Information System
HRU	Hydrologic Response Unit
IBC	Institute of Biodiversity Conservation
IGAD	Intergovernmental Authority on Development
ITCZ	Inter Tropical Convergence Zone
IUCN,	International Union for the Conservation of Nature
IWM	Integrated Watershed Management
IWS	Investment for Watershed Services
km^2	Square Kilometer
masl	Meters Above Sea Level

Mm^3	Million Cubic Meter
MoANR	Ministry of Agriculture and Natural Resources
MoFED,	Ministry of Finance and Economic Development
MoIWE	Ministry of Irrigation Water And Electricity
MoWR	Ministry of Water Resource
Mt	Million Tone
Mt yr^{-1}	Million Ton Per Year
NPFA's	National Priority Forest Areas
NGOs	Non-Governmental Organization
^oC	Degree Celsius
OFWE	Oromia Forest and Wildlife Enterprise
PCFEPDD	Public Consultative Forum of Ethiopia on Peace, Development and Democracy
PET	Potential Evapo Transpiration
SCRP	Soil Conservation Reserve Program
SLM	Sustainable Land Management
SWAT	Soil and Water Assessment Tool
SWC	Soil and Water Conservation
t ha^{-1} yr^{-1}	Ton Per Hectare Per Year
t m^{-3}	Ton Per Cubic Meter
USAID	United States Agency for International Development
USD	United Starts Dollar
USLE	Universal Soil Loss Equation
UTM	Universal Transvers Mercator
WLRC	Water and Land Resource Center

1 INTRODUCTION

6.1. Background

The Abbay basin is by most criteria the most important river basin in Ethiopia. It accounts for almost 20% of Ethiopia's land area; 50% of its total average annual runoff; 25% of its population; and over 40% of its agricultural production. There is an immense potential of land and water resources in the Upper Blue Nile (Abbay) basin. However, small and fragmented land holding, soil/land degradation, declining crop yield, increasing population, climate variability, desertification, and increasing upstream-downstream water use tensions have created enormous pressure in the basin.

Climate changes pose significant economic and environmental risks worldwide. The economy of Ethiopia mainly depends on agriculture, and this in turn largely depends on available water resources. The country has a fragile highland ecosystem that is currently under stress due to increasing population pressure and land degradation. The Abbay river basin is one of the most sensitive basins to changing climate and water resources variability in the region (Kim and Kaluarachchi, 2009).

Water is a scarce and precious natural resource to be planned, developed, conserved and managed in an integrated manner giving due regard to socio-economic and environmental issues. In addition, in Ethiopia and some other developing countries, the National Water Policy envisages that water resources planning, development and management have to be planned based on hydrological unit such as drainage basin as a whole or in a sub-basin multisectorally taking into account surface and ground water for sustainable use incorporating quantity and quality aspects as well as environmental considerations (El Bastawesy, et al., 2014).

Basin planning typically considers a range of social, economic and environmental issues. Therefore, conducting a situation assessment: gaining an understanding of the current and future conditions in the basin, as well as identifying and prioritizing the key issues is the preliminary work for the sustainable development of the basin. This document tries to address the environmental assessment of Abbay River Basin.

1.2. Objective of the Assessment

1.1.1. General Objective

The overall purpose of this document is conducting an environmental assessment for understanding the current and future conditions of the basin, as well as identifying and prioritizing the key issues either protection of the existing environmental quality, or restoration of degraded environments

1.1.2. Specific Objectives

- ♣ To understand system functioning and environmental flow of the river and how different activities within the basin affect those functions, assets and services prior to decision-making.
- ♣ To understand the status, ecosystem services and ecological importance of aquatic, floral, faunal and genetic biodiversity in the basin and the critical habitats upon which they depend.
- ♣ To protect, maintain and give priorities and management for key ecosystems, parks, environmental flow regimes, wetlands and high conservation value species in the basin.
- ♣ To apprehend the water quality status and pollution threats of the water resources of the Basin.
- ♣ To prioritize and set mitigation measures to protect natural resources degradation and environmental quality of the basin

2. STUDY METHODS AND DATA SOURCES

The methodology to collect information on the existing environment comprised literature review, field visits together with consultations with government officials, and nongovernmental organizations, identification of observed fauna and flora, and subsequently writing appropriate reports based on the study.

Secondary data were collected at the national level from government institutions, primarily from The National Regional State of Oromia Rural Land and Environmental Protection

Bureau, Benishangul Gumuze Regional State agriculture and rural development bureau Government of the Federal Democratic Republic of Ethiopia Institute of Biodiversity Conservation

Ethiopian wildlife conservation authority, the Oromia, Amhara and Benishangul Gumuze Environmental Protection Authority and various documented studies in the area. Secondary data were also collected from federal level research institutes, including the Ethiopian Wildlife and Natural History Society, Ethiopian Environment and Forest Institute, Forestry Research Centre, Addis Ababa, Ethiopia (FRC), International Water Management Institute (IWMI), Water and Land Resource Center, Addis Ababa University (WLRC), Public Consultative Forum of Ethiopia on Peace, Development and Democracy (PCFEPDD) and NGO Sustainable Land Management Ethiopia (SLM).

During the field study, there were plenty of opportunities to observe the existing conditions in the study area, including the cropping and livestock systems, living standards, and the natural environment. Although scanty, the various ecological systems in the project area were observed together with species of flora and fauna. Additional information was obtained from specialists of the Institutions who were addressing crop and livestock production, soil and water conservation, forestry development, soils, and socio-economic aspects.

The team provided briefings on the objectives required data and methodologies of the study from the important documents and conducted discussion with senior professionals like International Water Management Institute (IWMI), Water and Land Resource Center, Addis Ababa University (WLRC), and Sustainable Land Management Ethiopia (SLM).

3. PHYSIOGRAPHICAL CHARACTERIZATION OF THE BASIN

6.2. Physical Environment

3.1.1. Topography

The topography of the Abbay basin signifies two distinct features; the ***highlands***, ragged mountainous areas in the center and eastern part of the basin and the ***lowlands*** in the western part of the basin(Awulachew, S. B et al., 2008). The altitude in the basin ranges from 475 masl in the lowlands up to 4261 masl in the highlands. The slope of the basin can be grouped in to three as it indicated in the figure below. 85% of the basin areas have slope percentage of less than 30, 15% of the basin area have steep slope having slope percentage greater than 30%.

The Abbay leaves the lake close to the city of Bahir Dar at the southeastern corner of the lake and cuts a deep gorge first south then westwards, through a series of cataracts. Approximately 40 km downstream it drops 50 m over the Tiss Issat Falls (Figure 1) into the Blue Nile gorge.

Figure 1 Tiss Issat Fall

The catchment is cut by deep ravines in which the major tributaries flow. The valley of the Abbay itself is 1,300 m deep in some places (Figure 2). The eastern part of the basin has the highest elevation reaching above 4000 m above mean sea level and decreasing gradually toward the western outlet of the basin where the elevation is approximately 500 m above mean sea level as shown in figure 2.

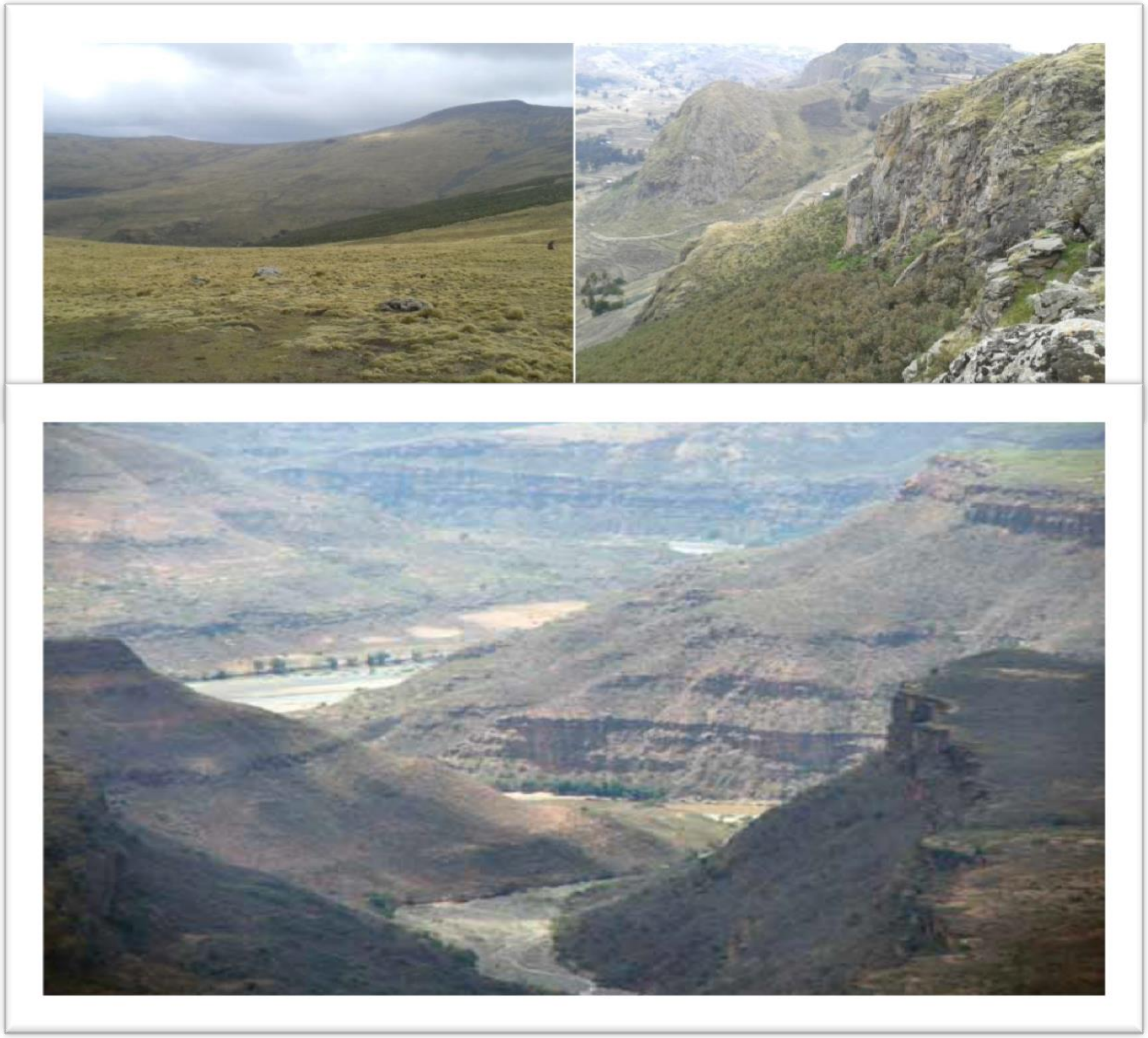


Figure 2 Mount Guna (up) and The Abbay(Blue Nile Gorge) (down)

3.1.2. Climate

i. Rainfall

Within the basin, rainfall varies significantly with altitude and is, to a large extent, controlled by movement of air masses associated with the Inter-Tropical Convergence Zone (ITCZ). There is considerable inter-annual variability, it increases from about 1000 mm near the Sudan border to between 1400 and 1800 mm over parts of the upper basin, and exceeds 2200 mm in some places in the south with a mean of about 1,420mm yr^{-1}(Awulachew *et al.*, 2008).;This proportion generally increases with latitude. Locally the climatic seasons are defined as; dry season (Bega) from October to the end of February; short rain period (Belg) from March to May the long rainy period(Kiremt) account for a large proportion of mean annual rainfall: roughly 70% occurs between June and September with the greatest rainfall occurring in July and August.

According to Köppen’s system, the Abbay basin is characterised by tropical, warm temperate and cool highland climate zones. Relatively high rainfall is found in the southern part of the basin in parts of the Didessa and Beles catchments and in the center of the basin and has a shorter, more pronounced wet season. In the eastern and north-western part of the basin in the Beshelo, Welaka, Jemma, Muger, Guder, and parts of Dinder and Rahad, rainfall is relatively low.(Ermias Teferi Demessie2015; Awulachew, S. B et al., 2008

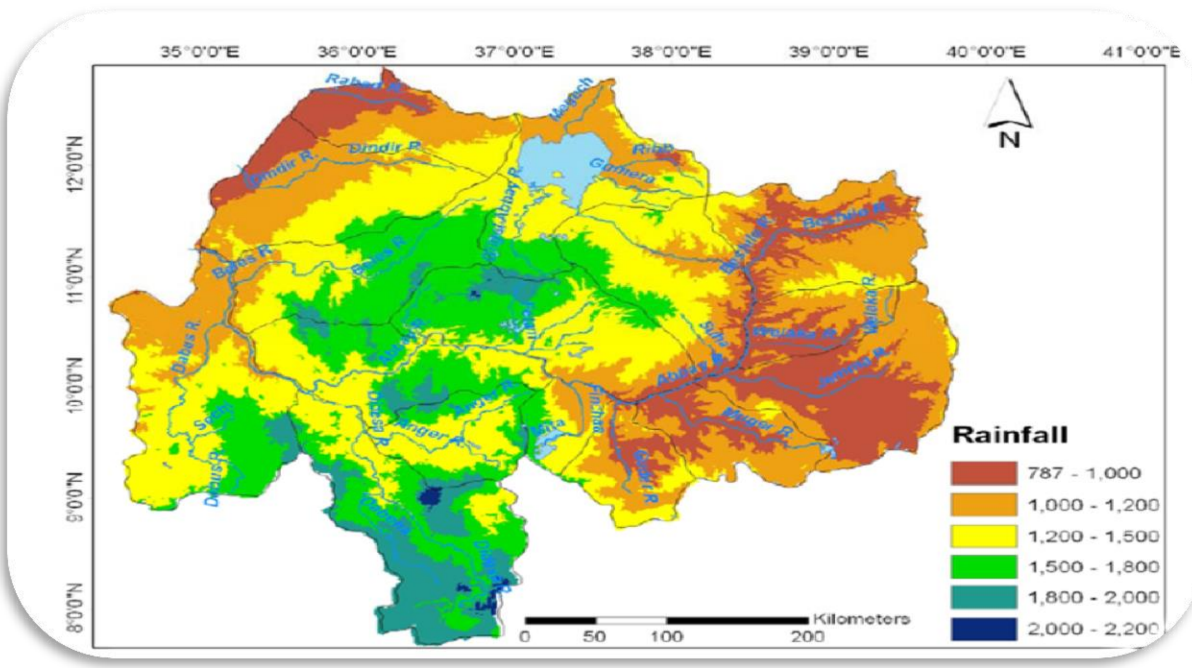


Figure 3 Rainfall distribution in the Basin

ii. Temperature

The spatial distribution of temperature is strongly related to altitude. The altitude of the Abbay basin ranges from 475 m.a.s.l.at the Sudanese border to 4,257 m.a.s.l. at the summit of

Mt. Guna. The highlands (i.e. altitude greater than 1500 m.a.s.l.) and the lowlands are the main landscape units observed in Abbay basin.

The highest temperature observed in the north western part of the basin, in parts of Rihad, Dinder, Beles and Dabus, the maximum temperature being 28^{o}C–38^{o}C and minimum temperature 15^{o}C–20^{o}C. Lower temperature observed in the highlands of Ethiopia in the central and eastern part of the basin. The mean annual temperature is about 18.58^{o}C with a seasonal variation of less than 28^{o}C [Kim et al., 2008].

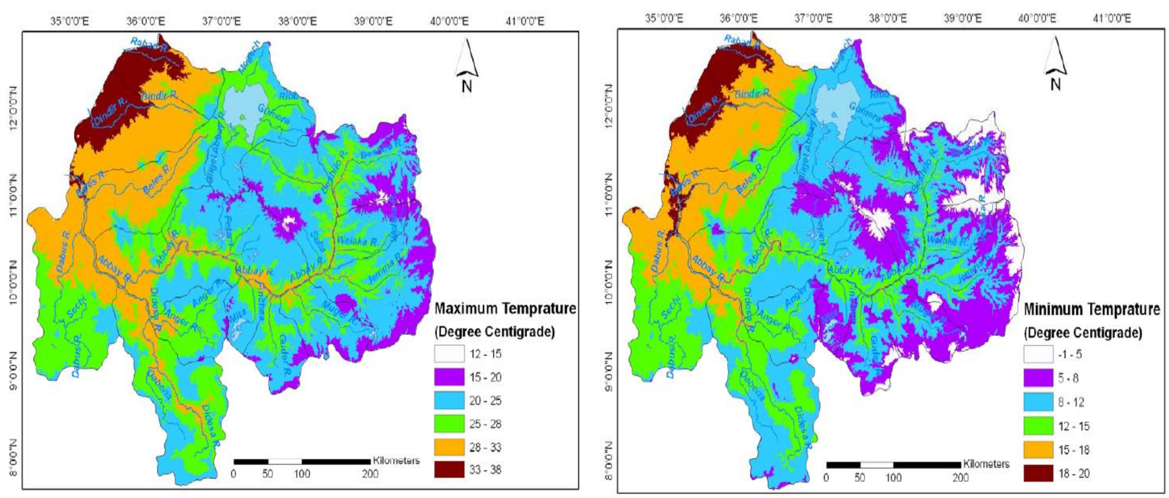


Figure 4 Maximum and minimum temperature distribution in the basin from left to right

iii. Evapotranspiration

Due to its equatorial positioning, the Abay River Basin is ripe for evaporation in its channels and reservoirs, and evapotranspiration through irrigation practices. Potential Evapotranspiration (PET) in the basin ranges between 1056 mm and 2232 mm per year. High PET is observed between 1800 mm and 2232 mm per year in North Western parts of the basin, in Dinder, Rahad, and parts of Beles and Didessa sub basins. The Eastern and southern parts having lower PET ranging between 1200 and 1800 mm per year and the lowest PET below 1200 mm per year observed in the parts of the highlands.(Abbay Basin Atlas, 2015) and, in many places, is less than rainfall in the rainy season. Consequently, rain-fed cultivation, producing a single crop in the rainy season, is possible, though risky in low rainfall years. Similar to rainfall and temperature, potential evapotranspiration also varies considerably across the basin and is highly correlated with altitude and also with the temperature.

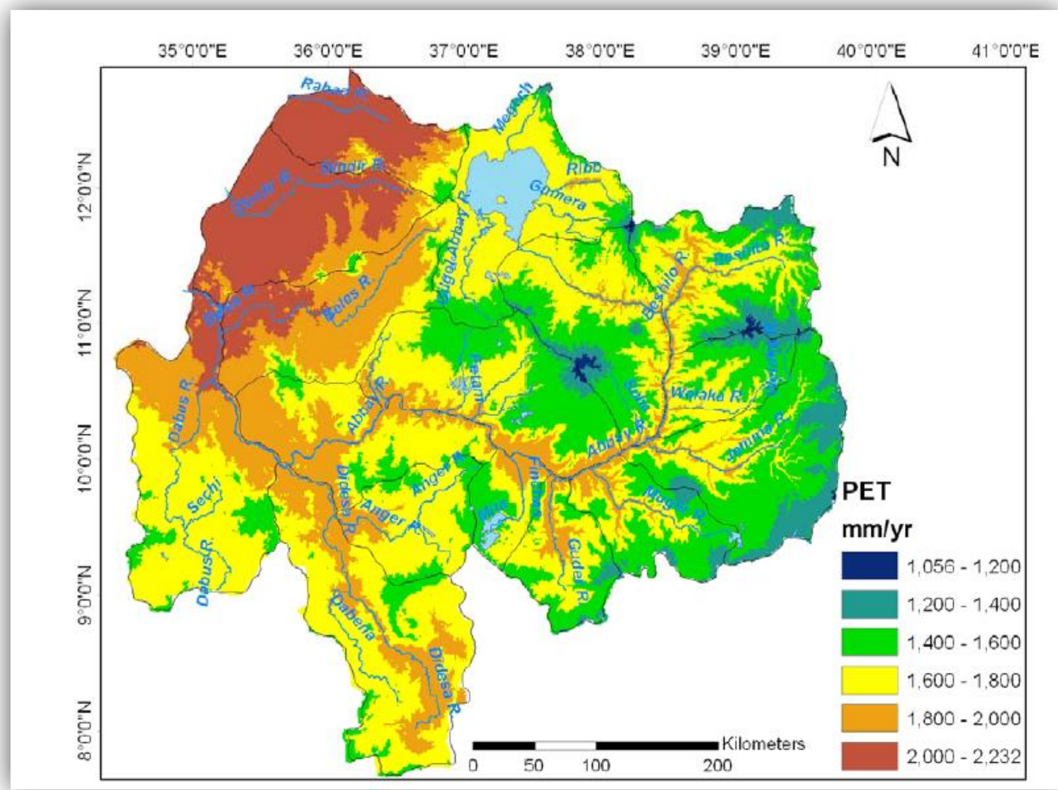


Figure 5 Potential Evapotranspiration of Abbay Basin

iv. *Hydrological Stations*

Overall there are a total number of about 159geo-referencedhydrometric stations in the basin but about 17 hydro-meteorological stations are not functional. Presently, out of this only 142 stations are operational. However data availability is limited for the stations. There are also 51 new and upgraded stations which will be established through the HIS/BIS project. All data from the monitoring network are collected by the Hydrological Branch Offices of ABA and data are transferred to MoIWE at regular time scales. The data collection activities are mainly engaged in surface water resources assessment which currently comprises collection of stream flow data, lake level, recording of suspended sediment sampling and water quality data.

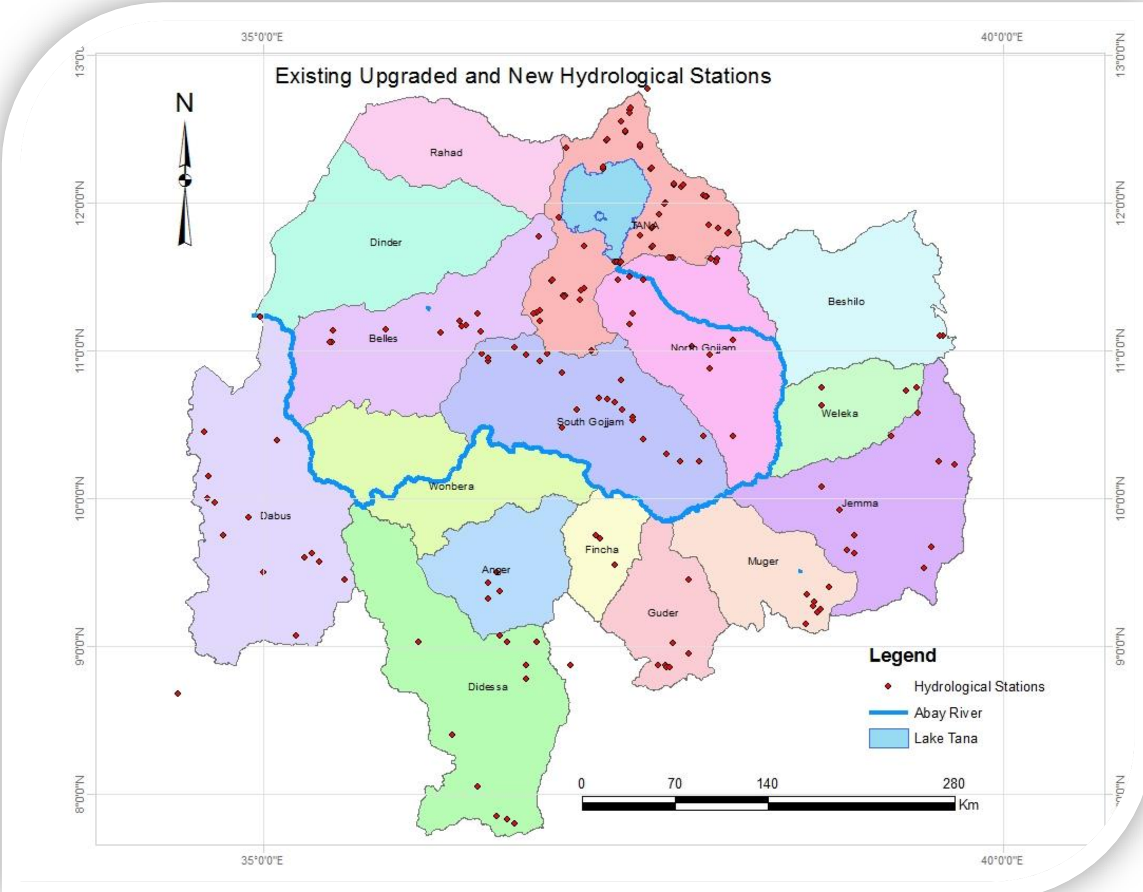


Figure 6 Hydrological stations in Abbay Basin

v. Meteorological stations

There are about 264geo-referenced meteorological stations in the basin. But the number exceeds 300 including meteorological stations located near to the basin borders that serve for the climate analysis of the basin. However data availability is limited for the stations. Station network particularly rainfall is important to obtain sufficient information on the geographical distribution, and the variability in time. This information is vital for the hydrological and basin information system, drainage requirement, rainfall-runoff modeling, the magnitude and frequency of floods and droughts, etc.

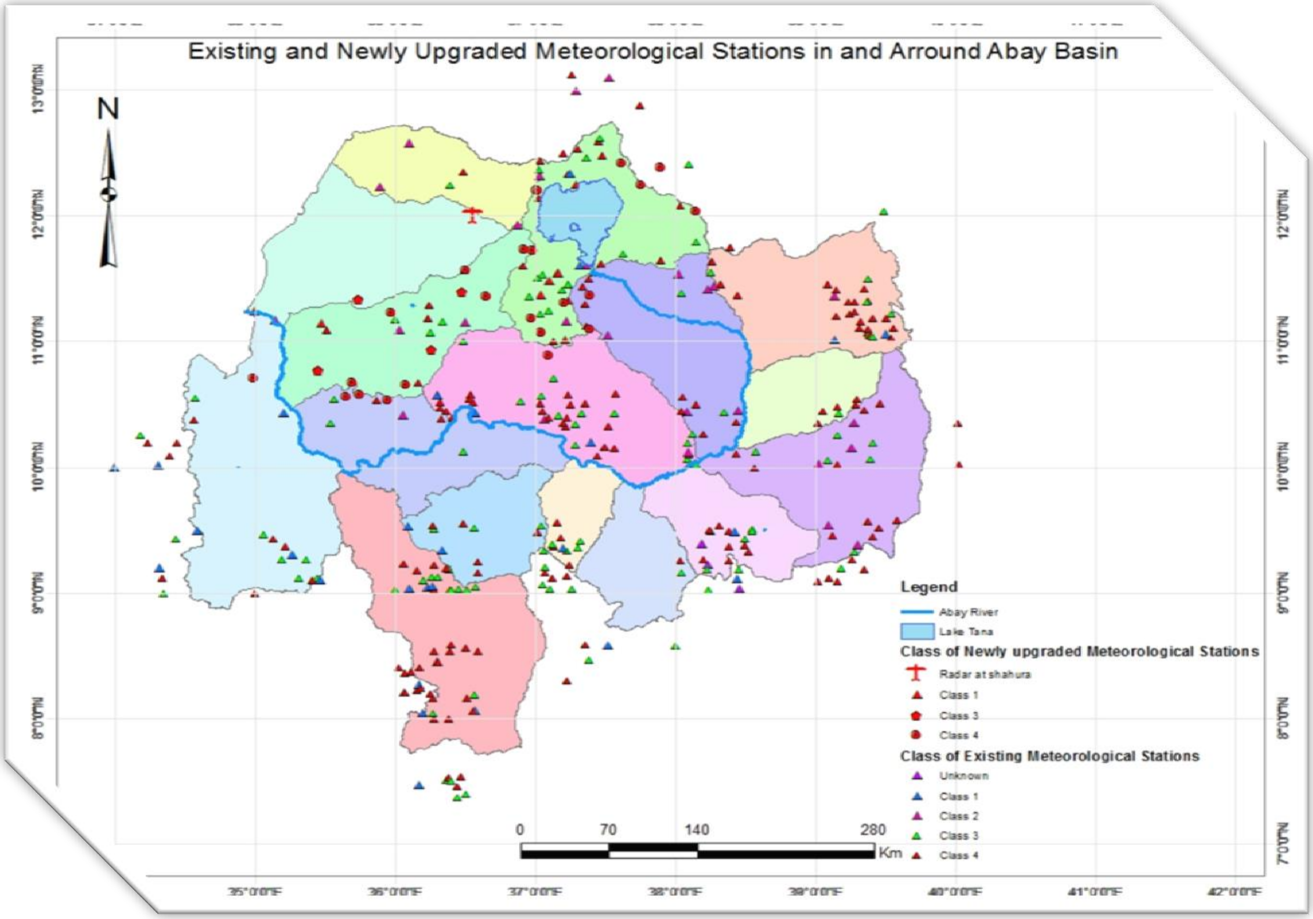


Figure 7 Meteorological stations in and around Abbay Basin

3.1.3. Environmental Flow of Abbay Basin

Environmental flow (or in-stream flow) is a term used to describe the hydrological component of aquatic ecosystems that is required to rehabilitate or protect biodiversity and ecological integrity. Environmental flows are prescribed for unregulated rivers, where limits on future demands must be set and on regulated rivers where efforts are being made to improve ecosystem functioning.

Environmental flows are *an ecologically acceptable flow regime* designed to maintain a river in an agreed or predetermined state. Therefore, second, EF are a compromise between water resources development, on one hand, and river maintenance in a healthy or at least reasonable condition, on the other. Another useful way of thinking about EF is that of ‘environmental demand’ similarly to crop water requirements, industrial or domestic water demand.

Despite the simplicity of the concept, difficulties arise in the actual estimation of EF values. This is primarily due to the inherent lack of both the understanding of and quantitative data on relationships between river flows and multiple components of river ecology. Ecologists agree that the major criteria for determining EF should include the maintenance of both spatial and temporal patterns of river flow, i.e., the flow variability, which affect the structural and functional diversity of rivers and their floodplains, and which in turn influence the species diversity of the river.

Thus, EF should not only encompass the *amounts* of water needed, but also *when and how* this water should be flowing in the river. All components of the hydrological regime have certain ecological significance. High flows of different frequency are important for channel maintenance, bird breeding, wetland flooding and maintenance of riparian vegetation. Moderate flows may be critical for cycling of organic matter from river banks and for fish migration, while low flows of different magnitudes are important for algae control, water quality maintenance and the use of the river by local people.

Therefore, many elements of flow variability have to be maintained in a modified-EF-regime. The focus on maintenance of flow variability has several important implications. First, it moves away from a ‘minimum flow attitude’ to aquatic environment. Second, it effectively considers that aquatic environment is also ‘held accountable’ and valued similarly to other sectors – to allow informed tradeoffs to be made in water scarcity conditions. Because wetland and river ecosystems are naturally subjected to droughts or low flow periods and can recover from those, then building this variability into the picture of EFA may be seen as *environmental water demand management.* This brings us back to the issue of ‘compromise’ and implies that EF is a very pragmatic concept: it does not accept a bare minimum, but it is prepared for a trade.

Bunn and Arthington (2002) have formulated four basic principles that emphasize the role of flow regime in structuring aquatic life and show the link between flow and ecosystem changes: Flow is a major determinant of physical habitat in rivers, which in turn is the major determinant of biotic composition. Therefore, river flow modifications eventually lead to changes in the composition and diversity of aquatic communities. Aquatic species have evolved life history strategies primarily in response to the natural flow regimes. Therefore, flow regime alterations can lead to loss of biodiversity of native species. Maintenance of natural patterns of longitudinal and lateral connectivity in river-floodplain systems determine the ability of many aquatic species to move between the river and floodplain or between the main river and its tributaries. Loss of longitudinal and lateral connectivity can lead to local extinction of species. The invasion of exotic and introduced species in rivers is facilitated by the alteration of flow regimes. Inter-basin water transfers may represent a significant mechanism for the spread of exotic species.

The Ethiopian Water Resources Management policy states that the basic minimum requirement, as the reserve (basic human and livestock needs, as well as environment reserve) has the highest priority in any water allocation plan.

Hence, the basin plan hast to give priority for the environmental flow requirements by using appropriate possible environmental flow estimation methods. The general methods used to determine environmental flows are listed here.

3.1.4. Environmental flow methods

Major environmental flow methods are classified into four classes: hydrological methods, hydraulic rating methodologies, habitat simulation methodologies, and holistic methodologies. These methods are stated below.

- ***Hydrological* -** Primarily use hydrological data (historical monthly or daily flow records) for making e-flow recommendations for maintaining river health at designated level
- ***Hydraulic rating* -** use changes in simple hydraulic variables (e.g. wetted perimeter) across single river cross-section as surrogate for habitat factors limiting to target biota
- ***Habitat simulation* -** Assess e-flows on basis of modeling of quantity and suitability of physical habitat available to target species under different flow regimes (integrated hydrological, hydraulic and biological response data)

- ***Holistic*** – identify important flow events for all major components of river, model relationships between flow and ecological, geomorphological and social responses, and use in interdisciplinary team approach to establish recommended e-flow regime/implications of flow scenarios (bottom-up or top-down)

3.1.5. Hydrology of Abbay Basin

The hydrology of the River Abbay is regulated by the interaction between climate and geography throughout the basin. The timing and volume of discharge in the main River Abbay depend on the flow patterns of its tributaries. In turn, water flow and balance within these tributaries and other water bodies within the basin depend on rainfall and temperature patterns; physical characteristics of river channels, lakes, and wetlands; vegetation; and human influences such as dams.

i. Surface flow

The Abbay River Basin with an area of 199,812 km^2 is the second largest basin in Ethiopia but has the largest quantity of runoff estimated to be 54.5Mm^3 (Abbay Basin Atlas, 2015). The Abbay River basin drains to Sudan through three main outlets: (i) the main channel of the Abbay River with a mean annual discharge of 49 Mm^3. This contributes 94 percent of the basin flow from a drainage area of 172,254 km^2; and (ii) the channel of the Dinder and (iii) the channel of Rahad rivers which drain to Sudan to the north of the Abbay channel and join the Abbay. Both the Dinder and Rahad have a mean annual discharge of approximately 5.5 Mm^3 and each contributes 7%of the Abbay River basin flow from a combined catchment area of about 23,160 km^2. The remainder of the catchment is distributed within smaller water courses on both banks of the Abbay River. These include on the left bank in descending order of entry; the Beshilo, Welaka, Jemma, Muger, Finchaa and Didessa rivers. On the right bank the rivers arising from the Gojam area of the Ethiopian Highlands have smaller more limited catchments and these rivers include; Abeya, Suha, Chemoga, Birr, Fettam and Dura. Two major tributaries join the Abbay in the lowlands and these include the Dabus on the left bank and the Beles on the right bank.

The gross runoff depth of each sub basin of the Abbay basin is shown in Table 1 below. The runoff for each drainage unit is gross runoff, which does not take evaporation and other channel losses into account.

Table 1 Seasonal flow of Abbay Basin

Location		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Main stem														
Lake Tana	Flow	203	127	94	70	49	45	114	434	906	861	541	332	3776
	run-off	13	8	6	5	3	2	7	28	59	56	35	22	244
Major tributaries														
Anger	Flow	44	25	21	22	37	114	386	717	716	436	141	75	2734
	run-off	6	3	3	3	5	14	49	91	91	55	18	10	348
Beles	Flow	6	2	2	1	2	36	393	846	637	218	42	12	2197
	run-off	0.4	0.1	0.1	0	0.2	3	28	60	45	15	3	1	155.8
Besheilo	Flow	4	4	4	5	5	14	494	1303	527	74	19	9	2462
	run-off	0.3	0.3	0.3	0.4	0.4	1	37	98	40	6	1	0.6	185.3
Dabus	Flow	306	155	114	88	94	214	534	917	1336	1460	1070	602	6890
	run-off	15	7	5	4	5	10	25	44	64	69	51	29	328
Didessa	Flow	109	62	52	54	93	283	958	1782	1779	1084	352	186	6794
	run-off	6	3	3	3	5	14	49	91	91	55	18	10	348
Dinder	Flow	0	0	0	0	0	17	291	968	917	376	34	4	2607
	run-off	0	0	0	0	0	1	20	65	62	25	2	0.2	175.2
Finchaa	Flow	45	29	21	18	16	20	108	347	464	409	220	91	1788
	run-off	11	7	5	4	4	5	26	85	113	100	54	22	436
Guder	Flow	0	0	0	0	0	7	43	66	50	15	1	0	182
	run-off	0	0	0	0	0	1	6	9	7	2	0.1	0	25.1
Jemma	Flow	6	5	6	7	7	18	662	1748	707	100	25	11	3302
	run-off	0.4	0.3	0.4	0.4	0.5	1	42	111	45	6	2	0.7	209.7
Muger	Flow	1	1	1	2	2	6	268	753	312	44	10	4	1404
	run-off	0.1	0.1	0.1	0.2	0.2	0.7	33	92	38	5	1	0.5	170.9
N. Gojam	Flow	6	5	6	8	8	20	730	1927	779	110	27	13	3639
	run-off	0.4	0.4	0.4	0.5	0.5	1	51	134	54	8	2	1	253.2
Rahad	Flow	0	0	0	0	0	1	132	342	354	201	26	1	1057
	run-off	0	0	0	0	0	0.1	16	41	43	24	3	0.1	127.2
S. Gojam	Flow	7	6	7	9	9	24	855	2257	913	128	32	15	4262
	run-off	0.4	0.4	0.4	0.5	0.6	1.4	51	135	54	8	2	1	254.7
Welaka	Flow	2	2	2	3	3	7	261	689	279	39	10	5	1302
	run-off	0.3	0.3	0.4	0.4	0.4	1	41	107	44	6	2	0.7	203.5
Wombera	Flow	72	41	34	35	61	187	632	1176	1174	715	233	123	4483
	run-off	6	3	3	3	5	14	49	91	91	55	18	10	348

Source: BCEOM (1998), with slight modifications based on more recent feasibility studies of

ENTRO (2007)

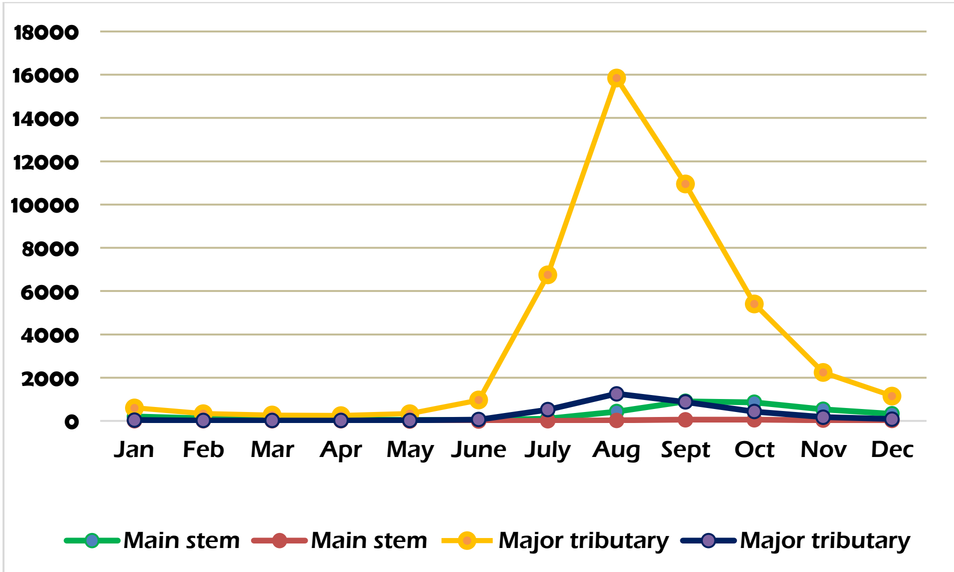


Figure 8 Seasonal flow of the Basin

ii. Ground Water resources

High temporal and spatial rainfall variability within the basin, when combined with the contrasting surface geology, accounts for large range and generally low rates of groundwater replenishment. Values derived from the handful of local field studies, used as independent checks, are within this range (0–200 mm yr^{-1}). At the African scale, based on a 50 x 50 km grid resolution, Döll and Fiedler (2008) determined recharge to range from 0 to 200 mm yr^{-1} across the Basin with similar magnitudes and patterns to those later reported by Bonsor et al. (2010). In several of the upper sub-catchments of the Abbay (Blue Nile, Ethiopia), recharge was estimated at less than 50 mm yr^{-1} in arid plains and up to 400 mm yr^{-1} in the highland areas of northwestern Ethiopia, using a conventional water balance approach and river discharge analysis, chloride mass balance, soil–water balance methods and river or channel flow losses (Ayenew et al., 2007).

3.1.6. Environmental flow Requirements of Abbay Basin Water Resources

Usually environmental flow requirements were determined based on the minimum flow rivers. Certain river basins leave 20-30 % of the river flow for ecological needs. If the water flow of the river is low and lack to reach the downstream ends the environmental flow requirement will grow from 50-60 % of the river discharge. McCartney *et al.* (2009) conducted a study to determine environmental flow requirements (both high and low flows) for the Blue Nile downstream of Chara Chara weir on Lake Tana. They estimate that an average annual allocation of 22 % of the mean annual flow (862Mm^3) is needed to maintain the basic ecological functioning in this reach, with an absolute minimum mean monthly allocation not less than approximately 10Mm^3. The Basin has many big rivers found in each of 16 sub Basins. The environmental flows requirements of at least major tributaries of Abbay River have to be determined using appropriate model by the proper professionals.

3.1.7. Drainage Networks

The whole area is intersected by streams, many of which are perennial though highly seasonal in their flow. The primary tributaries of the Abbay Basin are the Beshilo, Derame, Jema, Muger, Finchaa, Didessa and Dabus from the east and south; and the Suha, Chemoga, Keshem, Dera and Beles from the north. From which the main tributaries of the Abbay Dabus and Didessa Rivers accounts with 10% and 8.5% of the total flow at the border respectively.

Figure 9 Drainage networks of Abbay Basin

Table 2 Climatic Summary of the major sub-basins of the Abbay Basin.

S/N	Sub-basins	Catchment area (km^2)	Mean annual RF (mm)	Mean annual PET(mm)	Mean annual Run off (mm)	Mean annual Flow (Mm^3)	Coefficient of Run off
1	Anger	7,901	1,813	1,318	348	2,734	0.16
2	Beles	14,200	1,655	1,274	155.8	2,197	0.18
3	Beshilo	13,242	982	1,140	185.3	2,462	0.3
4	Dabus	21,030	1,112	2,276	328	6,890	0.13
5	Didessa	19,630	1,816	1,308	348	6,794	0.16
6	Dinder	14,891	N/A	N/A	0	0	N/A
7	Finchaa	4,089	1,766	1,290	436	1,788	0.25
8	Guder	7,011	910	1,307	25.1	182	0.34
9	Jemma	15,782	1,105	1,059	209.7	3,302	0.28
10	Muger	8,188	1,347	1,210	171	1,404	0.22
11	NGojam	14,389	1,336	1,242	253.2	3,639	0.23
12	Rahad	8,269	N/A	N/A	0	0	N/A
13	S Gojjam	16,762	1,633	1,183	254.7	4,262	0.18
14	Tana	15,054	1,313	1,136	244	3,776	0.19
15	Welaka	6,415	1,072	1,263	203.5	1,302	0.3
16	Wombera	12,957	1,660	N/A	348	4,483	0.18

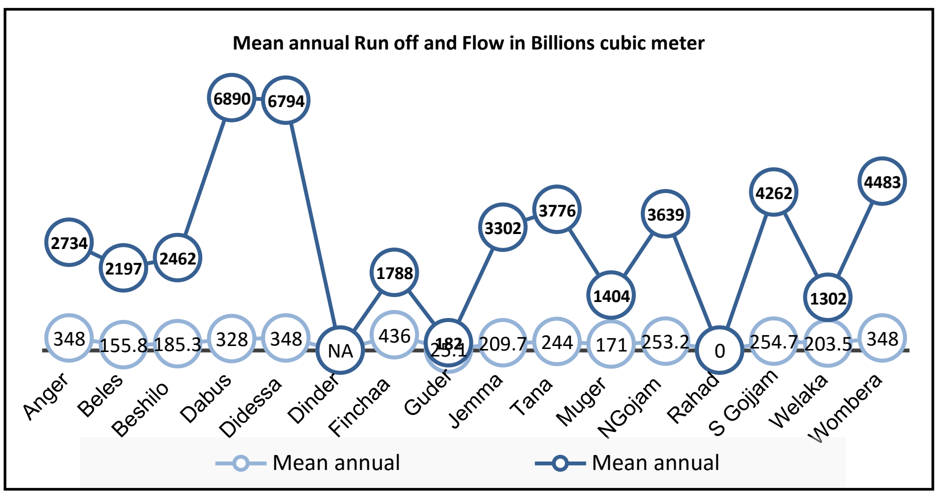


Figure 10 Abbay Basin Mean Annual Run Off and Flow in Billion Cubic Meter

Source: MoWR (1998) and Tesfahun et al. (2006).

6.3. Agro-Ecological Zones of the Basin

The agro-ecology of the basin is divided into three major climatic zones, cold to very cold, tepid to cold, and hot to warm, and further divided into moist, sub moist, humid and sub humid. The agro-climatic zones of the basin are considered based on the topographic nature that ranging from about 475masl to the highest elevation about 4261 amsl. There are five traditional agro ecological zones as described in the table below.

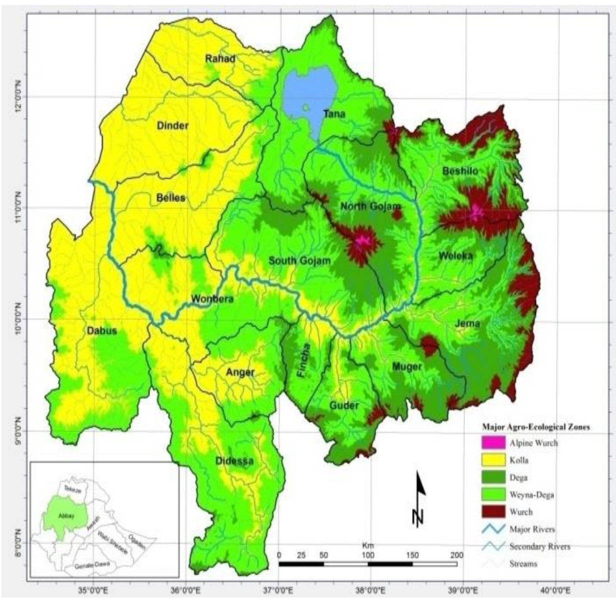


Figure 12 Traditional agro-ecological zone in the Abbay Basin

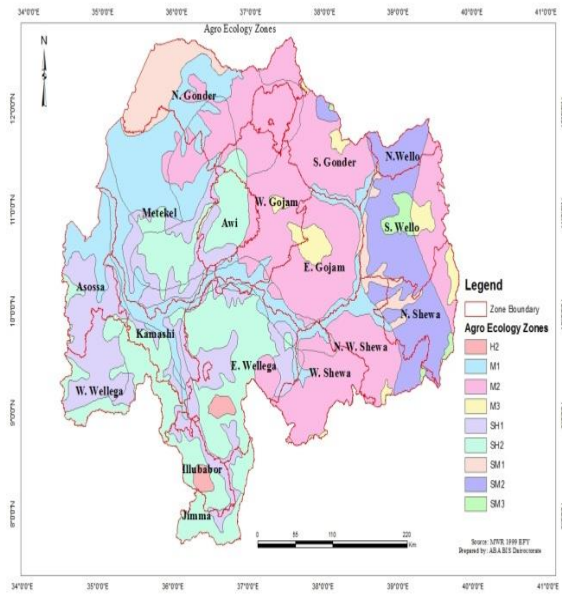


Figure 11 Major agro-ecological zone in the Abbay Basin

Table 3 Major Agro-Ecology of the Abbay Basin

Elevation in meters	Traditional AEZ	Proportion in %
< 1500	Kolla	37.3
1500 - 2300	Weyna-Dega	40.1
2300-3200	Dega	17.3
3200- 3700	Wurch	5.1
>3700	Alpine Wurch	0.2
Total		100

H2: Tepid to cool humid mid to high altitude
M1: Hot to worm moist low lands and high lands
M2: Tepid to cool moist mid to high altitude
M3: Cold to Very cold moist sub-afro alpine to afro alpine
SH1: Hot to worm Sub humid low land to the mid altitude
SH2: Tepid to cool Sub-humid low to high altitude
SM1: Hot to Worm sub moist lowlands and plateau ruminants
SM2: Tepid to cool Sub moist low to high altitude.
SM3: Cold to very cold Sub moist sub afro alpine to afro alpine

6.4. Land use/land cover

The land cover for the basin is mainly characterized by dominantly cultivated, in the eastern part, and grass land, wood lands, and forest to the western part according to the Ministry of Water Resources (Ethiopia) land cover classification.

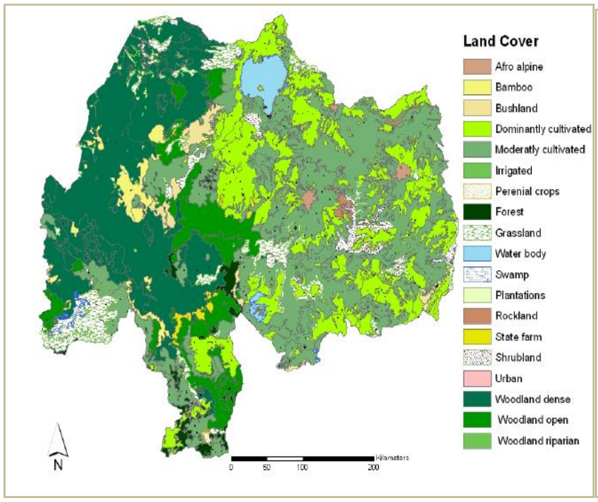


Figure 13 Land Cover of Abbay Basin

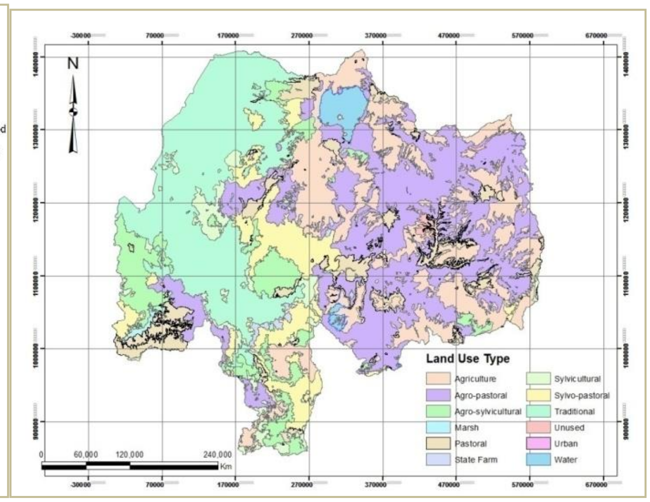


Figure 14 Land Use type of Abbay Basin

Table 4 Land Cover of Abbay Basin

Land	Amhara	Oromia	Beni-Gumuz	Total km^2	Total %
Use Category					
Cultivated	42,736	22,349	2,805	67,890	34%
Tree Crops	-	260	-	260	0%
Plantation	301	228	8	537	0%
Afro-alpine	927	174	2	1,103	1%
Disturbed forest	65	2,128	83	2,276	1%
Bamboo	918	872	5,536	7,326	4%
Woodland, bushland& shrub land	20,598	16,549	23,291	60,438	30%
Grassland	17,797	15,387	12,959	46,143	23%
Wetland	1,110	1,274	-	2,384	1%
Water body	3,045	370	-	3,415	2%
Rock	5,085	2,833	14	7,932	4%
Urban areas	58	50	-	108	0%
Total	92,640	62,474	44,698	199,812	100%

Table 5 Land Use type of Abbay Basin

Land Use type	Use in Hectare
Agricultural(A)	3987834.06
Agro-past(AP)	5561400.55
Agro-sylvic(AS)	1559728.84
State Farm(SF)	96832.99
Pastoral(P)	1458909.63
Sylvo-past.(SP)	1741791.59
Sylvi-cultural(S)	729763.19
Traditional(T)	4349205.46
Water(W)	46119.38
Marsh(M)	64829.28
Un useable(N)	70083.48
Urban(U)	10410.57
Lake tana	304162.64
Total	**19,981,071.66**

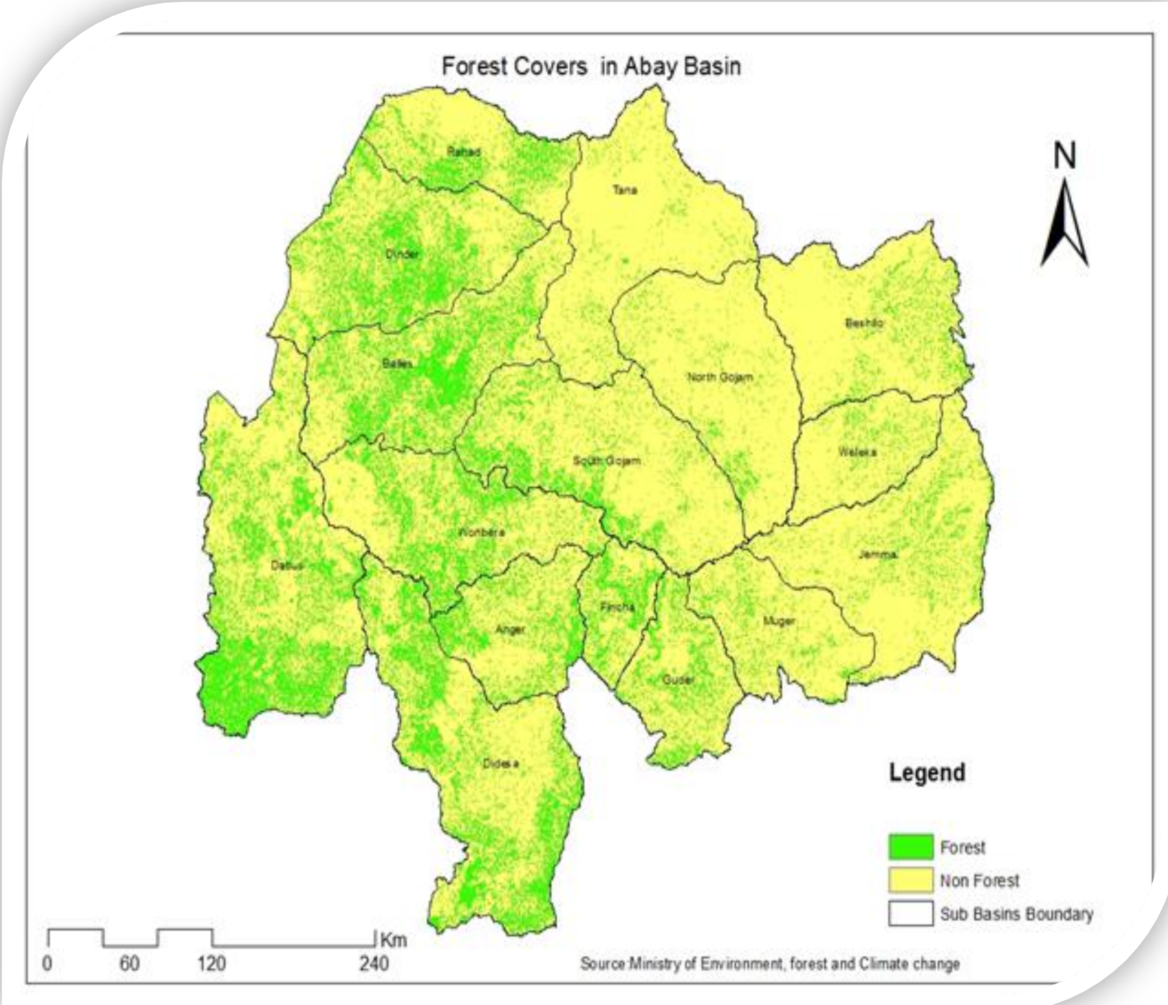


Figure 15 Forest Cover of Abbay Basin

Different Land Use/Cover Types in Brief

Cultivation**:** (67,890km^2; 34% of basin; 46 % of Amhara Region; 36% of Oromiya Region and 6% of Benishangul-Gumuz Region). Cultivation is mainly carried out in the highland areas on the large areas of favourable agricultural soils occurring as Luvisols, Cambisols and Vertisols. These areas are intensively cultivated and a variety of annual crops are grown including: wheat, barley, sorghum, *teff*, maize, finger millet, oil seeds, chick peas and beans. Due to the intensity of cultivation and lack of basic soil conservation practices, these areas are rapidly degrading from accelerated soil erosion. Amhara being the most densely populated region has the highest proportion of cultivation area (46%), with only 6% for Benishangul-Gumuz, the least populated region, where Nitosols are mainly cultivated. Consequently soil erosion is also greatest from the Amhara region and this is directly linked to the higher cropping and cultivation intensity within this region.

Tree Crops**:** (260 km^2; < 1% of basin). Coffee production in Jimma, Illubabor and some parts of Welega in Oromiya; Mango tree in Benshangul -Gumuze region is the only occurrence of this land use classification. As these are perennial crops which are mainly grown under a tree canopy, these areas are relatively stable.

Plantations (537 km^2; <1% of the basin): This mainly includes *Eucalyptus* spp. together with *Cupressus lusitanica* which have been planted for wood and fuel wood. Many of these are small plantations located around villages or are specialised areas set aside for reafforestation.

Afro-alpine vegetation (1,103 km^2; 1 % of the basin; Amhara 1 %). This includes areas above 3,200 masl such as Mt Guna and Mt Choke. These areas are characteristically almost devoid of any forest and this is replaced by moist moorland. At its lower extremity the afro-alpine vegetation consists of shrubs, sedges, short woody bushes and occasional trees. Cultivation may now extend up to 3,000 masl on many of these areas, which is now posing a threat to the stability of these extremely fragile areas. Other areas of afro-alpine vegetation occur in limited areas in Oromiya, while 2 km^2 has been reported for Benishangul- Gumuz Region.

Disturbed Forest(2,276 km^2; 1 % of basin). No areas of undisturbed forest remains anywhere within the Abbay basin. These have all been altered by some form of clearing or tree removal to create disturbed forest areas. 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 seriously disturbed environment. The greatest conversion has occurred in the Amhara and then in the Oromiya Region where areas of forest have been cleared for coffee planting. Disturbed forest areas remain at; Gera, Setema, Jimma, Komto, Chato and Guangua. All of these areas have been classified as National Priority Forest Areas (NPFA’s). Original tree cover within these areas included the two prevalent coniferous species of Ethiopia

Podocarpus falcatus and *Juniperus procera* which are altitude related. These forest areas provide important bird and animal habitats, however due to timber felling and intrusion by agricultural activities these areas are rapidly dwindling which will have serious concerns for wildlife and biodiversity conservation.

Bamboo (7,326 km^2; 4 % of basin; 1 % of Amhara and Oromiya areas; 12 % of Benishangul-Gumuz Region). Extensive stands of *Oxytenanthera abyssinica* and occasionally *O. borzii*, occur in the lower areas of the western part of the basin. Bamboo within these stands is maintained as a near dominant mono-species population by repeated burning which has produced a mosaic of thick bamboo stands interspersed with grasslands and fire resistant trees such as Camel foot (*Piliostigma thonningii*), *Terminalia schimperiana, Syzygiumma crocarpa, Trema orientalis, Combretum* spp. *Acacia siberiana, Maythenus addat* and *Stereospermum kunthianum*, which are also common to the following woodland category. The major bamboo zones are; Asosa, Kamashi and Pawe.

Woodland, Bushland and Shrubland (60,438 km^2; 30 % of basin; 22 % Amhara; 26 % Oromiya and 52 % of the Benishangul-Gumuz Regions). These areas occur mainly in the lower western slopes of the basin and are normally always associated with a grass understory or grassed areas between areas of low woody vegetation. These areas support pastoralism, while a major traditional economic activity has been the collection of *Gumarabic* and *frankincense*. Both Guba and Asosa are noted centers for the supply of aromatic gums to wider markets within Ethiopia and elsewhere. *Gumarabic* is also collected within the basin from; Mankush, Bambudi, Almahal, Gizen, Kurmuk, AmuruGarte, Delias and Ginde Beret.

The Grasslands: (46,143 km^2; 23 % of basin; 19 % of Amhara; 25 % of Oromiya and 29 % of Benishangul-Gumuz Regions). Two types of grassland occur within the basin; lowland tall grasslands and highland temperate grasslands.

Lowland Tall Grasslands: occur in low rainfall areas and are dominantly grassland interspersed with a few trees, shrubs, and other woody vegetation. The main grasses that occur within these areas are *Hyparrhenia* spp. *Digitaria spp*. and *Panicum spp* often in association with *Acacia* shrub lands. These grasses often occur together with gourds, wild squashes and *Acanathaceae* and *Convolvulacea*. Grasslands mainly occupy the lower humid valleys of the Beles, Anger and Didessa valleys where they are maintained as a fire deflected succession by repeated burning.

Highland Temperate Grasslands: occur above 2,000 masl and include palatable grass species such as *Pennisetum,Andropogon, Eragrostis* and *Cynadon.* Better areas may be interspersed with clovers such as *Trifolium* spp. (low grazing pressure) while herbs consisting of *Haplocarpha schimperi,* chickweed (*Cerastium*s pp.) and sedges (*Cupressus* spp.) occur in wetter areas. Due to an increasing shortage of grazing areas, especially in the Amhara Region many of these areas are intensively grazed, by cattle, sheep and goats. Consequently many of these areas are now suffering from overgrazing, loss of fertility from gathering of cattle dung for fuel. These areas are now actively degrading.

Wetland areas (2,384 km^2; 1 % of basin; 1 % Amhara; 2 % Oromia). These areas can be either permanent swamps such as the Dabus swamp or, else they may seasonally recede as around Lake Tana. This gives rise to recessional agricultural use during the dry season where plantings follow the water level down as the lake level drops.

Water Bodies (3,415 km^2, 2 % of basin; 3 % of Amhara; 1 % Oromia);these areas include inland lakes and waterways. Lake Tana at 3,042 km^2 is the largest inland lake in Ethiopia and is an important regulating feature for the Abbay River. It is also an important fishery resource and wildlife area with regard to its aquatic and wetland habitats. Other important water bodies are the Dabus, Finchaa and Chomen swamps. These areas are much shallower and have greater affinity as swamp and wetland areas rather than lacustrine environments. Other small lakes occur throughout the basin as crater lakes within extinct volcanoes, e.g. Lakes Zengena and Dendi.

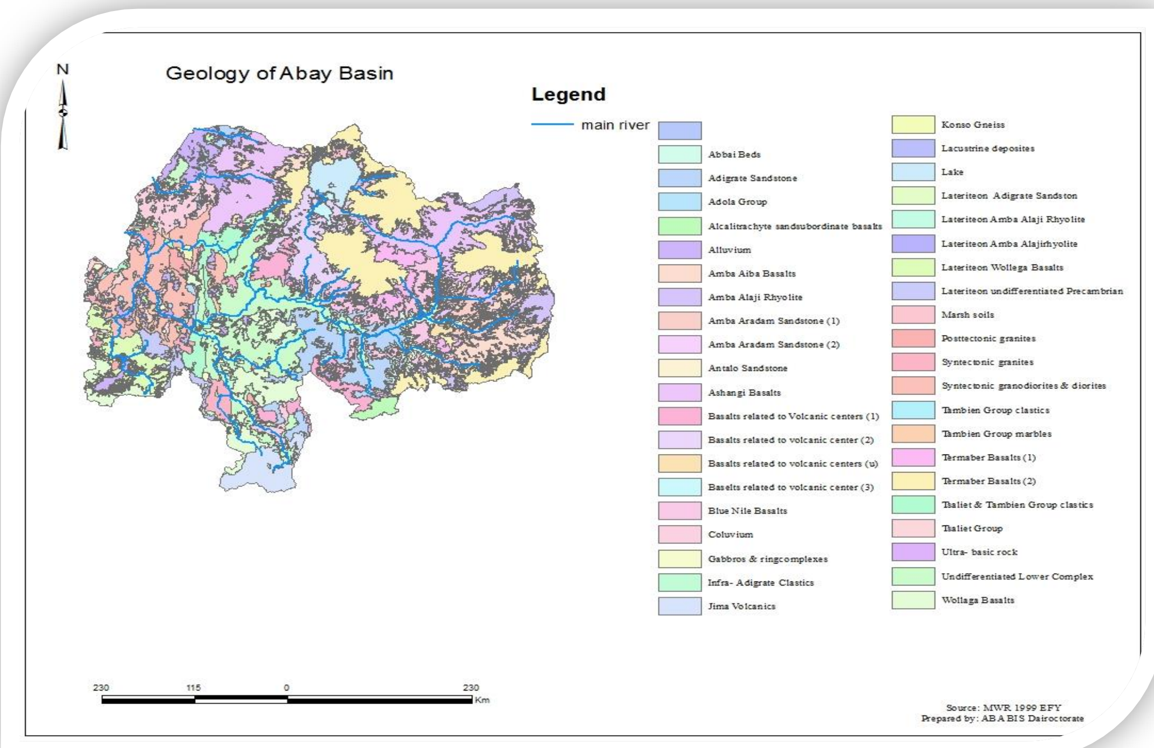
Rock (7,932 km^2; 4 % of basin; 5 % of Amhara; 5 % of Oromia);this is mostly accounted for by large areas of exposed rock on ridges, escarpment sides and valley bottoms e.g. the Abbay gorge. Other areas occur as exposed rocky ridges in hilly areas to the west of Gondar. There is very little of this unit in Benishangul-Gumuz as the area is mainly composed of lowlands with few steep rocky areas.

Urban Areas (108 km^2; < 1 % of basin). This is accounted for by land take required for towns e.g. Gondar, Bahir Dar, Nekemte, etc.

6.5. Geology

The geology of the basin is mainly volcanic rocks and Precambrian basement rocks with small areas of sedimentary rock (Conway, 2000). The Highlands of the basin are composed of basic rocks, mainly basalts(Tarmaber basalt, followed by Ashange basalt, and Amba Aiba basalt), while the lowlands are mainly composed of Basement Complex rocks as well as metamorphic rocks, such as gneisses and marble. Where the Abay has cut through the basalts there are restricted areas of lime stones and then sandstones before the Basement Complex is reached (Awulachew, S. B et al., 2008).

Figure 16 Geological map of Abbay Basin



6.6. Soil

The major soils of the basin are Leptosols, Alisols, Nitisols, Vertisols, Cambisols, and Luvisols, in order of decreasing areal coverage (BCEOM, 1998b). Leptosols (22%) represent the most widely occurring soils within the basin, mostly along the course of the Blue Nile/Abbay River and its main tributaries. They are shallow soils with limited profile development and are usually prone to drought. Alisols (21%) are the second most important soils in terms of area coverage. These soils are reddish brown in colour and have deep profiles (>100 cm). Alisols are mainly derived from basalts, granites and granodiorites and possess favourable drainage, structure and workability. Nitisols(16%) are the third most important soil group within the basin in terms of area. Nitisols are derived from basalts/tuffs and granites/associated felsic materials. On the flat plateaus in the Ethiopian Highlands are extensive areas of Vertisols (15%). These soils are reddish brown in colour, clay to clay loam in texture, well drained and very deep (>200 cm).

Table 7 Major Soils Located in the Abbay Basin

Major Soil Type	Percent of Area
Leptosols	21.46
Alisols	20.71
Nitisols	15.9
Vertisols	15.18
Cambisols	9.46
Luvisols	9.05
Acrisols	4.46
Regosols	0.71
Arenosols	0.66
Fluvisols	0.31
Phaeozems	0.05
Total	97.95
Miscellaneous Units	
Marshes	0.39
Urban Areas	0.03
Water Body	1.62
Total	2.04
Grand Total	99.99

Corresponding to the variation in landscape and other soil forming factors such as climate and vegetation, the soils of the basin are also highly variable. However, only four soil types, Leptosols (22%), Alisols (21%), Nitisols (16%) and Vertisols (15%). cover over 74% of the area.

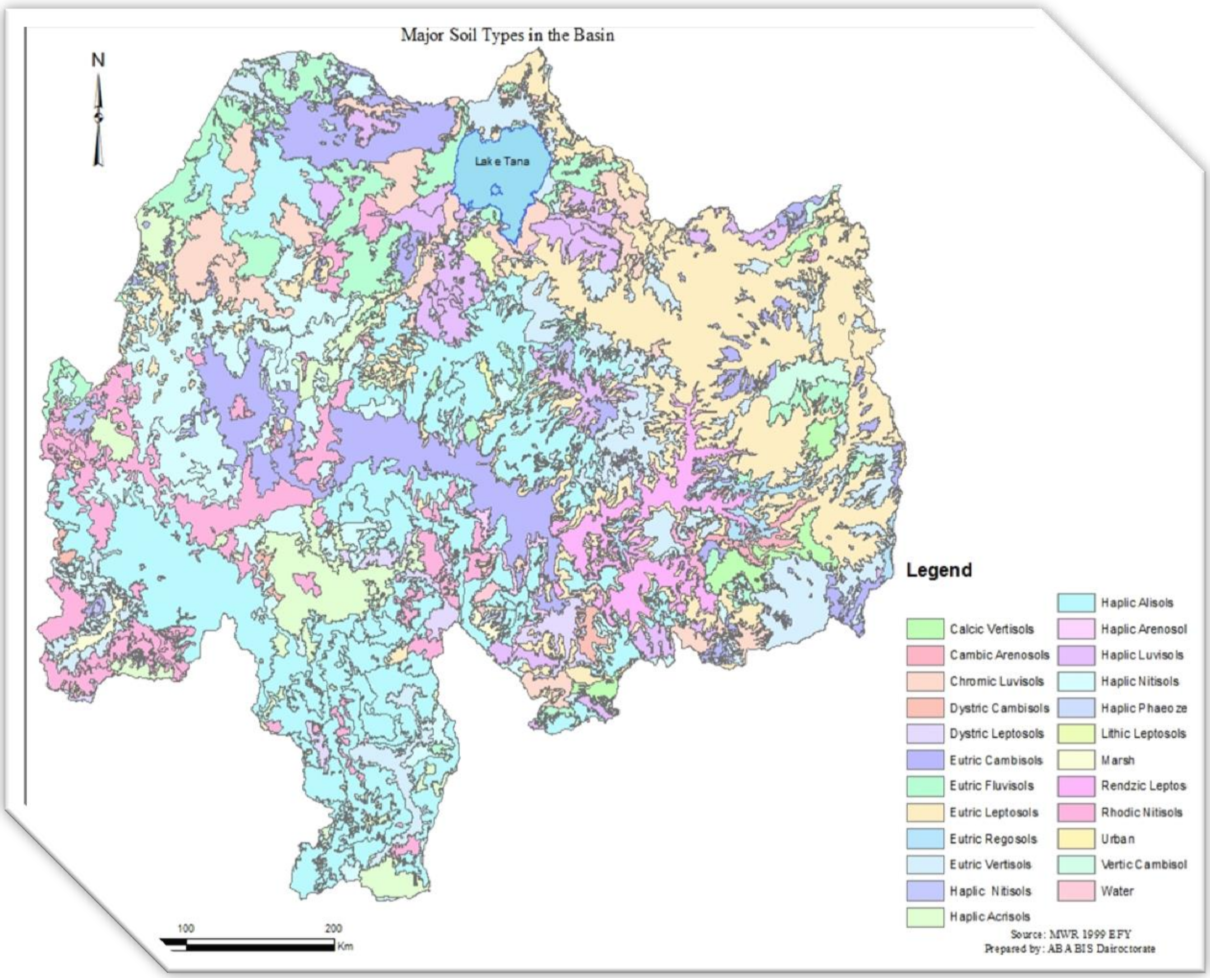


Figure 17 Major Soil Types in the Abbay Basin

4. BIODIVERSITY RESOURCE OF ABBAY BASIN

6.7. 4.1. Ecosystem Biodiversity

The status of biodiversity in an area may be most accurately conveyed through an examination of its constituent parts and the critical habitats upon which they depend. This section examines those parts and presents the status of aquatic, floral, faunal, and genetic biodiversity as well as the status of forests and protected areas, (Ethiopia's National Biodiversity Strategy and Action Plan 2015-2020).

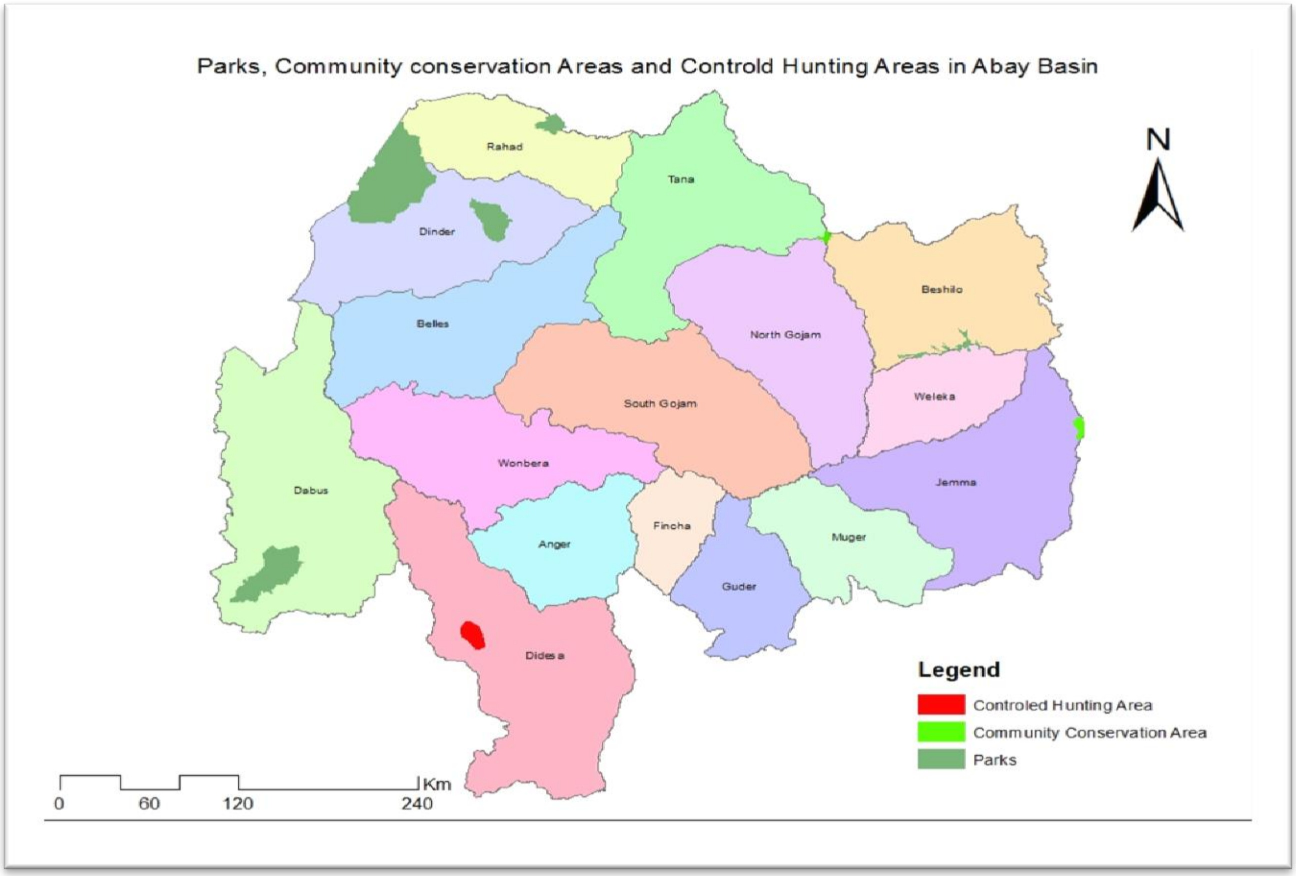


Figure 18 Parks, Conservation Areas and controlled Hunting Areas in Abbay Basin

4.1.1. Floral Biodiversity

Attempts to identify or classify ecosystems of Ethiopia have been limited or nonexistent thus far (IBC 2005). Vegetation types in the country are being considered as ecosystems. According to Friis et al. (2010) four types of vegetation can be identified in the basin: (1) Combretum-Terminalia broad-leaved deciduous woodland (e.g. *Boswellia papyrifera* and *Anogeissus leiocarpa*), (2) Dry evergreen Afromontane forest (e.g. *Juniperus procera* and *Olea europaea*), (3) Moist evergreen Afromontane forest (e.g. *Euphorbia amliphylla*), and (4) Afroalpine vegetation (e.g. *Lobelia rhynchopetalum* and *Erica arbora*). Based on these classification methods the Abbay basin ecosystem is illustrated as follows.

i. *Afroalpine and sub-Afroalpine*

The areas by average higher than 3,200 meters above sea level are generally referred to as the Afroalpine and sub-Afroalpine. The lower limit of the Afroalpine belt falls at about 3,500 meters, while the upper limit of vascular plants lies around 5,000 meters and sub-Afroalpine areas ranges between 3,200 and 3,500 meters. These areas include chains of mountains, mountain slopes, and tops of the highest mountains of the basin. The highest peak in Abbay Basin is Mount Guna, where an alpine climate near 0°C persists year-round, sometimes with a snow cover atsome wet months. The basin also include mountain slopes suchas Menz-Guassa, Choke, and Abune Yosef.

ii. Dry Evergreen Montane Forest and Grass land Complex Ecosystem

Dry Evergreen Montane Forest and Evergreen Scrub Ecosystem is situated between altitudinal ranges of 1,500 and 3,200 masl.The Ethiopian highlands contribute to more than 50 percent of the land area with Afromontane vegetation, of which dry montane forests form the largest part. The evergreen scrubland vegetation occurs in the highlands of Ethiopia either as an intact scrub (i.e., in association with the dry evergreen montane forest) or usually as secondary growth after deforestation of the dry evergreen montane forest. The dry evergreen montane forest and evergreen scrubland vegetations are the characteristic vegetation types of this ecosystem (Ethiopia Biodiversity and Tropical Forests, 2008).

iii. Moist Ever Green Montane Forest Ecosystem

The montane moist forest ecosystem comprises high forests of the country—mainly the southwestern forests—which are the wettest, and also the humid forest on the southeastern plateau known as the Harenna forest. The montane moist forest ecosystem is distinguished by supporting luxuriant growing epiphytes *Canarina*, orchids, *Scadoxus* and fern plants such as *Platycerium* and *Drynaria*. Mosses also occur in the wettest portions of forests, associated to major branches and barks of trees (Ethiopia Biodiversity and Tropical Forests, 2008).

iv. Combretum-Terminalia Woodland Ecosystem

This ecosystem is characterized by *Combretum spp., Terminalia spp., Oxytenanthera abyssinica, Boswellia papyrifera, Anogeissus lieocarpa, Sterospermem kuntianum, Pterocarpus lucens, Lonchocarpus laxiflorus, Lannea spp. Albizia malacophylla,* and *Enatada africana.* These are small trees with fairly large deciduous leaves, which often occur with the lowland bamboo, *Oxytenanthera abyssinica.* The understory is a combination of herbs and grasses. The herbs include *Justecia spp., Barleria spp., Eulophia, chlorophytum, Hossolunda opposita* and *Ledeburia spp.* The grasses include *Cymbopogon, Hyparrhenia, Echinochla, Sorghum, Pennisetum,* and others.The herbs usually dominate the ground layer at the beginning of the rainy season, while grasses dominate toward the end of the rainy season.(Ethiopia Biodiversity and Tropical Forests, 2008).

To address the threats, different efforts including plantation, implementation of PFM, awareness raising, demarcation and designation of protected areas such as Alatish, Anbessa Chaka is being made in this ecosystem.

v. Wetland Ecosystem

Ethiopia possesses a great diversity of wetland ecosystems (swamps, marshes, flood plains, natural or artificial ponds, high mountain lakes, and micro-dams) as a result of the formation of a diverse landscape subjected to various tectonic movements, a continuous process of erosion, and human activities. The different geological formation and climatic conditions have endowed Ethiopia with a vast group of water resources and wetland ecosystems, including 12 river basins, 8 major lakes, and many swamps, floodplains, and man-made reservoirs, with a total annual surface runoff of about 110 billion cubic meters (Ethiopia Biodiversity and Tropical Forests 2008).This ecosystem is serving as feeding, breeding and brooding sites for a large number of resident and migrant birds.

The Fogera and Chefa wetlands in Amhara region are, for example, highly affected by excessive use of swamps and flood plains for cultivation of rice and other horticultural crops. Efforts are being made in some regions such as Oromia, and Amhara to tackle these threats. To manage Wichi wetland found in Illuababor zone(Oromia region), for example, integrated watershed management, livelihood improvement, and family planning with the community are being conducted.

vi. Aquatic Ecosystem

The basin aquatic ecosystem includes rivers, reservoirs and lakes. This ecosystem harbours various species of mammals, birds, reptiles, amphibians, fishes and invertebrates. Several species of planktonic and benthic fauna have been reported from different rivers, lakes and reservoirs. Moreover, many important microorganisms such as bacteria, fungi, algae and protozoa exist in aquatic ecosystems of the basin. These aquatic habitats are also serving as feeding, breeding and brooding sites for a large number of resident and migrant birds, especially Lesser Flamingo(*Phoenicopterus minor*), Greater Flamingo (*Phoenicopterus roseus*), Duck and Pelican species.

4.1.2. 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 the presence of 36 fish species in the basin. Among the 36 fish species found in the basin 23 of them are endemic. Most of the endemic species are found exclusively in Lake Tana.

Surveys conducted in research centers indicated that a total of 29 fish species important for food has been known to present in all studied rivers (Abay, Anger, Beles, Dabus, and Dedessa). These species are grouped in to 11 families. The dominant family in these river systems is Cyprinidae with a diversity of 9 species of fish followed by Mormyridae with 5 fish species. Characidae and Distichodontida each had three species and Claridae have two species. But the family Bagridae, centropomidae, cichlidae, Malapteruidae, Mochkidae and tetraodontide are each represented only by a single species in the survey (Belay Abdissa and AlayuYalew, 2010).

Table 8: Fish Identified within Abbay and Tributary Rivers

Family Species	Abbay river	Tributary river
Mormyridae Hyperopisusbebe Mormyropsspp Mormyrus hasselquistii Mormyrus spp.	X X X X	
Characidae Micralestes spp.	X	
Bagridae Bagrus spp.	X	
Schilbeidae Schilbespp	X	
Mochovidaechiloglanis Synodontisspp	X	X
Cyprinidae Barbuspaludinosus Barbustrispilopeura Barbusintermedius Barbusspp Chelaethiopsbibie Garra spp. Labeocoubie Labeo spp. Leptocypris spp. Raiamas spp. Varicorhinusbeso	 X X X X X X X	 X X X X X X X
Cichlidaeoreochromisniloticus Cichlidae gen spp	X	X
Malapterurus Electricus Eutropiusniloticus Heterobranchus spp	X X X	

Table 9 Fish Species Composition of Some Natural and Manmade Water Bodies of the Amhara Region

Water body	No of spp	No 0f endemic spp	No of exotic spp
Abbay River	26		1
L.Tana	29	20	
L.Zengena	3		2
L.Tirba	2		2
Geray reservoir	5		3
Angereb	1		
Zana	1		
Bahirgiorgis	2		2

Source: Amhara agricultural Research Institute, Fish Research center

Table 10: Spatial Distribution of Fish Species in Benishangul -Gumuz Region

	Major Rivers						
Family	**Abay**	**anger**	**Beles**	**dabus**	**Dedessa**	**Species occurrence**	**number of species**
Bagridae	1	1	1			3	1
Centropomidae	1		1			2	1
Channidae	1	1	0			2	1
Characidae	2	2	2		1	4	3
Cichlidae	1	1	1	1	1	5	1
Clariidae	2	1	1	1		4	2
Cyprindae	5	4	3	1	3	5	9
Distichodontida	2	1	0			2	3
Malapteruridae	1		1			2	1
Mochokidae	1		1			3	1
Mormyridae	5	1	1		1	4	5
Tetraodontidae	1				0	1	1
Total	**23**	**13**	**12**	**3**	**6**		**29**

Source: Fish Resource Survey in Benishangul-GumuzRegional State, July 201

Table 11: Fish species in Major rivers and Lakes of Abay Basin in Oromia Region

	Zone in Oromia region	Major water bodies in Abay basin	Existing Fish species	Note
	North Showa	Jama river	Nile Tilapia (Oreochromisniloticus)	indigenous
			Common Carp (Cyprinuscarpio)	Introduced to Ethiopia in 1936
			Barbus (Labeobarbusintermidus)	Indigenous
	West Shoa	Muger river	Nile Tilapia (Oreochromisniloticus)	Indigenous
			Barbus (Labeobarbusintermidus)	
			Common Carp (Cyprinuscarpio)	??
		Guder river	Nile Tilapia (Oreochromisniloticus)	Indigenous
			Common Carp (Cyprinuscarpio)	Introduced to Ethiopia in 1936
			Barbus (Labeobarbusintermidus)	
	HoroGudur uWollega	Fincha, Amerti and Neshe Reservoirs	Common Carp	Introduced
			Nile Tilapia (Oreochromisniloticus)	Indigenous
			Tilapia Zilli	Introduced

Source: Information generated by Zeway Fisheries Research.

4.1.3. Animal Biodiversity/Fauna

i. Farm Animal Genetic Resources

According CSA, 2015 the population of animals found in the basin, are about (71.48 million heads) cattle 29 million, sheep 10million, goat 8million, horse more than half million, mule 0.15million, donkey 2.5million, poultry 19 million and beehive 2.33million. constitute the bulk of the livestock sector. Livestock in the Abbay basin could be classified into extensive, semi-intensive, and intensive systems depending on types of animals reared and whether for subsistence, traction or market. The most common farm animals of the basin are categorized into mammals, avian and honeybees. Cattle, sheep, goats, camels, donkeys, horses and mules are the major farm animals that lie under the mammalian category. Under the avian category are chicken, ostrich and turkey. However, the latter two avian species are not widely used in the country.

Out of the exotics, Holstein-Friesians and Jersey cattle, and their crosses with different indigenous breeds are the majority (IBC, 2012c). Crossbreeds used under medium input production system are those produced from crossings between exotic sires and five indigenous dam breeds, namely: Borena, Horro, Fogera, Arsi and Begait. Similarly there are several exotic poultry breeds and their crosses in the country. Thus; several layer, broiler and dual-purpose exotic chicken breeds and hybrids are being used by small and large-scale commercial producers in urban and peri-urban areas. In addition, some of their crosses with indigenous chicken are used by rural smallholders for egg and meat production.

4.2. Status and Trends

Increase in population size doesn't necessarily show the status of the domestic animal diversity in the country, given that the majority of the livestock populations are indigenous breeds, it appears that the resource is thriving well (CSA, 2014b). Identification and characterization activities conducted on livestock resources of Abbay basin are not exhaustive. As a result, there is no complete and up-to-date breed level data for most of the breeds, and this makes determination of the status and trends difficult. There are, however, some indigenous breeds which are known to be found at different threat levels. Sheko (the only taurine breed in East Africa) and Fogera cattle appear to be highly threatened as a result of interbreeding with other local breeds and changes in the production systems. In addition, Begait, Irob, Ogaden, Afar and Borena cattle breeds; Sinnar donkey, and Menz and Gumuz sheep breeds are also facing various degrees of threats.

In the basin, major causes of threat to the farm animal genetic resources are feed shortage, overgrazing, encroachment by invasive species and expansion of crop cultivation into both grazing lands in the highlands and marginal areas in the lowlands. Additional threats emanate from crossbreeding, interbreeding, diseases and parasites, shortage of quality drinking water and poor housing. Particularly, the gene pool of indigenous chicken breeds is under pressure from replacement by pure exotics and their hybrids (IBC, 2012c, and d).

ii. Wild Animal Genetic Resources

Ethiopia encompasses a broad range of ecosystems with great varieties of habitats contributing to the occurrence of high faunal diversity. Data and information on the diversity of wild fauna as a whole is not yet complete. According to the existing data, the Ethiopian wild fauna is comprised of 284 mammal, 861 bird, 201 reptile, 200 fish, 63amphibian and

1,225 arthropod (out of which 324 butterfly) species. Of these faunal resources, 29 mammal, 18 bird, 10 reptile, 40 fish, 25 amphibians and seven arthropods species are endemic to the country (USAID, 2008; IBC, 2009; Redeat Habteselassie, 2012). The variety of species and great proportion of endemicity within the group, especially in the highlands is the result of the isolation of the highland areas of the country from other highlands within and outside the country by the surrounding lowlands (IBC, 2005).McKee (2007) described a number of charismatic flagship species of mammals in Ethiopia, as well as in the basin most notably the Gelada (an endemic genus and the world's only grazing primate), the Ethiopian Wolf. There are also remnant populations of Elephant (an estimated 850, including 150 of *Loxodonta africana orleansi*), Lions (an estimated 1,000) and large ungulates. Spotted hyenas are abundant. There is at least one or two isolated populations of black rhino (IUCN, 2007 cited in USAID, 2008), but it is widely believed that this species might have gone extinct.

Information on the status and trends of wild fauna as whole is limited. According to the International Union for the Conservation of Nature's (IUCN, 2008) red list, Ethiopia has five critically endangered, 27 endangered, and 47 vulnerable species of wild animals. Of the total 284 mammalian species, those that require urgent conservation action include Walia Ibex (*Capra walie*), Gelada Baboon (*Theropithecus gelada*), Mountain Nyala (*Tragelaphus buxtoni*), Ethiopian Wolf (*Canis simensis*) and Starck's Hare (*Lepus starcki).* Some of these endangered species have very restricted distribution which is the most endangered mammalian species in the world (IBC, 2005, 2009). All wild mammals which occur in the basin and rated as critically endangered (CR), endangered (EN) or vulnerable (VU) in the 2004 IUCN Red List of threatened animals.

All the important ecosystems in the country are not represented in the existing PAs. This is a major drawback for conservation of threatened endemic and unique species. Even the areas dedicated for wildlife protection are faced with many problems such as limited institutional, legal and financial capacities; population growth, deforestation, invasive species and open access to resources, conversion of natural habitat to agricultural lands and overgrazing by large livestock population (USAID/Africa, 2008; EWCA, 2009).

6.8. 4.3. Values of Biodiversity and Ecosystem Services in the Basin

Ecosystems and the biological diversity contained within them provide provisioning(food fresh water, fuel wood, fiber, bio-chemicals, and genetic resources), supporting(soil formation, nutrient cycling, primary production), regulating (climate regulation, disease regulation, water regulation, purification and pollination) and cultural (spiritual, religious, recreation, eco-tourism, esthetic, inspirational, educational, and cultural heritage) services that are essential to the economic prosperity and other aspects of human welfare. However, data and information on the monetary values of biodiversity and ecosystem services are scanty in the basin. Therefore, information provided in this chapter on values of ecosystem services and biodiversity of the basin is very limited.

4.3.1. Values of Agricultural Diversity

I. Crop Genetic Resources

Crops have vital roles in agricultural production as a driver for economic growth and food security. Five major cereals (teff, wheat, maize, sorghum and barley) contribute 29% to the agricultural GDP, 14% to the total GDP and 64% to the calories consumed(ESSP, 2011). Pulses contribute 9.3% to the total grain production and are sources of income for smallholder farmers, as a higher-value crop than cereals and as a low-cost source of protein that accounts for approximately 15% of protein intake. Pulses have significant role in Ethiopia's economy generating an export earning of USD 129 million per annum (MoFED, 2010). Earnings from coffee contribute 4-5% to the GDP, about 20%to the government revenue and 60% to the total foreign exchange. The highlands of the basin are the major producers of these cereals, pulses and coffee and the lowlands are also the major gum production contributors of the country.

II. Farm Animal Genetic Resources

Livestock play important roles in providing food, household income, draught, farmyard manure and fuel, ecological and social functions. In addition, livestock serve as sources of commodities for export such as live animals, meat and meat products, hides and skins, and honey and bees wax to earn foreign exchange. About 80% of Ethiopian farmers use animal traction to plough their fields. According to MoFED (2009), the contribution of livestock to the GDP, excluding ploughing services is 25%. If the value of their ploughing services is included, however, their contribution to the GDP will rise up to 45% (IGAD, 2011), increasing the overall role of agriculture to the national GDP. Livestock have also socio-economic values indifferent cultures serving as insurance to mitigate risks and as indicators of social status. In the last two decades, hides and skins provided on average 90% of official livestock sector exports, whereas live animals and meat provided 6% and 4%, respectively. At present, the total value of livestock and their products stands at about 20% of all national exports (IGAD, 2011, IBC 2012c).

III. Forest and its Ecosystem Services

Forest resources have been contributing to economic, ecological and social benefits at national and local levels. Their biodiversity play vital and diverse roles to ensure food security, and sustainable livelihoods for millions of households throughout. Forests contribute an estimated 4% to GDP through the production of honey, forest coffee, and timber. Recent estimates indicate that about 26-30% of the total coffee production of the country originates from wild and semi-managed coffee forests.

Ecosystem services provided by the forest biodiversity include provisioning, regulating, supporting and cultural services. Other NTFPs such as forages from forest largely serve as the feed sources of livestock in the country. Fodder driving from forests provides 10% and 60% of the livestock feed in the wet and dry season, respectively. Similarly, many edible wild plants have supplementary, seasonal and the only source of food for a significant number of rural populations during times of critical food shortage. In Benshangul Gumuz region, for example, edible wild plants contribute 30 to 40% to food security in normal and at times of food shortage.

IV. Microbial Genetic Resources

Microbes have both direct and indirect economic values. However, data on values of microbial genetic resources in Ethiopia is limited. Microbes play pivotal roles in preparation of traditional foods and local drinks both in the rural and urban areas of the country. Traditional foods such as Injera, Kocho, Bulla and Cheese, and local drinks such as Tella, Tej, Borde, Cheka and Areke are the means of livelihood and sources of income for millions of rural and urban communities of the country. In many part of the country, several species of mushroom are considered as delicious food, and currently small scale mushroom farming is emerging in urban areas benefiting thousands of low income households with economic contribution. With growth of agro-industries such as dairy, beverage, food and ethanol production, and health sector, contribution of microbial genetic resources to national economy is increasing over time. Pulses are one of the most important crops that have significant values in the national and local economy. Yields of pulse crops depend on available soil nitrogen fixing microbes. Similarly, roles of microbes in biochemical processes that contribute to improved plant nutrient availability such as mineralization, phosphate solubilization, siderophores production, plant growth regulation and induced resistance have been reported for different farming systems, including Ethiopian coffee (*Coffea arabica*) and traditional agro-forestry system (Diriba Muleta, 2007).

6.9. 4.4. Wildlife and Ecosystem Services in Protected Areas

4.4.1. Dhati -Welel National Park

Dhati-Welel National Park is the newly established protected area in western Ethiopia, National Regional State of Oromia. The park has been gazetted by the regional government and announced on May 25, 2012, regulation no. 149/2012. The Dhati-Welel National Park is the most important wetland ecosystem in western part of the Abbay River basin; it is results of the study approximately 1035 km^2 in size. The most important feature of this park is the extensive wetlands, 900 km^2 (almost more than 85% of the park) located in the headwaters of the Dabus River, one of the important tributaries of the Abbay River

The park located midway between two Zones; Qellem Wellega zone to south-east, south and south-west, and west Wellega zone from north-east, north and north-west. It is bordered by six districts namely Gawo Qebe, Jima Horo, and Gidami in Qellem Wellega Zone, and Begi, Kondala, and Babo Gambel woredas in West Wellega Zone. Most of the area fall between an altitudinal range of 1390 – 1500, whereas the highest altitude, but not yet measured, but may be at the peak of the mountain '*Gara Arba' (mountain of Elephant)* located to western edge of the park.

According to the information obtained from the park office at Wellega branch office of OFWE at Gimbi town, until now 20 species of mammals and more than 150 species of birdlife has been recorded, however, more species expected to be found in the area. Species of wetland birds are abundant, some of them includes; *Pellican spp*, *Marabou stork, Crowned crane, African jacana, African fish eagle, Redy shelduck, Hummer kob, Grey heron,* commonly observed in the area. S*tandard winged night jar, Hammer kob, Hemprich's hornbill, White winged cliff chat, Breasted wood peaker, Speckled mouse bird, Nubian wood peaker, Long crested Eagle, Black crowned crane, Erlanger's lark,* are some among remarkable bird species of the area. The most important associated resources are; the wetland biodiversity including; wetlands dependant and wetlands associated birds, the extraordinary richness of Mega-fauna such as African Buffalo (*Syncerus caffer*), and Hippopotamus (*Hippopotamus amphibius*), few population of African Lions (*Panthera leo*) and ample fish fauna. Vegetation consists of various floral species including wetland dependant and wetland associated plants, and vegetation type known the Sudan Guinea savanna biome.

Figure 19 Hippopotamus (*Hippopotamus amphibius)* in Dhati Welel National Park

4.4.2. Haro Abba-Diko Controlled Hunting Area

Haro Abba Diko Controlled hunting area is other Wildlife Conservation area in the study area particularly located in Ilu Abba Bora zone, Dhidhessa Sub Basin. The area is bordered by Chewaka district from in the east, Meko district in the west, Gimbi and Haro districts of West Wellega Zone in the north and Dabo Hana district in the south. Geographical location of this controlled hunting area's is between co-ordinates of 37p 170313-186775 E and 37p 970625-993750 N UTM with an area of 244 square kilometer. This is Wildlife Conservation area mainly conserved for sustainable Wildlife utilization through sport hunting. The main economic contribution of Wildlife is its potential for tourism. Wildlife tourism industry, which comprises both consumptive and non-consumptive uses of Wildlife resources where the second value has been practiced in Controlled hunting areas such as Haro Abba Diko in the study area. Common Wildlife species found in this area include Defasa Waterbuck (*Kobus defassa*), African Buffalo (*Syncerus caffer)*, Grey Duiker (*Sylvicapra grimmia*), Common Bush pig (*Potamochoerus porcus*), leopard (*Panthera pardus)*, lion (*Panthera leo)*, Anubis Baboon (*Papio anubis*), Blue Monkey (*Cercopithecus mitis)*, Black and White colobus Monkey (*Colobus gureza*), Warthog (*Phacochoerus ethiopicus)*, Grivet Monkey (*Cercopithecus aethiops ellenbeckii*) and many different bird species among which the common once include Splendid Glossy Starling, Moustached grass warbler, Grey –Tit

Flycatcher, Black-faced Fire finch, White-crowned Robin Chat, Red-faced Cisticola, Pale Flycatcher, Eurasian Beeeater and Brown Snake Eagle.

4.4.3. Tulu Lafto Sadden Proposed Wildlife Conservation Area

In an effort to develop additional protected areas in the region as well as in the country, Agriculture and Rural Development Bureau of Oromia Regional state with collaboration of EWCA, Wildlife potential assessment was conducted in Tulu Lafto Sadden proposed Wildlife Conservation area in Abe Dongoro district of Horo Guduru Wellega Zone in 2009. As the result of the assessment indicated the area has got great potential of Wildlife and some population estimation of wild animals including Colobus Monkey (469), African Buffalo (49), Vervet monkey (184), Giant Forest Hog (30), Common Duiker (8), Anubis Baboon (1049), Abyssinian Hare (10), Ground squirrel (58), African Civet (droppings), Common Bush buck (droppings), Waterbuck (Dropping), Crested Porcupine (droppings), Hyena (droppings), African leopard (droppings) and Aardvark (burrow). The area has been identified with relatively reasonably high potential of Wildlife resources. However, the area is also under high human pressures that are threatening the Wildlife resources and needs conservation attention to save the resources. The major human induced problems threatening the potential of the proposed Wildlife conservation include various anthropogenic factors such as expansion of agriculture, poaching, settlements and intentional bush fire. According to information from Wellega branch office of OFWE, one of potential Wildlife areas identified in Dhidhessa Sub basin which is under study by OFWE and Ethiopian Wildlife Conservation Authority (EWCA). The flora of the area is also including common plant species such as *Olea africana, Cordia africana, Syzygium gunesses, Albizia gumifera, Teclea nobilis, Aningeria adolfi federicii, Podocurpus falcatus,* etc. Woodland forest and different species of grass. The area has been also identified with varieties of Wildlife species like Buffalo, Lion, Leopard, Common bushbuck, Blue monkey, and different species of forest birds. This area could be developed into any form of Wildlife Conservation area possibly to Controlled Hunting area and add the number of Wildlife Conservation areas of the Sub Basins.

4.4.4. Didessa Wildlife Reserve as Proposed Wildlife Conservation Area

This potential Wildlife area is the area adjacent to Haro Abba Diko Controlled hunting area which has been identified as the great potential Wildlife area. The area was known to be Dhidhessa wildlife reserve which does not receive proper conservation measures. According to information from OFWE, this area is under reconnaissance study to identify the potential of Wildlife in detail by different scholars and researchers from Addis Ababa University. The Wildlife species identified in this area include Lion, Leopard, Forest buffalo, Waterbuck, Greater kudu, lesser kudu, Hippopotamus, Black and white Colobus monkey, Blue monkey, Anubis Baboon, tree hyrax, rock hyrax, Aardvark, Spotted Hyena, Striped Hyena, Aardwolf, etc. There is also information of the unique and uncommon Wildlife species called 'Water buffalo' in this area. However, further investigation and detail monitoring is important to identify the real Wildlife potential of the area. Various avifaunas have been also identified in the area.

4.4.5. Alatish National Park

Alatishis located between 11^{0}47'5.4" to 12^{0} 31'3.6"N latitude and 35^{0} 15'48" to 35^{0} 48'51" E. longitude in north western flat plain part of Ethiopia. The general topography of Alatish is flat to undulating plain with general slope inclination from south to north interrupted by valleys, streams, scattered hills, and seasonal wetland. According to Mesfin Wolde Mariam, 1972 the geological formation processes which divided the whole of Ethiopia in to four major physiognomic regions places Alatish under associated low lands of the north western highlands. ALNP falls within Nile Basin found in east of Soudan's Dander National Park (DNP). It shares about 74km (Arial) its western boarder with DNP with possibility of forming a new trans-boundary park. Alatish were not severely devastated and could be covered with *Acacia*, *Terminalia* and Balanites spp dominated by undifferentiated scattered wooded grasslands. Alatish is bordered by Gelegu River in the northern edge Amejalie to Alga, south and south east Ayima River with Beshangule Gumez Regional State. Gumuz villages at Bambahoo, Bayiwa in Quara and Aybeza, Abunta, Aygumba, Kuslie Hymenshmis, Balankure and Omedela to the direction of Beshangul Gumuz National Regional State (BGNRS) are villages along Ayima River inhibited by indigenous Gumuz ethnic group. In eastern and north eastern bordering Kebeles (the lower administrative units) the Amhara ethnic group composed of settlers from highlands of different parts of the region and Agew are inhabited in Bmabahoo, Gelegu, Mehadid, Gerara, Gumuz Wuha, Marwuha and Dubaba of Quara Woreda. Topographically, ALNP falls within the flat endless plains interrupted by scattered rocky hills and multilayered wooded and shrub lands within Blue Nile Basin at the western foot of north western Ethiopian highlands (Abraham Marye et al, 2008).

Natural Resources Status*:(bush and forest trees):* In terms of the tree/shrub species resources, the Woreda in general and the park in particular is very rich and it is possible to say it is a place where majority of the Region's forest cover is existing. Based on the this assessment there has been 84 tree species, shrub species, 29 Herbal Food and Medicinal Plant Species 17 grass species identified. As identified earlier almost 85% of the land is covered by forest and bush trees and grass. These potential is referred as a green belt which is contributing on balancing the Nubian Desertification.

Figure 20 Overview of the Alatish National Park and the Forest Resource

Wildlife Resources: The Park is rich with wild life which includes large mammals, small mammals, reptiles, fish and birds. Based on the assessment there has been 37 mammal species (8 are not recently seen), 204 bird species, 7 retails and 27 fish is identified. Among the referred ones Lion, elephants leopards are available. The details are described in the zoological report. Rivers and Water bodies: In addition to the forest resource the Woreda and the park is rich with rivers with high fish potential and water for wildlife of the park. Rivers like Ayima, Shinfa (Abraham Marye et al, 2008).

6.10. Why We Need to Conserve Wildlife?

Because of human activities the rate of loss of biodiversity is increasing. Especially since the late nineteenth and early twentieth century, many parts of the world experienced wildlife declines owing to overexploitation. Biologists argued that much of the wildlife is declined, because of the economic, medical, aesthetic, recreational, scientific, and ecological value of all species.

4.4.6. Scientific and Ecological Importance

Every species has scientific values because each can help scientists to understand how life has evolved and functions, and how it will continue to evolve on this planet. Some wildlife species also involve in recycling nutrients essential to the ecosystem and become very useful in maintaining soil fertility. Moreover, they control potential crop pests and disease carriers, and makeup a vast gene pool for future evolutionary processes.

4.4.7. Economic and Medical Importance

It is obvious that many animal species are used as a source of food and become economically very important. They are also used as medical importance since they are used as an experimental animal to test drugs, vaccines, chemical toxicity, and surgical procedures, and in studies of human health and disease. Under intense pressure from animal rights groups, scientists are trying to find testing methods that minimize animal suffering or, better yet, do not use animals at all. However, they warn that alterative techniques cannot replace all animal research.

4.4.8. Aesthetic and Recreational Importance

People love life, a phenomenon called "biophilia". It is easy to find evidence of our aesthetic, spiritual, and emotional affinity for other species. Wild animals are a source of beauty, wonder, joy and recreational pleasure for many people. Wildlife tourism (ecotourism) generates some amount of dollars in revenues each year in Ethiopia. However the wildlife tourism in Ethiopia is at its infant stage as compared to other African countries like Kenya and Tanzania Therefore they are very important to us in many ways and it is better to protect and wisely utilize such invaluable biological resources.

4.4.9. Bioethics and Wild species

To some people each wild species has an inherent right to exist-or to struggle to exist. According to this view, it is wrong for us to hasten the extinction of any species and we have an ethical responsibility to protect species from becoming extinct as a result of human activities. Some proponents go further and assert that each individual organism, not just each species, has a right to survive without human interference, just as each human being has the right to survive. Many conservationists believe that every species has intrinsic value. Meaning its value is independent of its usefulness to people and to other species or within an ecosystem. Therefore, every species has its own value without reference to anything but for its own existence. Even though the idea of having without reference to humans is hard to accept it does appeal to many conservationists.

6.11. Major Causes of Wildlife Loss

Extinction usually refers to the disappearance of a species from the earth. When a species disappears from a small area this is called a local extinction. Although conservation biologists are most concerned about global extinction, smaller scale extinctions are also of some concern because they foreshadow extinctions on a larger scale. The risk of extinction at different spatial scales is a key consideration when deciding which endangered species are high priorities. The larger the scale at which an extinction is likely to occur the more important it is to try to prevent it.

There are two root causes of population reduction and extinction of wildlife. These are human population growth, and economic systems and policies that fail to value the environment and its ecological service. In developing countries, the combination of rapid population growth and poverty push the poor to cut forests, grow crops on marginal land, overgraze grasslands, deplete wildlife species, and kill endangered animals for their valuable furs, tusks, or other parts in order to survive. The combination of such underlying causes lead to other direct causes of the endangerment and extinction of wild species including habitat loss and degradation, habitat fragmentation, commercial hunting and poaching, predator and pest control, sale of exotic pets, climate change and pollution as well as deliberate or accidental introduction of non-native species into the ecosystem.

The greatest threat to most wild species is reduction of habitats as we increasingly occupy or degrade more of the planet earth. Tropical deforestation is the greatest eliminator of species, followed by destruction of coral reefs and wetlands, ploughing of grasslands, and pollution of freshwater and marine habitats. Many "homeless" species become extinct because they can't migrate to new areas or change their feeding habits or other behavior to get the food, water, cover, and space they need to survive. In addition to habitat loss, an increasing amount of the planet's remaining wildlife habitat is being fragmented into vulnerable patches by roads, fences, fields, towns and variety of other human activities. Habitat surrounded by such different practices becomes a "habitat island" for most of the species. Most national parks and other protected areas are 'habitat islands' since many of them are surrounded by potentially damaging logging, mining energy extraction, and industrial activities. Freshwater lakes are also habitat islands that are especially vulnerable when non-native species are introduced. Island species, many of them found nowhere else on earth, are especially vulnerable to extinction and most have no other place to go.

The main problems caused by habitat fragmentation are a decrease in the sustainable population size for many wild species and an increased surface area (edge) which makes many species vulnerable to predators. Some species are more vulnerable than others to premature extinction because of low productivity, specialized feeding habits, large size and limited or specialized nesting or breeding areas.

Humans have become a primary factor to the premature extinction of more and more species of wild life. Protecting biodiversity and managing of wildlife in their natural habitat by using treaties and laws are some of the strategies used for protecting wildlife from their extinction. It is therefore, wrong for us to hasten the extinction of any species and we have an ethical responsibility to protect species from becoming extinct as a result of our own activities.

6.12. 4.6 Wetlands of the Basin

Wetlands are areas of the landscape where the water table is at or near the surface, or where the land is covered by shallow water for a significant portion of the year. Abbay basin has abundant wetland ecosystems that are distributed across the sub basins. Of the total estimated wetlands area of Ethiopia, the Abbay basin covers about 1.43% wetlands area.

4.6.1. Types of wetlands in the basin

According to the Ramsar Convention on Wetlands, there are three general categories of wetlands: (1) marine/coastal wetlands; (2) inland wetlands; and (3) artificial wetlands. All three types of wetlands are found within the Abbay basin.

a. Fresh water wetlands

Most of the wetlands in the country can be classified as fresh water wetlands. This in turn can be classified as riverine wetlands that are associated with presence and flow of rivers, palustrine wetlands that are associated with temporary and permanent freshwater marshes and swamps and lacustrine wetland types that are lakes and wetlands associated with lake systems.

Riverine Wetland Types: Examples of riverine wetland types in Ethiopia are the floodplains of Fogera, Dembia and Kunzela in Amhara Regional State, Beles in Benishangul Gumuz Region, and floodplains of Dabus, Geba, Dedessa Rivers in Oromiya Regional State and others.

Figure 21 Riverine wetlands in Abbay Basin

Palustrine wetland types: The palustrine wetlands are represented by Borkena/Cheffa, Fincha Swamps, Gumero Wetland and others.

Lacustrine wetland types: Lake Tana is an example

b. Salt water wetland

There are limited salt water wetlands in Ethiopia as well as in Abbay Basin. The example of salt water wetlands includes wetlands of Dallol Depression in Afar Regional State.

c. *Human made wetlands/Lakes*

Human made wetlands includes Koga, Diddesa, Fincha, Alwero and other hydropower and irrigation dams. Further, municipal and small water reservoirs like dams built for various purposes, aquifers and wells.

4.6.2. Distribution of Wetlands in the Basin

The total area of wetlands in Abbay basin was estimated to be above 188,528 hectares of marshy or swampy areas and water bodies. Out of 43 wetlands inventoried in the country by the Environmental Protection Authority, about 19 wetlands (44%) including lakes, swamps, marshes and human made reservoirs and peat and forested wetlands are found in the basin

(Aloba Lake, Ashenge Lake, Chomen Lake, Fogera Swamps, Tana Lake, Wonchi Lake, Zangana Lake), and there are many other small wetlands within the basin.

Tana sub basin being the largest area of wetlands that comprises Fogera and Dembia flood plains which are the largest wetland areas in Ethiopia. These wetlands are providing services being shelters for indigenous and migratory bird species that come from England and other European countries to cope up seasonal weather conditions. It is also a shelter of wetland animal species. In addition these wetlands consist of plant species like papyrus, gicha, filla, sedges …etc. 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 Western Wellega zone of the Oromia region.

Wetlands are much more common in the Amhara region (2.74% of area of which 90% of the wetlands are found within Abbay drainage system (Woody Biomass 2002) than in Oromiya (1.11%) or Benishangul-Gumuz (0.45%) (AMU, 2009).The wetlands of Amhara Region are distributed all over the region, but the largest portion of the wetlands are found in the Abay River drainage system which accounts associated with Lake Tana such as Fogera, Dembia, Kunzela flood plains, marshes and swamps are dominant within Awi and Western and Eastern Gojjam zones and Cheffa(Borkena), are some of the many wetlands that dominate the region’s land surface. These wetlands make a significant contribution to the livelihood of many citizens in the region. Wetlands of the sub basins are also rich in bird, plant and large mammals’ diversity including reptiles.

Furthermore the Oromiya Region, especially that of the Abbay Basin with a varied landscape and considerable rainfall up to 2200mm in Illubabor highlands, has varied wetlands from small wetlands scattered all over to larger and bigger wetlands located deep in forested areas. The dominant types found in the region include valley bottom swamps, marshes, floodplains, human made reservoirs mainly Fincha, peat swamps and forested and riverine wetlands. As an example, valley bottom wetlands such as marshes and swampy wetlands dominate the South-west highlands, mainly Illubabor, Masha, Wollega and Jimma Zones (Afework 2005; Wood 1996), whereas peat and forested wetlands are common in highland Illubabor and

Masha Zones. Benshaungul Gumez Regions are dominated by riverine types of wetlands associated with Dubus Rivers.

4.6.3. Functions of Wetlands in the Basin

The major functions of wetlands are water storage, ground water recharge, flood control, shoreline stabilization, water quality control, moderating climate and community structure, regulating floods, etc. They are also a source of substantial biodiversity in supporting numerous species from all of the major groups of organisms – from microbes to mammals.

Figure 22 Geba Flood Plain from Illubabor

The ecological functions of wetland ecosystems in Ethiopia as well as in the Basin part are poorly studied and recorded. However, the wetland ecosystem in the basin and the country provides many ecological functions which maintain and protect nature and systems which benefit people through services such as maintenance of water quality, flow and storage, flood control, nutrient retention and microclimate stabilization (Afework and Wood 2006).

Lake Tana and wetlands throughout Southwest Ethiopia are recognised as important for birdlife and other wild animals because of the preservation of natural vegetation and habitat. The wetlands in the south-west especially are well-known for their birds and several forest/wetland combination sites have been designated as important bird areas. In addition, the slopes coming down to wetlands within the forest often have stands of wild coffee, while biodiversity concentrations are high in the eco-tone from wetland to forest (Zerihun Woldu, 2000).

Furthermore, out of a total of 73 Important Bird Areas identified in the country about 30 (41%) of them are wetlands and out of these 10 (33%) of them are found within the Nile Basin part of Ethiopia (Abbay Basin) and they support a variety of bird species including some birds endemic to Ethiopia, as well as the worldwide endangered bird species the White Winged Fluff tail.

4.6.4. Major Threats to the Wetlands of Abbay Basin

The loss of wetlands in the Northern Highlands is a major cause, along with catchment degradation, for flash flooding which affects many lower terrain areas, such as the Fogera Plain on the eastern side of Lake Tana (Afework and Wood 2006).

However, currently many wetlands in the basin are at the edge of collapse due to continuous threats they are facing. Draining for growing food crops which involves double cropping, overharvesting of the resources, year round and over-grazing, the appearance of invasive plant species due to mismanagement of the resources, and the introduction of perennial crops into the wetland ecosystem are the major threats that are posing a dangers to the countries wetlands. On top of that, lack of clear awareness with the general public, decision and policy makers coupled with the absence of a clear policy and direction on wetlands issue are contributing to the problems mentioned before.

The overall impact from the aforementioned threats to the Ethiopian wetlands is immense and could result in the loss of many wetlands. The study undertaken by EWRP in Illubabor has revealed this reality and some of the wetlands that played a significant role in the lives of the local communities have disappeared due to mismanagement and unwise use. The loss of such wetlands will firstly and directly jeopardise the lives of many communities that are dependent on them for their livelihoods. Secondly it is a net loss to the country as well. In summary the impacts from the current threats on wetland resources in general have the following negative outcomes:

- Decline and eventually total loss of food production,
- Loss of resources that will be collected from the wetlands,
- Lowering ground water table and drying up of water springs,
- Change in water quantity and quality,
- Change in the ecosystem as a whole,
- Loss of biodiversity, and
- Loss of dry season grazing site, etc.

6.13. Causes and Consequences of Biodiversity Loss

4.7.1. Direct Threats and Root Causes of Ecosystem Biodiversity Loss

***Clearing for Agriculture*:** Conversion of natural forests, woodlands and savannah ecosystems to agriculture is the greatest single threat to ecosystem biodiversity. Conversion results in the loss of nearly all species of fauna and flora on the site and leads to increasing fragmentation of the remaining ecosystems. Root causes of clearing for agriculture include population growth, low productivity of agriculture, unsustainable agricultural systems (soil erosion and inability to maintain soil fertility), tenure systems that allow the conversion of common lands to farmland and lack of enforcement – even some of natural parks have been heavily encroached by farmers.

People have been also expanding their holdings by clearing the forest as way out to tackle land shortage caused by population pressure. If the trend goes ahead, it would be reasonable to contemplate about the possibility of demands for the fertile plains of the park holding that could arise from private ventures to develop mechanized high-tech agriculture as the entrenched threat looming over the fate of the park ecosystem.

Emerging of rural towns, villages and the associated infrastructures, facilities and market places and in hand with settlement programs are the imminent factors accounted as possible menaces just around the corner to endanger the vegetation resources of the park and its surrounding.

Figure 23 Farming going on around the park-200 meters away as one of major threats to the forest resources in the sub basins.

***Over-cutting and unsustainable levels of harvest*:** Over-harvest of both woody and non woody products are occurring on a widespread basis leading to deforestation, ecosystem degradation and biodiversity loss. Root causes include demographic pressures and growing demand, especially urban demand, for firewood, charcoal and other products, land tenure and resource access rights resulting in open access to forest/wild lands, lack of political will to enforce forestry legislation, lack of sustainable management models for most ecosystems and lack of incentives for local communities to conserve.

Figure 24 Harvesting process of matured plantation forest of *Cupressus lustanica* by OFWE for production of timber

Overuse of Park Resource**:** Patches of the lowland bamboo /*Oxytenanthera abyssinica*) have occupied commonly an *ecologically sensitive* spots on undulating hillsides and rock outcrops. Clearly, bamboo trees are serving double roles, both productive and protective functions. It minimizes soil erosion from rolling slopes of the hillsides, which are prone to soil erosion. The excessive removal of bamboo from such susceptible sites of the park aggravates erosion and land degradation further. If the ongoing trends of unmanaged utilization of bamboo as coupled with the regular and frequent burning during every dry season continues unadjusted, it inflicts huge far-reaching devastation in the ecological integrity of the park ecosystem. Besides, the aesthetic beauties of the park landscape will be lost irreversibly.

In addition, extraction of resin, for production of Frankincense, from trees of *Boswelia papyrifera* is another issue of concern since it has been done through the traditional systems, which involves wounding the live trees by cutting and scratching on the barks. The frequency and intensity of wounding and oozing trees are not controlled and managed in views of the tree physiology of this species hence; it may result in the total demolition of the *Boswelia papyrifera* species from the park and its surroundings.

Over-grazing**:** The major threat on the vegetation of the park is overgrazing by the ever-increasing number of livestock conveyed from the local Ethiopian population and cross-border pastoralist tribes named as *Felata, who* enter from Sudan during the dry seasons. The estimated 600 households of Falatas owning about 300,000 cattle, 180,000 shoats, 800 camels and 1200 domestic donkeys have been occupying the park illegally(informal report) denuding resources, depleting pasture, water and other necessities for wildlife within the park.

Overgrazing and over-browsing in the swampy communities are also degrading vegetation resources in the areas triggering the expansion of unpalatable weeds replacing the sub-ecosystems compacting water sources, thereby changing composition of species over the park's landscape.

Overgrazing results in decreased soil cover, increased erosion, decreased quality and productivity of range resources, reduction or elimination of the natural regeneration of woody species and preferred forage species, bush encroachment in some areas and loss of biodiversity. Root causes include demographic growth, the break down in traditional pastoral/range management systems, land tenure and open access torange lands in some parts of the country, lack of incentives for sustainable use and lack of range management models in some areas.

Figure 25 Free Grazing in the Basin

Poaching and Hunting**:** According to unpublished reports, the local people and park scouts have confirmation that the population of wild animals had been gradually declining citing that sighting *black Rhinos, giraffe, buffalo, roan antelope and Hartebeest Tora,* have been becoming rare in contrast to the conditions previously. The apparent reason for this tragedy becomes no other than the excessive disturbance, poaching and hunting by cross border pastoralists of Felatas and other Sudanese tribes especially in the case of Alatish park.

Besides, it would be self-evident that wild animals have been evacuating from the ALNP to relatively the safer areas, most likely the contagious areas of Dinder National Park across the Sudanese border since Dinder National Park is intensively patrolled, as to reports indicated.

Alien invasive species: are one of the major factors threatening biodiversity resources globally. Alien invasive species lead to ecosystem disruption by destroying or displacing indigenous species through rapid reproduction and expansion. Alien species cause severe damage by reducing crop yields, displacing indigenous species, obstructing irrigation infrastructures and aiding the spread of other crop pests. Alien species are found in many parts of the country. Although no detailed studies have been available on their impact, they are causing enormous problems in the various ecosystems and the economy. The prominent alien species that cause damage across the country include *Parthenium hysterophorus*, *Prosopis juliflora*, *Eichornia crassipes* and *Lantana camara*. Introduced, or alien invasive, species can have significant negative impact on global and national levels. *Prosopis* is becoming a major problem on semi-arid rangelands.

The effects of other exotic but useful species on the native fauna and flora of Ethiopia have not been well documented. In attempts to meet the increasing demands of a rapidly growing human population, fast growing exotics have been introduced to alleviate shortages in timber, fodder, and fuelwood. Prominent among the exotics tree species are *Eucalyptus* spp. Extreme care is required in the selection of species to be introduced to minimise any impacts on native species. Introductions should be considered only if absolutely necessary and should be accompanied by strategies to assess the magnitude of any threats to indigenous species. Where practical, indigenous flora and fauna should be restored to reduce loss of native biodiversity.

Uncontrolled Fire**:** ALNP is placed in the part of areas *set on fire* most frequently and regularly in African continent (Sebsebe Demissew, *et al*, 2005). The *Acacia seyal and Balanites* woodland communities are swept by fire frequently every dry season in ALNP. Deliberate uncontrolled fires from pastoralists, for the apparent purpose of improving pastures, and unintended fires from honey collectors have devastated the ground-level vegetation in wooded grasslands and other crucial communities triggering proliferation of invasive species, which is threat to the *genus loci* of the natural landscape. Fires have catalyzed the replacement of dominant perennial grasses, in most areas of the park, by annual species of invasive potentials. Casual fires often removed the ground covers exposing the clay soil bare. This apparently has increased the rates of erosion and eventual siltation of the flat lands of the park including its swampy communities thus inducing unfavorable alterations in microclimates.

Figure 26: Wild Fire around Benishsngul Gumuz Regional state

Climate change/drought: Average global temperature has been rising for more than a century, either as a result of natural fluctuation or the build-up of greenhouse gases. Climate change is likely to reduce biodiversity, and the goods and services that ecosystems supply in Ethiopia by:

- Increasing desertification in arid and semi-arid areas.
- Increasing flooding.
- The desiccation and die-back of forests and.
- Reduced agricultural production.

***Replacement of local varieties and breeds*:** Agricultural biodiversity provides essential raw materials for improving the productivity and quality of crops, livestock, fish and other resources. However, due to high attention to the improved varieties many farmers' varieties /breeds of both plants and animals have been replaced. According to the information from the Bureau of Agriculture of different region, farmers' varieties of wheat, teff, and maize have been locally lost due to various factors, including wider use of improved varieties. EOSA (2007) reported that about 77% of durum wheat has been replaced by improved varieties in

Eastern Shewa, mainly due to displacement by bread wheat varieties which took place gradually in a time of three decades. Sheko cattle breed is among threatened local breeds, resulting from interbreeding with the local zebu breed and changes in the production system (IBC, 2009). Similarly, chicken genetic resources of the country are highly affected by replacement by exotics and their crosses. The Fogera cattle breed also lost around the area. Generally, loss of agricultural biodiversity results in loss of ecological, economic, nutritional and cultural benefits, and increases vulnerability to climate change and food insecurity.

4.7.2. Indirect Causes

***Demographic change*:** Population growth is directly correlated with increase in resource consumption. Uncontrolled population growth puts undue pressures on all natural resources of the country. Abbay basin one of the densely populated basin in Ethiopia and the population has reached to more than 28 million almost 1/3 of the country. The population increase causes expansion and intensification of land use, over utilization of biological resources, exploitation of marginal lands and the weakening of traditional resource-management systems. As the result, it is putting undue pressures on all ecosystems and biodiversity of the country.

***Poverty*:** poverty, particularly in situations where people depend directly upon consumption of biodiversity or other natural resources for survival, is one of the causes of biodiversity losses. Poverty prevents people and nations from assuming long-term economic and environmental attitudes. There exists a vicious circle of poverty, resource degradation and further impoverishment in Ethiopia. Poor farmers, fishermen, pastoralists and other users extract whatever they can from the environment to support their families.

According to the data from CSA (2014a), the national poverty head count indices and inequality has reached 26% (MoFED, 2014), this together with high unemployment rate of 17.4% in cities (CSA, 2014c), are creating huge pressure on the country’s biodiversity and ecosystem services.

Low level of awareness and lack of coordination**:** contribution of biodiversity and ecosystem services to the national economy and sustainable development are undervalued due to low level of awareness. Decision makers and local communities often take actions that negatively affect biodiversity and ecosystem services. Lack of relevant and timely information to the public and decision makers is another factor for loss of biodiversity and unsustainable utilization of resources. Biodiversity and ecosystem services are not well mainstreamed into the formal education system and other relevant sectors. Community knowledge on biodiversity, its cultural practices in the management of biodiversity and ecosystems are not well promoted and applied.

There are several stakeholders (institutions, researchers, policy makers and public)working on biodiversity conservation and sustainable utilization. However, further strengthening of coordination of the stakeholders is required for the effective conservation and sustainable utilization of biodiversity and ecosystems. (National biodiversity strategy and action plan)

5. AN OVER VIEW OF WATER QUALITY AND POLLUTION THREATES IN ABBAY RIVER BASIN

6.14. 5.1. Potential Source of Water Pollution in Abbay Basin

The important point and non-point sources of water pollution in the Abbay basin are *natura*l due to erosion and anthropogenic because of developmental activities, urbanization, and population pressure including agriculture. Industrial and domestic waste, agricultural runoff and mining activities are among possible sources of pollution that threatens the water resources in the basin. This portion of this assessment presents information on status of possible sources and fates of pollutants.

5.1.1. Agricultural Practices

Although agriculture contributes to a wide range of water quality problems, anthropogenic erosion and sedimentation is a global issue that tends to be primarily associated with agriculture. In Abay basin as more than 80% of the population is agrarian, agriculture is an important source of sediment, nutrients, pesticides, salts, and pathogens. Agricultural activity has the following impact on water quality:

Many of the rivers in the Abbay basin are originated from mountainous areas where there is high level of deforestation and poor natural resource management is practicing which could be the major causes of erosion in the basin. Disturbing the soil through tillage and cultivation and leaving it without vegetative cover may increase the rate of soil erosion. Sediment is the largest contaminant of surface water by weight and volume (Koltun et al. 1997), and is identified by as the leading pollution problem in rivers and streams of Abbay basin.

Accelerated reservoir siltation reduces the useful life of reservoirs. Sediment can clog roadside ditches and irrigation canals, block navigation channels, and increase dredging costs. Suspended sediment can increase the cost of water treatment for municipal and industrial water uses and destroy aquatic wildlife habitat, reducing diversity and damaging commercial and recreational fisheries.

Nutrients, chiefly nitrogen, potassium, and phosphorus, promote plant growth. Nutrients move from fields to surface water while dissolved in runoff water or adsorbed to eroded soil particles. Nitrogen and phosphorus can cause quality problems when they enter water systems. Nitrogen, in the form of nitrate, is easily soluble and is transported in runoff, in tile drainage, and with leachate. Phosphate is only moderately soluble, and relative to nitrate, is not very mobile in soils. Erosion can transport considerable amounts of sediment-adsorbed phosphate to surface waters.

Nitrogen and phosphorus from agriculture accelerate algal production in receiving surface water, resulting in a variety of problems including clogged pipelines, fish kills, and reduced recreational opportunities. In Abay basin it is common to use fertilizers like UREA and DAP containing high level of nitrogen and phosphorus to improve productivity of the land and to feed large number of people inhabiting in the basin. Every year nearly 3.5million DAP and almost similar amount of UREA were added in 13 sub basins. Large amount of fertilizer is transported to water bodies through erosion and causing eutrophication of the Lake Tana and reservoirs found in the basin.

i. Irrigation

In Abbay basin there is high potential of irrigable land nearly 815,581 hectare (MoWR, 1998b)from this area of irrigable land, in addition to problems of waterlogging, desertification, salinization, erosion, etc., that affect irrigated areas; the problem of downstream degradation of water quality by salts, agrochemicals and toxic leachates is a serious environmental problem. Indeed, only in the past few years has it become apparent that trace toxic constituents, such as Se, Mo and As in agricultural drainage waters may cause pollution problems that threaten the continuation of irrigation in some projects" (Leteyet al., cited in Rhoades, 1993)

ii. Livestock

The trends of growing animals in most part of the people in the basin is free grazing type and the waste of these huge number of cattle is dissipated in the field and consequently reaches to water (surface and ground water) bodies through erosion and infiltration.

High-producing pastures and stock (cows) combined with high stock densities, mean that contaminant losses to fresh water are often greater per hectare of dairy land compared with other land uses. For example, dairying land occupies only 22 % of the land area in Waikato, but it is estimated by Environment Waikato to account for 68% of nitrogen and 42 % of phosphorus entering the waterways of the region (Environment Waikato, 2008). And although daily faecal loads to land are broadly similar for most types of stock animal (eg, dairy cattle, beef cattle, sheep), the loadings from direct deposition to water are greatest from stock crossings, which are typically more active on dairy farms.

The socio economic data (2015) showed that there were more than 50 million cattle and non-ruminants like donkey, horse and mules in the basin. The waste from this huge number of animals in the basin exacerbated by free grazing trend could impose on the water quality of the basin

iii. Pesticides and Herbicide Application

Although there is no organized data showing the amount of herbicides and pesticide application in the basin, a wide variety of pesticides are applied to agricultural crops to control insect pests, fungus, and plant diseases every year on farmland and certain chemicals can travel far from where they are applied. Pesticides move to water resources, in runoff, run-in, and leachate. In addition, pesticides can be carried into the air attached to soil particles or as an aerosol, and deposited into water bodies with rainfall. The common herbicides used in the basin are 2, 4-D and round up and the pesticides malathion, bayfidam, byleton and endosalfine. Most of these chemicals are harmful for human and aquatic lives found in water bodies.

The rapidly growing floriculture industry in the basin around Bahir Dar, Debere Berhan, and north of Addis Ababa (Sululta) is using pesticides intensively. The most visible impact of floriculture on the environment comes from the massive use of toxic chemicals including fertilizers & pesticides, soil fumigants and plant growth regulators. Because of the activities of the flower farm around Lake Tana, rivers and streams in the basin &their water quality may seriously deteriorate and fish catches will decline. It is estimated that less than 0.1 percent of the applied pesticide floriculture reaches the target pest, leaving 99.9 percent as a pollutant in the environment, including the soil, air, and water, or on nearby vegetation(Mulugeta, 2009).. Commonly used pesticides can be harmful to people, pets, and the environment.

5.1.2. Industrial Waste

Industrial activities in the basin is currently limited to the Regional capital& towns like, BahirDar and Zonal center towns like Gonder, Debremarkos, Debrebrhan, Sululta around Addis Ababa, Ambo and Nekemte. However, the attempt made to estimate industrial waste load was unsuccessful due to lack of appropriate information from industries about their wastewater discharge and their production capacity. Although there were more industries in around Debre Berhan, Bahir Dar and Sululta; some of the major industries found in ARB having the potential of water pollution are shown below in Table 2.1.

Table 12 Major Water Consuming and Wastewater Discharging Industries in Abbay River Basins

Sub basin	Type of Industries											
	Textile	Tanner	Chemical	Brewery &Alcohol	Soft drinks	Food processing	Sugar	Cement	Lime stone	Paint	Pipe	Total
Tana				1	1	2						4
N. Gojam	1	2			1					1	1	6
Beshilo												
Welaka	-	-	-	-	-	-	-					
Jemma	1	1		3								5
S.Gojam	-	-		-	1	-		1				2
Muger		1	1			4		4				10
Guder	-				1				2			3
Fincha	-	-	-	-			1					1
Didessa				1			1					2
Anger												
Wombera	-	-	-	-	-							
Dabus												
Beles							1					2
Dinder												
Rahad												
Total	2	4	1	5	4	6	4	5	2	1	1	35

From the industries listed above wastewater discharge data was collected from major industries having the potential of discharging large volume of liquid waste; during the assessment study on industrial waste management practices, it was found that around 1970148m^3 partially treated or with limited process of treatment wastewater could be discharged in to the streams, rivers and to the environment. Some of the industries found in the basin that uses considerable amount of water and discharge significant quantities wastewater into the environment are listed below.

i. Brewing and Other Alcoholic Liquor

The process of malting will generate organic wastes and odor during germination and additives to facilitate malting processes. The brewing process requires a significant amount of water and produces wastewater with high *biochemical oxygen demand, soluble organics, suspended solids, heavy metals, as well as, nitrogen, phosphorous, color and turbidity.*

Water consumption for breweries generally ranges from **4-8** cubic meters per cubic meter of beer produced.

The main component of waste from brewing process includes caustic boil-out solutions used for clean-ups in the brew house, soak solutions and caustic rinses in the bottling area, organic loading, spent grain and hops, filter cakes in dry form and accidental losses from operational errors and leaking equipment.

The uncontrolled discharge of untreated wastewater can lead to depletion of dissolved oxygen in surface water and generation of noxious odors. Furthermore, wastewater may contain nutrients which stimulate aquatic plant growth and contribute to eutrophication. Some of industries have wastewater treatment plant butgreater numbers have limited treatment process and discharge their wastewater to the nearby stream

Figure 27 Wastewater discharge Mechanisms for some Industries

ii. Tanning Industry

In the basin there are 4 tanneries with poor or no waste treatment plant and discharging their waste water and disposing their solid waste to the environment with municipal solid waste disposal system or to the nearby environment. A major pollutant in tannery wastes consists of: Chlorinated phenols (e.g. 3, 5-dichlorophenol) as an organic pollutant associated with the tanning industries have been found to be highly toxic and affect the cellular compounds of organisms exposed to such waste (Pasco et al. 2000). Other pollutants include Azodyes, Cadmium compounds, Cobalt, Copper, Antimony, Barium, Lead, Selenium, Mercury, Zinc, Arsenic, Polychlorinated Biphyenls (PCB), Nickel, Formaldehyde resins and Pesticides residues. NaCl2 and pesticides, strong alkaline and sulphides, inorganic residual compounds, dissolved matter and chromium salts.

Trivalent chromium is unable to enter into cells but Cr6+ enters through membrane anionic transporters. Intracellular Cr6+ is metabolically reduced to Cr3+. Cr6+ does not react with macromolecules such as DNA, RNA, proteins and lipids. However, both Cr3+ and the reductional intermediate Cr5+ are capable of coordinated covalent interactions with macromolecules (Shrivastava et al., 2002).Most of the industries discharge their waste in to the nearby water bodies with no or minimal treatment

Figure 28 **Properly untreated tannery wastewater discharge in to Abbay River**

iii. Textile Factories

There are two textile industries in the basin using large amount of water in their operations and therefore discharge large volume of wastewater contains a variety of chemicals into the environment.

The wastewater contains acid used in desizing, dyeing, and bases like caustic soda used, inorganic chlorine compounds and oxidants, eg., hypochlorite of sodium, hydrogen peroxide and per acetic acid for bleaching and other oxidative applications. Organic compounds are also present, eg. Dyestuff, optical bleachers, finishing chemicals, starch and related synthetic polymers for sizing and thickening, surface active chemicals are used as wetting and dispersing agents and enzymes for desizing and degumming. Salts of heavy metals are also present, eg, of copper and zinc, and iron (iii) chloride used as printing ingredients. The common characteristics of textile wastewater are high chemical oxygen demand(COD), high biological oxygen need (BOD), high temperature, high pH, solid materials, phenol, sulfur and the colors caused by different dyes (Demir et al., 2000). Most of the BOD/COD ratios are found to be around 1:4, indicating the presence of non-biodegradable substances.

Figure 29 Textile waste water Treatment and Discharge

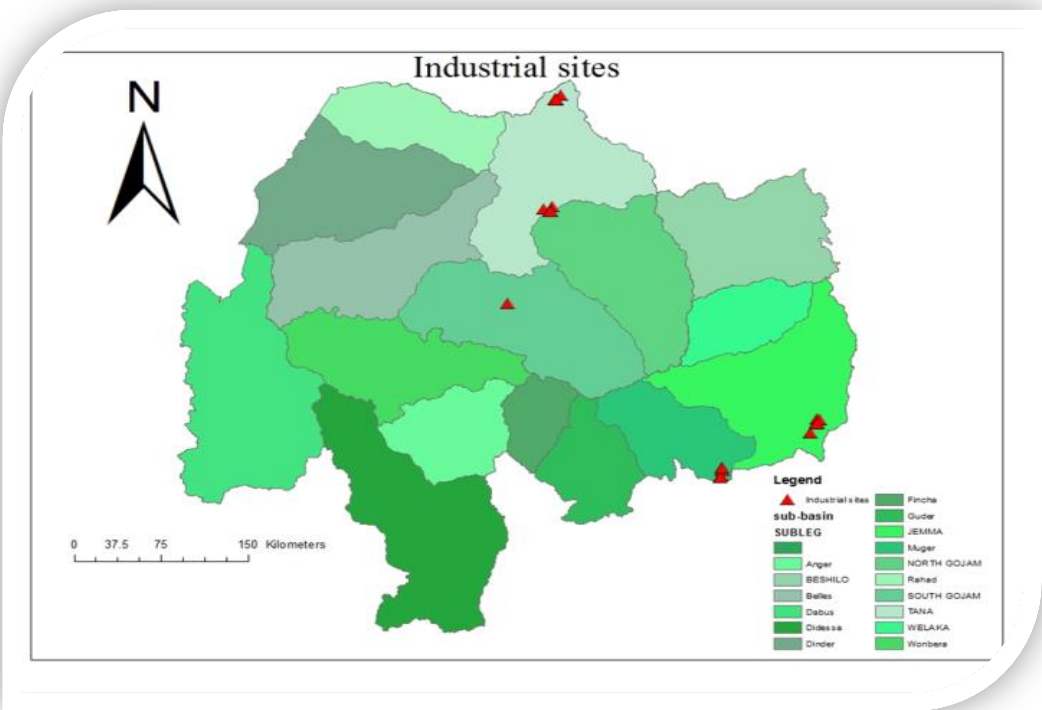


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Figure 30 Major Industrial sites and sources of Water pollution in Abbay Basin

5.1.3. Medical Waste

Health-care waste generation varies according to national income level, for low-income countries annual waste generation (kg/head of population for all health-care waste is 0.5–3.0 (Halbwachs, 1994). A study by FEPA (2005) found that 430.7 tons of contagious waste is generated by the 29 hospitals located in Addis Ababa (Mafuta et al, 2011). In Abay basin there are 47 hospitals,1134 health centers and 5497 health posts that can serve for more than 30 million people and thus possibly produce around 30,000 tons of contagious waste ever year. Some of the health organizations have sort of incinerators to burn the waste but most of them have no a standard incinerator for the hazardous waste; while some others dispose it to the nearby streams, river Abbay (Blue Nile) or Lake Tana. Unless treated properly it will cause high level of impact on human health and the ecosystem.

5.1.4. Poor Waste management Practices of Urban Centers

i. **Municipal Solid waste**

The term "municipal solid waste" (MSW) covers wastes from different sources: from domestic, commercial, industrial (small and cottage industries), institutional (public administration, schools, etc.) activities; markets centers; and street sweeping. In all urban environments, management of solid waste is the responsibility of the municipal authorities. There is poor management system of solid waste in Abbay basin although it is not well managed only Gondar town has sanitary landfill system in the basin in the rest of the towns including Bahirdar solid waste is collected from residential areas, institutions and business centers and damped somewhere without proper management. In Abbay basin the trend of solid waste collecting is very poor which is not greater than 50% of the solid municipal waste generated from each town.

According to UNEP 2013, the solid waste generation in low income Countries is *around 0.25-0.*6kg/cap/day or nearly 0.25to/cap/year. Based on this information it is possible to estimate solid waste production in different towns of the sub basins, although there is some variation based on technology and living conditions

The assessment study of waste management practices was conducted at major towns of Abbay basin Ambo, Assossa, Bahirdar, DebreMarkos, Debereberhan, Gondar, Injibara, Debretabor, Fiche, Shambo and Nekemte towns .The result of the survey study showed that most of the towns have no appropriate sanitary land fill for solid waste and wastewater management. Most urban centers in the basin dispose solid wastes in open damping disposal site. There are about 6,224,434 urban populations within the basin. Taking in account the solid waste generation rate of most cities and towns in the country and the basin itself for residential the amount is estimated to be 0.25 kg/capita/day, about 1,556 tons solid waste per day or 567, 980 tons solid waste per year is disposed in to open damping site in Abbay River Basin that eventually contaminates the surface and ground water resources and pollutes the ambient air quality

From the total volume of waste generated from the urban area the volume less than 50% is expected to be collected and transported to the disposal site. Generally there are poor waste management trends in the towns of Abbay basin; as a result there were many illegal dumping of municipal wastes on the river banks or on the roadside posing environmental and economic threats.

Figure 31 Solid waste damping sites of selected towns in Abbay Basin

The major reasons for this low performance of waste management in these towns include: inadequate and malfunctioning operation equipment, lack of properly designed collection route system , open burning of garbage, poor condition of the final dump site, insufficient funds and poor promotion on-waste reduction: like recycling, practice of energy option, waste separation and composting , lack of awareness, illegal dumping, lack of full private sector and community involvement, incompetence of organizations in terms of both equipment required for operation and man power qualifications as well as poor coordination and weak enforcement of the laws.

Figure 32 Liquid waste discharging sites of selected towns in Abbay Basin

i. Urban Wastewater

Wastewater is a combination of one or more of: domestic effluent consisting of backwater (excreta, urine and faecal sludge) and grey water (kitchen and bathing wastewater); water from commercial establishments and institutions, including hospitals; industrial effluent, storm water and other urban run-off; agricultural, horticultural and aquaculture effluent, either dissolved or as suspended matter.

Not all water that is consumed ends up as wastewater to be disposed of by sanitation systems. Some is lost in evaporation and cooking, some is lost in washing uses, and some is lost in watering gardens and vegetable plots. The amount of water lost is dependent upon the standard of housing and the traditional water uses. For example, in a low cost housing area water is usually at a premium and so none is wasted on what are perceived to be unimportant uses and the losses are generally low. On the other hand, in high income dwellings, consumption of water will be high and wastage on uses such as car washing will also be high. Population projections should be based on historic growth in the catchment area, together with projected housing and industrial developments and the programs of construction. When available, water consumption for an area should be used to estimate wastewater flow generation. At least ***50 to 80%*** of the water consumption reaches the sewer system (the lower percentage is applicable in semi-arid regions). If water consumption data are not available or an area is undeveloped, an estimation of flow per capita can be used to generate expected wastewater flow (Nozaic and Freese, 2009).

It is also possible to estimate wastewater discharge volume by using water consumption and supply information from the national GTP 2 plan. As per the GTP-2 water supply service level standard, it is intended to provide safe water in minimum 25 l/c/day for rural while in urban a minimum 100 l/c/day for category 1 towns/cities with a population more than 1 million, 80 l/c/day for category 2towns/cities with a population in the range of 100,000-1million, 60 l/c/dayfor category 3 towns/cities with a population in the range of 50,000 - 100,000, 50 l/c/day for category 4 towns/cities with a population in the range of 20,000-50,000 up to the premises, and 40 l/c/day for category-5 towns/cities with a population less than 20,000.

Table 13 Wastewater Projections in Urbana and rural areas of AB(m3/day)(2017)

Status	Estimated Population size	Daily water Consumption (l)/individual	Total water consumption(m3 /Day)	waste water discharge(m3)/ day	Estimated Monthly production of WW
Rural	24,545,846	20	490916.92	319095.998	9572879.94
Urban	6,224,434	50	311221.7	202294.105	6068823.15
Total				521390.103	15641703.09
NB; considering 65% of water reaches to sewer system as wastewater(WW)					

(Extrapolated from the above information and Socio economic data, 2009 E.C)

This figure indicates the volume of wastewater generated in the towns of Abbay River Basin. Most of the wastewater will continue to seep into the ground through pit latrines and soakage pits, evaporate as sullage thrown onto adjacent ground, or find its way into watercourses by being disposed of into street drains. It is only when wastewater is collected in a piped sewerage system to a central location for treatment and disposal that it becomes important to quantify the flows. This is not true in the case in any of the urban towns in the basin, and is unlikely to be for some time in the future.

Piped sewerage systems are not common or almost unknown in Ethiopia. Within the Abbay River Basin, only main towns are reported to have a sewerage system: Gondar, Bahirdar, Nekemt, Debereberhan, Debre Markos, Ambo. In general, the most common sanitation system in urban areas is the use of a dry latrine outside the dwelling. However, in some of the small and medium-sized towns, open defecation, usually in surrounding fields, is the most common method of disposing of body wastes. Very few dwellings have flush toilets connected to a septic tank and soakage pit.

In Ethiopia responsibility for urban water supply and sanitation rests with the regional Water Management Energy Development Bureaus but, because the Ministry of Health is known to be involved in the health and hygiene aspects of sanitation and that it constructs model latrines, and now working strongly to reach every households to have its own at least pit latrine. In this regard there is some confusion in the minds of some officials in the Bureau as to where the responsibility for sanitation lies. This problem needs to be addressed and the demarcation of responsibilities for sanitation needs to be clearly identified to all parties.

Although the urban sanitation situation is extremely poor, some groups are clearly aware of the health dangers of neglecting sanitation. An increase in concentrations of the pollutants should be anticipated if the major contribution to the sewage is from lower income groups. Conversely if the contributing area is a high-income area, the sewage will be of lower strength. The above table showed there could be high level of pollutants originated from urban wastes that could be discharged to water bodies in the basin without treatment.

5.1.3. Other Sources of Water Pollution

The survey study also found that many organizations such as slaughter house/ abattoirs, prison, schools, universities, garages and car washes have no waste treatment plant for reducing pollutions and they discharge waste below the standards set for waste discharge of the country in many of the urban areas of Abbay basin there is shortage of advanced system of discharging wastes from slaughters houses where large number of animals were slaughtered for their beef. Untreated slaughterhouse wastewater comprises a mixture of fats, proteins and fibers, resulting in a high content of organic matter and causes a contaminating effect to the rivers and sewage systems. It also increases nitrogen, phosphorus, solids and BOD5 levels of the receiving water body, potentially leading to eutrophication.

Figure 33 Garages & Car wash service on Abbay River

5.1.4. Incidence of Invasive Species

There are various species of invasive aquatic weed such as water hyacinth and Azolla plants invading Lake Tana and Abbay River. It was in September, 2011 officially declared since then it is rapidly intensified, 20,000 ha of the shore infested with Water Hyacinth in 2012 survey. Currently the weed was distributed in Dembia, Gondar Zuria, Fogera, Libokemkem and Dera districts and Bahirdar town administrative area at some places Abay river and wetlands around Peda Campus.

Azolla filiculoides (**water fern**) is native to warm temperate and tropical regions of the Americans. It is a floating aquatic fern with very fast growth, capable of spreading over lake surfaces to give complete coverage of the water in only a few months. The Azolla was introduced by Agricultural research center which was designed for improving the nitrogen fixation of the area by this small plant. The high growth rate of plant is currently trying to block the normal flow of water following the natural path

Figure 34 Water hyacinth in Lake Tana, Abbay River Bank and Azolla at the mouth of Megech River

6.15. Water Quality Overview of Abbay River Basin

Water quality refers to the chemical, physical, and biological characteristics of water. It is a measure of the condition of water relative to the requirements of one or more biotic species and or to any human need or purpose. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards used to assess water quality relate to health of ecosystems, safety of human contact, and drinking water

The water quality status of Abbay Basin is evaluated using the data collected from MoWR database, Abbay River Basin Master Plan Study Report (1998) and the Land and Water Study of the Blue Nile (1964). The WQ results reported by USBR, 1961 & BCEOM, 1997 are stipulated in Table-4.2. The location of sampling sites by USBR is depicted in Figure-4.2. Its collective usefulness is limited by its inconsistent nature. Interpretation and synthesis of this information, which would result in a more coherent understanding of water-quality conditions, trends, controlling factors, and process is a difficult and challenging task but would be of considerable value.

Although these samples are not representative of the whole Basin in terms of space and time, they do illustrate some physico-chemical composition of the water. The collected Abbay Basin Meta data are evaluated for compliance against: • "*Guideline standards for priority surface water pollutants with regard to protection ofaquatic species*" prepared by EPA, in August 2003 and waiting for Government endorsement and; • *"Ethiopian Guideline for Drinking Water Quality"*, prepared by MoWR in March 2002. Major findings of Abbay Basin surface and ground water quality are presented as follows.

The shallow depth nature of Lake Tana, (Max 14m & average depth of 8m), low temperature variation and presence of fairly strong wind after sunset generally allows the water to be well mixed (BCEOM, 1998). Hence there is no stratification layer in the lake. Table-4.3 presents the physico-chemical composition of Lake Tana analyzed in different years. Chemical composition of Lake Tana characterized it as Oligomesotrophic (Nagelkerke & BCEOM, 1997 cited by BCEO, 1998). The pH (long period measurement value) of Lake Tana is slightly alkaline and within acceptable range of ambient standard for aquatic species as well as for drinking purposes. The low TDS and EC value show that the water is soft and suitable for domestic purposes. The limnology part of the master plan study report by BCEOM (1998) associates it with low fish productivity of the lake. The primary production of the lake is dependent on the availability of carbonates, nitrates and phosphates which is evaluated in bulk by the EC measurement. The 6.5 mg-DO/l is the average value of 216 observations (Nagelkerke, 1997 cited by BCEOM, 1998). The report acknowledged that oxygen content of the Lake can drop down to nil without anoxic layer. Major towns like Bahir-Dar & Gonder and villages situated in the Lake Tana sub-basin don't own any form of waste collection and treatment facilities. Therefore, it is obvious that the waste is directly discharged to the lake. Hence, the population pressure and industrialization trend of the area will be pollution concern of Lake Tana in the near future. The physico-chemical water quality of the remaining smaller lakes and reservoirs is presented in Table-4.4. The samples were collected from the water bodies by BCEOM (1996). Their water quality results during sampling were within the acceptable range of ambient water quality standard set by EPA (2003) for aquatic species.

5.2.1. River water Quality

There is an indication of water quality deterioration of rivers in Abaybasin, it may increase rapidly if the trend continues as it is. Although the samples collected were not representatives of the whole basin in terms of space and time, the water quality status of Abbay basin is evaluated using the data collected on some water quality monitoring stations.

A total of 143 water samples at 19 sampling stations of the basin were collected with different seasons (summer, dry and spring seasons). The collected Meta data were evaluated with respect to guidelines provided by World Health Organization (WHO) and Ethiopian ambient water quality standards.

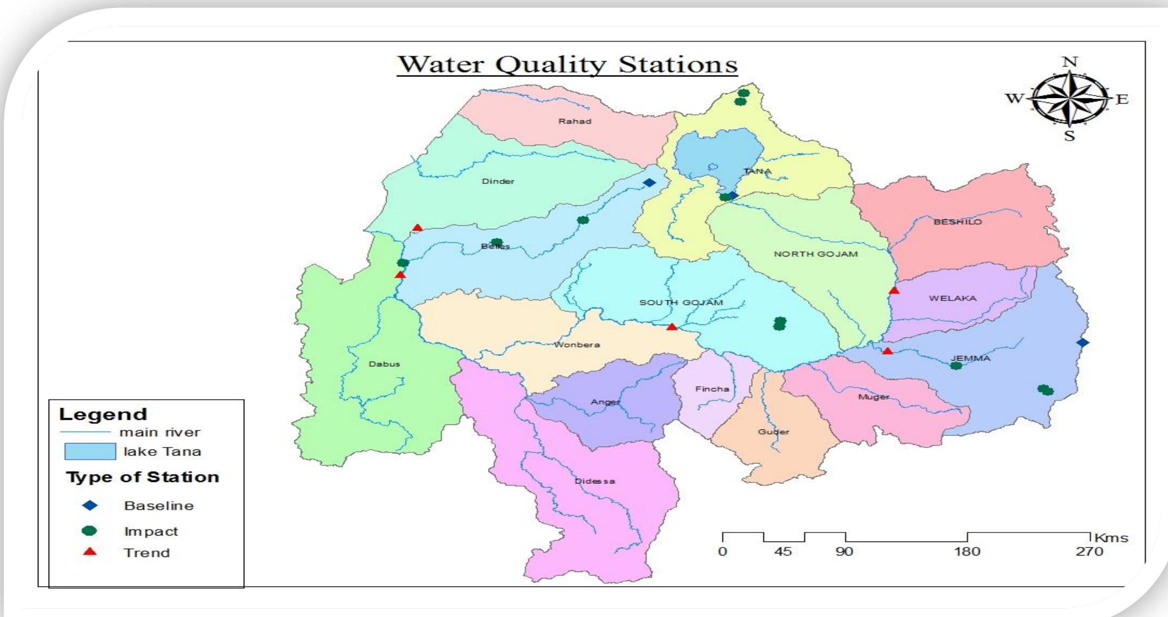


Figure 35 Water quality stations at Abbay river and its tributary where WQ data were collected

5.2.1.1. Physico-chemical parameters of water Quality

a) Temperature

Water temperature is one of the most basic physical parameters because it varies temporally and spatially, and affects many other factors such as conductivity, dissolved oxygen, density, etc. Temperature, therefore, is an important physical parameter which to some extent regulates many of the beneficial uses of water. “Temperature, a catalyst, a depressant, an activator, a restrictor, a stimulator, a controller, a killer, is one of the most important and most influential water quality characteristics to life in water".

The temperatures of water at the studied area were found between 13.7 and 25.8 and an average value of 20.25. It is known that the temperature of the water body is directly dependant of the surrounding temperature; and therefore it was higher at the dry season.

b) pH

pH is considered an important chemical parameter that determines the suitability of water for various purposes. pH of water is very important for the biotic communities because most of the aquatic organism are adapted to an average pH.

Changes in pH can change the aspects of water chemistry. For example, as pH increases, smaller amounts of ammonia are needed to reach a level that is toxic to fish. As pH decreases, the concentration of metal may increase because higher acidity increases their ability to be dissolved from sediments into the water. The pH of these river water samples were found in the range 5.3 to 11.5 and the average value were 8.05. It is ranged from weakly acid to basic characteristics (alkaline).

c) Total Dissolved Solids (TDS) and Electrical Conductivity (EC)

Total dissolved solids characterized mainly by major anions and cations are directly related to the electrical conductivity of the water. The low Electrical Conductivity (EC) and TDS value in general shows that the water is soft in nature and has low salinity. Moreover, the low conductivity is sign of low fertility of the water with regard to aquatic life.

Electrical conductivity (EC) measurements were ranged from 68 (minimum) to 750 (maximum) value. The highest value was recorded at the trans boundary station near Sudan border during the rainy season. TDS ranges from 44mg/l to 441mg/l, all values were within the recommended limit of WHO and Ethiopian standard.

d) Sulphate

Sulphate is the oxy-anion of sulphur in the +VI oxidation state and forms salts with various cations such as potassium, sodium, calcium, magnesium, barium, lead and ammonium. Potassium, sodium, magnesium and ammonium sulphates are highly soluble, whereas calcium sulphate is partially soluble and barium and lead sulphates are insoluble. Consumption of excessive amounts of sulphate in drinking water typically results in diarrhoea. Sulphate imparts a bitter or salty taste to water, and is associated with varying degrees of unpalatability.

Excess sulfate leads to problems for livestock ranging from reduced water intake to poisoning and death. At higher concentrations of sulfate, i.e. levels greater than 3000 ppm, are acutely toxic.

The average concentrations of $SO4^{2-}$ were 120.7 mg/l. But the recorded value was highly varied, between 2mg/l and 950mg/l. The highest value was observed at the trans boundary station after the confluence of all rivers in the basin.

e) Total Alkalinity (as $CaCO_3$)

The total alkalinity of water is a measure of its acid-neutralizing capacity to a designated pH. It is an aggregate measure of the sum of all titratable bases in the sample. Alkalinity in most natural waters is due to the presence of carbonate ($CO_3^{=}$), bicarbonate (HCO_3^-), and hydroxyl (OH^-) anions. However, borates, phosphates, silicates, and other bases also contribute to alkalinity if present. This property is important when determining the suitability of water for irrigation and/or mixing some pesticides and when interpreting and controlling wastewater treatment processes.

Alkalinity is important because it buffers the pH of water within the system. Without this buffering capacity, small additions of acids or bases would result in significant changes of pH, which could be deleterious for aquatic life. Alkalinity also influences the distribution of some organisms within aquatic systems.

The alkalinity values were ranged between 35 and 2700mg/l. There were high variations between the recorded low and high values. It is high during the rainy season at the extremely downstream sites.

f) Sulfides (S^{2-})

Includes all dissolved sulphide species (e.g. HS^- and H_2S etc), plus any acid-volatile metallic sulphides present in particulate matter. Contamination by industrial waste, sewage and presence of sulphate reducing anaerobic organisms may bring in sulphides in to the water. The decomposition of organic matter produces sulphides in sewage. The presence of sulphide indicates pollution in system and cause an objectionable of rotten egg odour. In most sampling stations, the recorded values of sulfide were zero, but the detected concentrations were ranged from zero to 1.7 mg/l.

g) Total Hardness

The hardness of a water is governed by the content of calcium and magnesium salts (temporary hardness), largely combined with bicarbonate and carbonate and with sulfates, chlorides, and other anions of mineral acids (permanent hardness). Cations of calcium, magnesium, iron and manganese contribute to the hardness of water. Although hard water has no effect on health but it is unsuitable for domestic use. It also forms heat insulating scales in the boilers reducing their efficiency.

The hardness of a water sample is reported in milligrams per liter (same as parts per million, ppm) as calcium carbonate (mg/l $CaCO_3$). Calcium carbonate hardness is a general term that indicates the total quantity of divalent salts present and does not specifically identify whether calcium, magnesium and/or some other divalent salt is causing water hardness.

The range of the hardness value at all observed sampling stations were from 65mg/l to 2050mg/l, critically varied. This high variation between low and high value of each parameter were depends on the nature of the station, the time of sampling (seasonally) and human activities around the station.

h) Salinity

Salinity is the measure of the concentration of salt dissolved in the water. Concentrations are usually expressed in parts per thousand (PPT) which can also be donated by the symbol ‰. Salinity measurements can be used to track the impacts of storm water runoff as well as the impact of drought. Salinity levels control, to a large degree, the types of plants and animals that can live in the water. Salinity can be measured either by physical methods (conductivity, density or refractivity), or by chemical methods (measuring the chloride concentration with a field test kit).

The salt content of water samples collected in the basin were ranged between 0.03mg/l to 0.16mg/l, which is within the acceptable limit.

i) Turbidity

Turbidity is a measure of the clarity or cloudiness of water, and is measured by the amount of light scattered by the particles in the water as nephelometric turbidity units (NTU). As well, there are aesthetic concerns with cloudy water, and particulate matter can clog water filters and leave a film on plumbing fixtures.

Moderately low levels of turbidity may indicate a healthy, well-functioning ecosystem, with moderate amounts of plankton present to fuel the food chain. However, higher levels of turbidity pose several problems for stream systems. Turbidity blocks out the light needed by submerged aquatic vegetation. It also can raise surface water temperatures above normal because suspended particles near the surface facilitate the absorption of heat from sunlight.

The recorded values were extremely varied, from 1.98 NTU to 1016NTU. During the rainy season the river water were highly turbid, sediment from the agricultural land were directly loaded to the water body. The observed value also indicate that the down streams were higher turbidity than the upper streams.

j) Nutrient Load

Nutrient concentration of surface water expressed in terms of phosphate and nitrate are usually the main causes of algal blooming in surface water. *Eutrophication r*esults from nutrients entering surface water, either from a point discharge or in run-off from agricultural land.

Nutrients enter the Basin’s waterways primarily through urban and agricultural storm water runoff. In between storms, nutrients, pesticides, volatile organic compounds, and other contaminants accumulate on impervious surfaces and are later washed into waterways during storms. Other sources of nutrients include wastewater treatment plant effluent and septic tank systems effluent.

Nitrogen as Ammonia- Ammonia (NH_3) is one of the most important pollutants in the aquatic environment because of its relatively highly toxic nature. It is discharged in large quantities in industrial, municipal and agricultural waste waters. In aqueous solutions, ammonia assumes two chemical forms: NH_4^+ - ionized (less/nontoxic) and NH_3 - unionized (toxic). Ammonia concentration were ranged from

Nitrogen as Nitrate- Nitrate (NO_3^-) generally occurs in trace quantities in surface water. It is the essential nutrient for many photosynthetic autotrophs and has been identified as the growth limit nutrient. It is only found in small amounts in fresh domestic wastewater, but in effluent of nitrifying biological treatment plants, nitrate may be found in concentrations up to 30 mg nitrate as nitrogen/L. Nitrate is a less serious environmental problem, it can be found in relatively high concentrations where it is relatively nontoxic to aquatic organisms. When nitrate concentrations become excessive, however, and other essential nutrient factors are present, eutrophication and associated algal blooms can be become a problem.

Nitrogen as Nitrite- Nitrite (NO_2^-) is extremely toxic to aquatic life, however, is usually present only in trace amounts in most natural freshwater systems because it is rapidly oxidized to nitrate. Higher concentrations may be present in sewage and industrial wastes, in treated sewage effluents and in polluted waters.

The nitrogen content of the recorded value was ranged 0.01mg/l to 2.9mg/l as ammonia, 0 to 25.8mg/l as nitrate and 0 to 0.98 as nitrite. All highest value was measured during the rainy season and at transboundary station. The main source of nitrogen is expected from the artificial fertilizers. Ammonia and nitrite concentration were beyond the limit set by Ethiopian standards.

Phosphate:-Phosphorous occurs most commonly in dissolved form as the inorganic phosphate (PO_4^{3-}) ion. Soluble Reactive Phosphorous (SRP), i.e. immediately available phosphorous and phosphorous that can be transformed into an available form by naturally occurring processes, is seldom found in quantity in non-polluted water as it is utilized by plants and sequestered in cells. Knowledge of the role of processes and mechanisms that control the supply of phosphate is essential for the management of catchments, rivers and lakes to avoid eutrophication. Phosphates may also occur, in agricultural runoff, industrial wastes, municipal sewage and synthetic detergents.

The statistics of phosphate reading has average value of 3.07 mg/l, minimum values of 0.11 mg/l, and maximum value of 25.2 mg/. The highest value of phosphate was recorded at Beles River where extensive irrigation activity is practiced and therefore it is very high when compared to standards set by WHO.

k) Iron

Iron can be present in a water supply in many different forms (soluble, chelated, organic, and precipitated) and may or may not be apparent to the eye. These forms include ferrous (Fe^{+2}) or dissolved iron, which is invisible, while the ferric (Fe^{+3}) or oxidized (rusted) iron becomes apparent through precipitation, and usually appears as brownish red colored particles suspended in the water.. Iron is generally present in surface waters as salts containing Fe (III) when the pH is above 7. The presence of iron in water supplies intended for domestic use is objectionable for a number of reasons that are unrelated to health. Under the pH conditions prevalent in drinking water supplies, Fe(II) salts are unstable and react with water to form insoluble hydroxides, which settle out as rust-coloured silt. Water in which this occurs often tastes and appears unpalatable and can stain laundry and plumbing fixtures.

Iron is a common water contaminant that is not considered a health hazard; however, its presence at elevated levels can cause aesthetic problems onornamental plants, buildings and structures, and its accumulation on irrigation equipment can lead to clogged emitters.

The average concentration of iron was 1.06mg/l and its minimum and maximum values were 0.01 mg/l and 8.6mg/l, respectively. At the tans boundary station where almost all human interferences with different activities were influenced in addition to natural sources, high value were recorded for most stations.

Table 14 Measured values of selected parameters for rivers water quality in the Abbay River Basin.

Parameters	unit	No. of samples	Minimum	Maximum	Mean
pH	pH unit	34	5.3	11.6	8.05
Temperature	^{O}C	34	13.7	25.8	20.25
Electrical conductivity	µS/cm	31	68	750	222.5
Total Dissolved solids	mg/l	31	44	441	132.7
Salinity	mg/l	25	0.03	0.16	0.13
Turbidity	NTU	31	1.98	1016	244.3
Alkalinity	mg/l	32	35	2700	367.2
Hardness	mg/l	25	65	2050	402.2
Iron	mg/l	34	0.01	8.6	1.06
Nitrate	mg/l	26	0	25.8	3.4
Nitrite	mg/l	34	0	0.98	0.14
Ammonia	mg/l	38	0.01	2.9	0.57
Phosphate	mg/l	38	0.11	25.2	3.07
Sulfate	mg/l	34	2	950	120.7
Sulfide	mg/l	28	0	1.7	0.26

l) Sodium and Potassium

The Na+ and K+ reading expressed in terms of Sodium Adsorption Ratio (SAR) is the useful parameter for the evaluation of the water body for irrigation purpose. For irrigation water it is important to measure the sodium adsorption ratio as follows:

SAR= $\boldsymbol{Na+/\sqrt{(Ca2+Mg2+)/2}}$

The higher the SAR value of the water the less suitable will be for irrigation purposes. The Water quality test results major rivers (USBR, 1996, and BCEOM, 1996 cited by BCEOM Abbay River basin study, 1998) indicated that the maximum computed value among the readings was 0.62 which was less than 10. This illustrates that the water is very much suitable for irrigation purpose.

m) Total Suspended Solids (TSS)

The EPA has set a TSS concentration standard of < 25 mg/l [annual mean] and < 50 mg/l [maximum value]. As a result of steep topography, strong seasonal rainfall and deforestation all the tributaries of Abbay are known to have significant sediment load during the rainy season. The monthly sediment load of Gilgel Abbay near Merawi, tributary of Lake Tana, is presented in Figure-4.2. The period of record is from 1982 to 1990. There is no data for Suspended Solid concentration value for the other tributary rivers in the Basin. The effect of high suspended solid on the aquatic life is well documented. It absorbs heat from the sun, increase the water temperature and thus cause the O2 level to fall down. The low O2 level has negative effect on reproduction of aquatic organisms. Suspended solids can clog fish gills, reduce growth rates, and decrease resistance to diseases and decrease egg and larva development of the aquatic life. Particles can also settle at the bottom of the river and smother the egg of fish and other aquatic organism.

n) Chloride

The chloride concentration of the rivers found within the Basin was very low (nil to 6 mg/l), at times of sampling in 1964 by United States Bureau of Reclamation (USBR). Hence the parameter was in conformity with the standard set by EPA (250mg/l for aquatic species).

5.2.2. Lake Tana Water Quality

Lake Tana water quality assessment has been made at various sites during August 2011 to July 2012 by TaSBO. The assessment result on the physical and chemical characteristics of the major tributary rivers of Lake Tana, river mouths and lake shore areas were significantly different from open station of the Lake. It has been realized that the major cause of water quality deterioration on Lake Tana were main tributaries and hence anthropogenic activities at the catchment areas.

Based on the assessment result, Lake Tana physico-chemical characteristics were described as follows.

The pH range was between 6.98 and 9.97; it is slightly alkaline of acceptable pH range. The temperature varies between 16.4^{o}c to 31.3^{0}c. It has low TDS (20 to500mg/l) and EC (60 µS/cm to 1000µS/cm) values acceptable limit based on WHO and Ethiopian standards. The turbidity value (ranges 5.1 to 989 NTU) with high seasonal variation, high during rainy season. The high turbidity were attributed from the poor farming activities which result in large quantities of top soil ending up in the river and the Lake after heavy rains.

The total hardness value ranges between 65 mg/l to 5300 mg/l which highly varied between the low and high values. The alkalinity value varies between 21 to 3630mg/l, ammonia value varies between 0 to 6.6mg/l, phosphate value varies between 1.55 to 15.8mg/l, and sulphate value ranges between not detectable to 1000 mg/l. Although the high values were recorded only during the rainy season, these high values were beyond the acceptable limit set by USEPA and Ethiopian standard.

Generally, the existing Lake Tana physical and chemical water quality were compared with United States Environmental Protection Agency(USEPA) aquatic life criteria, Canadian water quality guidelines for the protection of Aquatic life (CWQGPAL) and Ethiopian surface water Quality standards.

6. LAND DEGRADATION AND IMPACTS ON ABAY BASIN

Despite the natural and historical/cultural richness of the basin, natural resources have been poorly managed, and the basin has been critically degraded. Land degradation in the Abbay basin is mainly soil erosion by water, while chemical degradation (mainly soil acidity) has also expanding at an alarming rate within the last 50 years. Deforestation and conversion to agricultural land is still ongoing, thereby accelerating land and soil degradation. Considering the high dependence of the population on subsistence agriculture i.e.87% out of 28 million people inthe basin are rural and considering the basins role as a major supplier of agricultural products cites and the rest of Ethiopia; land degradation is the most important development challenge and negatively affects the livelihood of millions of people inside the basin in major sites of the country. Considering the high population growth (about 2.8% in rural and 4.55 in urban areas) and the growth of demand for consumption, the situation will be worse in the future if the current rate of land degradation continues unabated.

Long term test plot measurements in rural on farm observatories (SCRP 2000) show that soil erosion by water reach to more than 200 t ha^{-1} yr^{-1} and 170 t ha^{-1} yr^{-1} in the north – eastern and central parts, respectively, of the intensively cultivated highlands using subsistence agricultural means. This is alarming considering that 35% of the basin is cultivated (ENTRO 2006), which is in conformity to assessment made by Herni et al (2010), indicated that about 30% of the highlands of Ethiopia are cultivated, and about 50% of the cultivated lands are heavily degraded due to uncontrolled land degradation.

While the northern and north-eastern parts are already severely degraded as a result of many (i.e. hundreds of) years of human settlement and unsuitable agriculture, the central and south eastern parts of the basin, which have a high agricultural potential but are currently under high rates of land degradation both by sheet, real and gully erosion (figure..). The detailed analysis of the observatory watersheds showed that about 11% of watersheds are extremely degraded while about 50% are moderately to highly degraded, indicating that land degradation by water is extremely serious in these high potential parts of the Abbay Basin(WLRC, 2012). The situation is very alarming and deserves quick action, as the basin is almost losing its function as a bread basket for the region because of unabated land degradation. The major gorges and valleys of the Abbay River and its major tributaries are also devoid of vegetation and highly degraded because of uncontrolled deforestation over the centuries.

Figure 36 Land Degradation in Abbay Basin

6.16. On-site effects of land degradation

6.17. Soil Erosion Rates, Variability, Impacts and Sedimentation in the Abbay Basin

The Abbay Basin is currently experiencing a high soil erosion rate with quite large spatial variation, ranging from 0 in water bodies to 200 t ha^{-1} yr^{-1} on degraded slopes, and a mean area-specific value of 27.5 t ha^{-1} yr^{-1} for the whole basin. The corresponding absolute soil loss from the entire basin is 473 Mt yr^{-1}, of which 10% comes from gullies. The relative contribution from gullies will double if we assume the mean gully erosion to be 10 t ha^{-1} yr^{-1}. From analysis made by (Haregeweyn *etal.,* 2017) about a third of the basin's total area is being incised by gullies or river channels. The sediment yield varies from 0 to 40 t ha^{-1} yr^{-1} and has a mean value of 7.34 t ha^{-1} yr^{-1} for the entire basin. This implies that. 26.7% of the total soil loss, or 126 Mt yr^{-1}, leaves the country in the form of sediment yield. The equivalent volumetric value of this lost soil, obtained after dividing by mean dry sediment bulk density value of 1.2 t m^{-3}, based on Haregeweyn et al. (2006) is 105 Mm^3. The soil loss rates from this study are comparable to a mean soil loss of 29.9 t ha^{-1} yr^{-1} reported by a recent national level review of observed soil loss rates due to sheet and rill erosion at plot and small watershed scales (Haregeweyn et al., 2015a). As an extreme case, Hurni (1993) reported a soil loss rate of. 300 t ha^{-1} from cropland. Sonneveld et al. (2011), stressing the paucity of data, prepared a tentative nationwide map of mean annual soil loss in which soil loss varied markedly, from zero in eastern and southeastern Ethiopia to >100 t ha^{-1} yr^{-1} in the region including the Abbay basin.

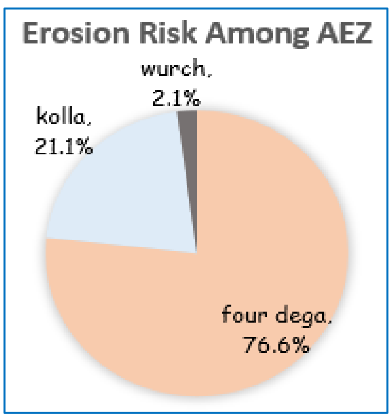
The estimated gross soil loss for the Abbay basin, which covers 16% of the nation's area, accounts for 31% of the national gross soil loss (1.5×10^9 t) estimated by Hurni (1988) on the basis of data from six soil erosion research stations. Hurni et al. (2015) estimated the gross soil loss at the GERD site to be 320 Mt yr^{-1} by applying a modified form of USLE (USPED), an estimate 25% less than Haregeweyne. However, their study did not explicitly account for gully or channel erosion, and they used relatively coarse elevation and rainfall data sources. The estimates of sediment yield variability within and total sediment yield from the basin are in reasonable agreement with most previous studies. A regional sediment yield study in the Abbay and Atbara River basins by Balthazar et al. (2013) reported spatial variability between 4 and 49 t ha^{-1} yr^{-1} whereas in Haregeweynes study the range was between 0 and 50 t ha^{-1} $yr^{-1}$and overall mean of 7.3 t ha^{-1} yr^{-1}. Betrie et al. (2011), using a SWAT model without accounting for channel or gully erosion, estimated a total annual sediment yield of 118 Mt at the outlet of the Abbay basin, which differs by 5% from modeling results. At El Deim station, Ali et al. (2014) used established rating curves for locations along the Blue Nile River network to quantify the long-term annual average sediment load at 130 – 170 Mt yr^{-1}, using three different approaches. Garzanti et al. (2006) estimated sediment budgets and erosion patterns based on the petrology of Nile River sands in Ethiopia and Sudan, reporting a gross annual sediment yield of 140 ± 20 Mt for the Blue Nile River at Khartoum, where the total drainage area is 330,000 km^2. The soil erosion rate in the Abbay basin is high at least by African standards (Vanmaercke et al. 2014).

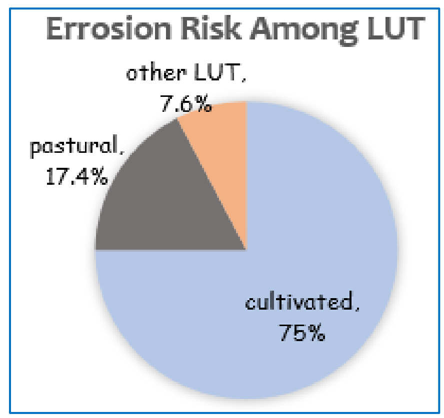
6.17.1. Prioritization of Soil Erosion-Risk Areas

Haregeweyene (2017), developed a factor-based scoring method for assessing erosion risk based on the different zones delineated based on erosion HRU in each of the four factor layers (agroecology, soil type, land use, and slope). Zonal average soil loss rates were extracted for each layer. Among the agroecology, the four Dega categories, which account for 67% of the basin area, contributed 76.6% of the total soil loss in the basin, ranging from 6.8% from the Wet Dega to 30.7% from the Wet Weyna Dega. The Kolla agroecology contributed 21.1%, and the three Wurch agroecologies contributed 2.1%. Of the 23 soil units in the basin, Eutric Leptosols and Haplic Alisols, which account for 40% of the basin area, generated 59.6% of the total soil loss. Among land uses, cultivated areas (intensively cultivated, mixed agriculture, state farms, and traditional lands) covered 68% of the total basin area and accounted for 75% of the soil loss, with a range from 37.8% in moderately cultivated areas to 11.8% in traditional land use types. Pastoral and agro-silvicultural areas accounted for 17.4% of the soil loss, and the remaining land use types together accounted for <10%. Of the slope zones, moderately steep slopes accounted for 32.4%, sloping land for 22.9%, gently sloping land for 18%, and very steep slopes for 18% of the soil lossAnalysis of soil erosion risk.

Haregeweyene (2017) estimated that over 77.3% of the basin is currently experiencing “moderate” to “very severe” soil erosion risk, of which 36.6% is “severe” and 1.4% is “very severe.” The remainder has “very slight” or “slight” soil erosion risk. We found a strong association between erosion-risk areas and population density in that 70%, 75%, and 54% of the very severe, severe, and moderate erosion risk areas, respectively, are in areas with high or very high population density 69% of the severe and very severe erosion risk areas are in areas where population density is very high, implying that slight erosion risk is a characteristic of very sparsely populated areas. This finding is consistent with the work of

Grepperud (1994) and others who have reported that under comparable physical conditions, heavily eroded areas in Ethiopia occur in highly populated regions. Similarly, the Global Assessment of Human-induced Soil Degradation (GLASOD) reports that the most severe degradation is commonly associated with very high population densities. But this trend may have reversed recently in some parts of Ethiopia outside the Abbay basin, consistent with a study in Kenya (Tiffen et al., 1994). Although there is a widespread trend toward increased removal of remnant vegetation, the trend has slowed and even reversed in some areas of northern Ethiopia because of the government's set-aside policy (Nyssen et al.,2004b). Other studies have found a significant increase in woody vegetation and SWC structures in areas with higher population densities, especially during the last two decades (Nyssen et al., 2009b, 2014). Riverbeds also have become stabilized after SWC interventions as a result of decreased runoff (Frankl et al., 2011, 2012, 2013, Nyssen et al.,2006).





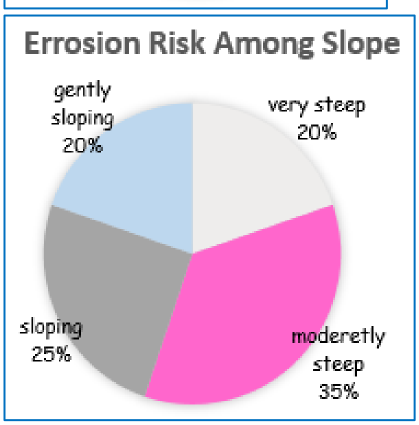


Figure 37 **Erosion Risk of Abbay Basin among different AEZ, LUT and Slope ranges**

Soil degradation in the Abbay River basin is mainly caused by water erosion. Sheet erosion (Wt) is the main type of water erosion and is covering the entire study area. There are some strong regional differences in the extent and degree of soil degradation. Soil degradation is most severe and frequent in the Eastern and Southern part of Abbay River Basin. Moderate levels of water erosion are occurring in the Lake Tana region, while the Western and Central parts of the Abbay basin are less affected by water erosion.

There are four main areas of high sheet erosion in the Abay Basin (Hydrosult Inc et al. 2006b). The first is the steep slopes around Mount Choke in East and West Gojam. This is an area of high rainfall which, because of the problems of providing effective water disposal structures, causes problems in developing physical soil conservation structures. The second area of high erosion hazards occurs in the Lake Tana Basin. This area includes the steep cultivated slopes around mounts Guna (South Gonder) and Molle (South Wello). A third, more restricted, area is found in the upper Jema Sub-basin in South Wello on the high hills north and west of Debre Birhan. A fourth area is located south of the Abay and encompasses the upper and middle steep and cultivated slopes of the Middle Abay Gorge in East Wellega. Two subsidiary areas with a high erosion hazard are the Upper Didessa Valley and along the escarpment hills to the west of Lake Tana in the upper Dinder and Beles valleys.

6.18. Off-site Impacts of Land Degradation in Abbay Basin

Soil erosion is having unprecedented consequences, both in Ethiopia and in the downstream countries of Sudan and Egypt. If this erosion rate continues, the sustainability of downstream reservoirs, including the nearly completed GERD, will be threatened by sedimentation. Moreover, soil erosion is also responsible for the export of sediment-bound nutrients, which are deposited in reservoirs and riverbed sediments. These nutrients could lead to eutrophication of reservoir water (Withers and Lord, 2002) in addition to loss of agricultural productivity in the contributing area. Adopting the sediment nutrient content data of Haregeweyn et al. (2008b), we estimate that each year, based on the present (2016) sediment yield value, 0.17 Mt of total nitrogen, 0.62 Mt of available phosphorus, and 1.89 Mt of organic carbon and other unquantified sediment-bound nutrients are exported from the Abbay basin. However, the current impasse surrounding the construction of GERD reservoir by Ethiopia seems to mainly arise out of perceiving only its potential impact in view of flow reduction to Sudan and Egypt. On the other hand, the analysis shows that the life of GERD dam itself will be threatened by the excessive sedimentation rate unless proper SWC measures are implemented in the upstream sub-basin. This situation could offset the concern raised by the downstream countries in that the dam could serve as silt-trap and flow regulation so that they will be less affected by sedimentation, pollution and flash floods. These negative consequences of soil erosion, together with the prospect of large water resource developments may present opportunities for cooperation along the Eastern Nile (Whittington et al., 2014).

6.19. Efforts on Sustainable Land Management in Abbay Basin and Current Status

Though agriculture has been started millennia ago in the Ethiopian Highlands (where Abbay Basin is located), large-scale conservation led by the government only started after the 1966-1974 great Aphelian droughts, which hit the north-eastern part of the Abbay Basin badly (Gete 2000, Hurni et al 2005, Hurni et al 2010, Hurni et al 2013). The soil and water conservation efforts mainly physical and biological measures of various kinds, afforestation (woodlot) and are a closure of degraded hills, gully rehabilitation and small-scale water development. Much of the effort has been concentrated at plot or small watershed level. Large scale sustainable land management was concerned in highly degraded and food insecure parts of the country, which induced the North and North-eastern parts of Abbay Basin. As a result the most productive parts of the basin (central, south and south western parts) were not given priority for natural resource management efforts of the government (Hurni et al (2013), Gete 2000, Gete & Hurni, 2001) however this has been changed in the last five to six years with a commitment of multimillion dollar, large scale initiative on sustainable land management in high potential areas in 2008. Since 2011, the government has also started a community mobilization program for watershed management throughout country. This is different from previous attempts because the policy makers have been involved directly at all levels.

Though there is a long way to go, the Abbay Basin indeed benefited from this two initiatives. The recent analysis of the SLM coverage of the Abbay Basin (as part of WLRC's IWS initiative) shows that 106,812 km^2 which is 61% of the whole basin that drains to GERD requires intensive SLM intervention. Out of this area only 9.5% of the area is fully terraced, 9% is partially terraced, 1.4 % of the area is covered by indigenous agroforestry system (mainly close to homesteads). This means the remaining 80% of the area need to be treated immediately while not forgetting the need to improve quality and sustainability of the already treated watersheds and those 9% partially treated watersheds. The Water and Land Resource Center of Addis Ababa University (WLRC) through its investment for watershed services (IWS) is now working to identify type and magnitude of SLM interventions on these area and what it requires both in resource and time.

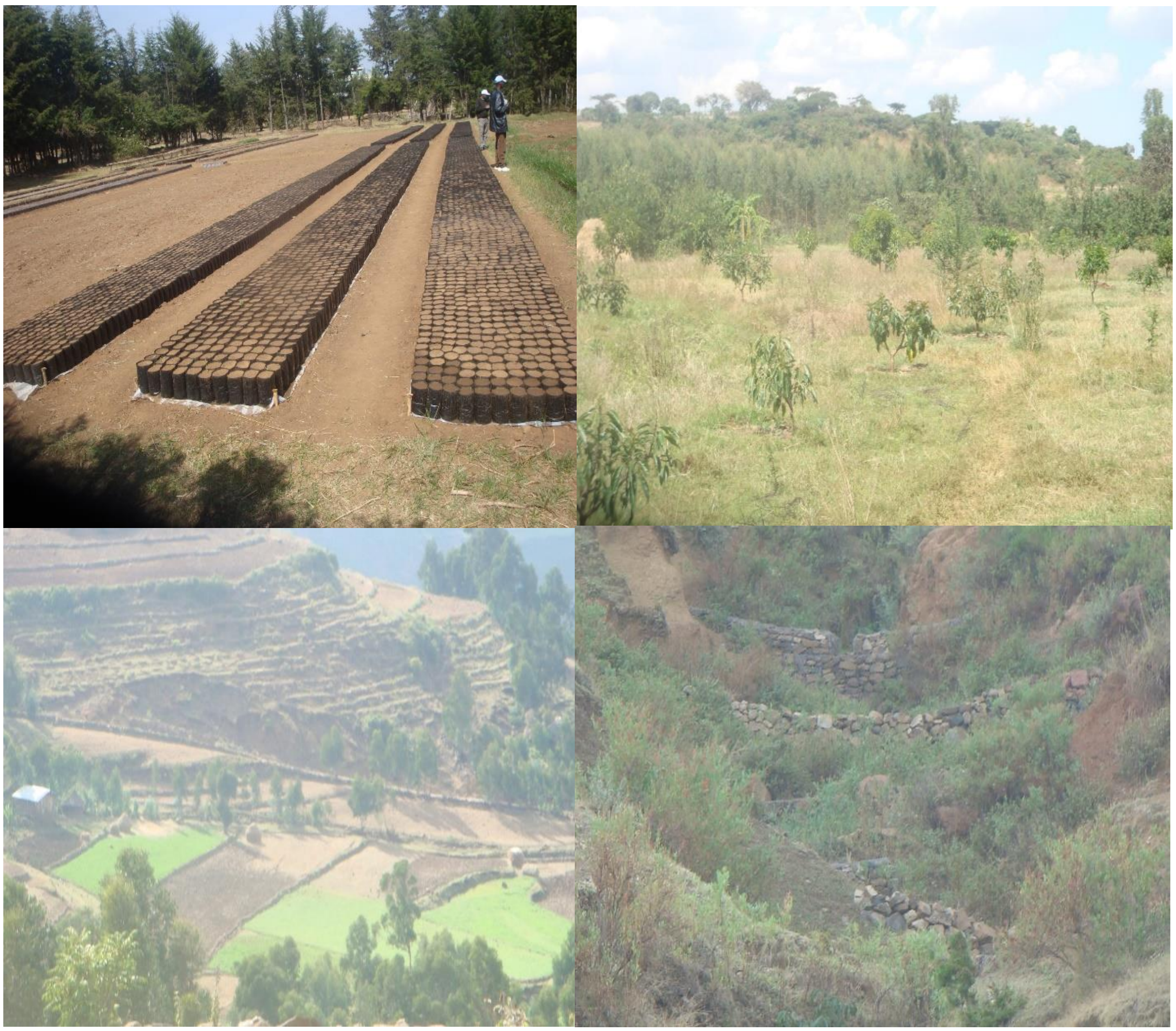


Figure 38 SLM activities performed Abbay Basin Authority

Unresolved Challenges: - In order to have these results a coordinated and systematic planning need to be established. However, the steps so far are not comprehensive enough, the federal and the regional states coordinate their engagements in terms of policy making, planning execution, decision-making, monitoring and evaluation processes, many spillover effects will not be addressed.

Most of the basin's population depends on agriculture for its livelihood. However, the combined factors of environmental and soil degradation, and adverse climate change, and drought have militated against adequate food production. The loss of soil and nutrients by erosion and the serious and worsening situation of moisture levels due to aver all environmental abuse have increasingly eroded the productivity of agriculture. The size of livestock, that has been a prominent source of asset building for centuries, has also declined owing to the disappearing grazing space, roughage, water supply and the various diseases that have cropped up from the consequent ecological disturbance and imbalance.

Worsening land fertility, landlessness has become a critical problem in the Basin, many young adults having no land of their own to depend on, and those that have access to land have to increasingly face less holdings leading to a situation where it is difficult to produce enough food to meet the intake requirements of the average household.

The marginalized former tries anything to survive by working on the land that he or she is not supposed to, like plowing on the mountains or face migration to the cities to face the unexpected challenges. The construction of the grand renaissance dam is underway through the public and government financing. The soil and water conservation activities in the basin, Amhara, Oromiya and Benishangul-Gumuz, are also in progress to help reverse the environmental damage. The public commitment of these regions, in soil and water conservation, would help reduce the problem of siltation in the Dam and increase the supply of water that can sustainably feed the Dam and generate power with a continuous flow of water to the neighboring countries.

Figure 39 Unresolved challenges in the Abbay Basin

7. CONCLUSIONS AND RECOMMENDATIONS

6.20. 7.1 Conclusions

The Abbay Basin provides the major water supply of the Nile River along with other demographic and ecological assets. At a time when freshwater is increasingly in high demand, the Abbay Basin has been continuously supporting livelihoods and right along world famous civilizations within and outside of its enclave. Abundant water resources and many rivers are draining in the Abbay River Basin and featuring the biggest freshwater lake in the country, Lake Tana, which is the largest in the country. However, the absence water quality monitoring stations and consistent water quality monitoring data was the core problem to define the current water quality status of water resources in the Basin.

Urbanization and industrial expansion with in the basin is growing from time to time but the waste management practice is primitive and business as usual except some few industries that install proper waste water treatment technologies. Most industrial establishments and urban centers are disposing their wastes in to the environment without proper handling and treatment.

The Basin has been an important source of biodiversity, food, wildlife, bird life and stunning scenery of diverse ecology ranging from desert like environment to alpine conditions. However, the Basin's natural resource including its biodiversity, socio-cultural values and relics have seriously been affected by its century's long ***environmental degradation***. There has not been adequate attention paid to the Abbay Basin despite its monumental role as a lifeline to millions of people and biodiversity in the country and in the region.

Though awareness-raising efforts about the importance of sustaining upstream environmental integrity have been made, there has hardly been any investment to shore up the Basin's development. Hence, the Basin's acute degradation has been there for all to see with dismaying consequences such as acute food shortages and regrettable displacement of the hungry, regional warming, wastage in farmable space and loss of wildlife.

Unless the acute ***environmental degradation*** of the Basin was addressed properly and reversed, the desired tenure of the Dam was in question. Furthermore, to the extent that water was the prime mover of the whole enterprise, it was thought that every effort needed to be exercised to increase and sustain the water supply of the Basin for reliable use by both Ethiopia and the riparian countries downstream.

Considering the vastness of the Basin and the severity of its degradation, the Basin Authority was of the view that unless the whole reclamation effort was driven by the people living in the Basin and supported by the remaining population of the country, the desired development would be neither affordable nor sustainable. The public's passion to finance the cost of the Dam by purchasing bonds has been encouraging and can also be taken as an indication of commitment incorporated with other Basin's development activities.

From this environmental renewal, our wildlife will return opening up wider possibilities for tourism. Our biodiversity will also be restored. Furthermore, with the stabilization of climatic conditions, we can count on forestry as one strategic sector of industry. In the final analysis, as people's livelihoods improve based on the fruits of their labor rather than on their exploitation of the environment, I the balance between nature and development will be increasingly enhanced and from this wisdom sustainable interdependence will be achieved within the basin and beyond.

We saw that land degradation in the Abbay Basin is very alarming, with serious consequences on livelihoods of people within the basin, as well as other parts of the country and on sustainable utilization of GERD. This is true because nearly 87% of the population living inside the basin is directly dependent on subsistence agriculture and the basin is the major supplier of agricultural products to major cities of the country. The off-site implications of land degradation in Abbay Basin particularly related to siltation of GERD and other water storage structures and irrigation schemes is also worrying. Thus, the improvement of livelihoods with in the basin and the sustainability of GERD and its multiple benefits to Ethiopia can only be maintained and passed for generations if the Abbay Basin is managed properly with IWM that has dimensions beyond restoration of degraded lands.

Despite the positive impacts of land management in pockets areas of the basin and elsewhere in Ethiopia, it remains a challenge for Ethiopia to address land degradation in a holistic manner and throughout the basin. This is mainly attributed to lack of proper awareness about the purpose of IWM and its desired end results at all levels, very weak technological integration (only focus on SWC and some plantation), limited investment and lack of suitable resource mobilization strategy, weak institutional integration and poor implementation of support actions for sustainability. Therefore, it is strongly recommended that the IWM initiative should address the above gaps in line to the recommendations made.

Abbay River Basin has the largest proportion of wetlands that exist in Ethiopia. Among the most figurative sub basins that have significant all season wetlands are Tana , Didessa, Dabus and Fincha sub basins. South Gojjam sub basin also has considerable wetlands while Beles sub basin has seasonal wetlands that exist in the rainy season most commonly. The current wetland management systems are not well organized.

Wetlands found in the basin provides quite a lot of services to the surrounding community being source of raw materials, and source of food, shelter and breading center for aquatic species like fish and larger mammals. Wetlands of Tana and Fincha Sub basins are host centers of indigenous and migratory birds that come from Europe and Middle East countries during the cold season. In addition these wetlands are sources of varieties of plant species used for artefacts and serve as carbon sequestration like papyrus.

The management of these wetlands is very poor and unsustainably exploited and endangered by illegal encroachment, free grazing and agricultural expansion. Significant wetland area in shesher and welela wetlends around Lake Tana losses are observed in less than a decade. This was because of irrigation and recession agriculture expansion, and absence legal frame works that direct the conservation and sustainable utilization these biodiversity enriched environmental endowed resources.

Wetlands are not waste lands rather they are wealth lands, if we properly manage and use them. Nowadays wetlands are getting attention for their eminent ecological, socio-cultural & economic importance. Their importance is significantly recognized by rural communities as sources of, among others, food, water & pastures & as last resorts for survival during dry seasons & drought times. It is also vital to underscore that besides their local & national importance, the wetlands of Ethiopia including the Abbay Basin wetlands have global relevance, among others, in their biodiversity hotspots, nesting/stopover/breeding sites for migratory birds & climate change mitigation & adaptation.

In spite of the above, the wetlands of the Abbay Basin have not yet received the attention they ought to get. One of the basic reasons for this situation is that issues of wetlands have not been well mainstreamed or treated separately in the contents of national policies & other pertinent documents. But they are briefly or implicitly addressed within policy contents of sustainable development, conservation and wise use of natural resources. As a result, implementations of such policies have barely dealt with problems of wetlands in Ethiopia.

Thus the commitment of decision makers to introduce wetland law and put in place a workable institutional arrangement is critical. Local communities are the immediate beneficiaries of wetlands and are also first level victims of wetland loss. The participation of local communities in wetland management is of paramount importance. Community based organizations need to be strengthened by developing laws in order to regulate wetland abuse, enhance wise use and lead in planned manner. Developing and implementing management plans through active participation of the communities in a way that addresses their vision and objectives is also basic to materialize wise use of wetlands at community level.

6.21. 7.2 Recommendations

- Although the effort to address land degradation threats by government, communities and development partners is approached, the challenge is serious and requires more systematic approach end actions. The following sections describe such actions to be recommended in extensively.
- ***Better knowledge about the purpose of IWM at all levels***: The purposes of implementing IWM are to ensure rational utilization of our natural resource base without compromising the future generation and combat the threat of land degradation and climate change. The end results of IWM are: i) improve environmental quality, ii) improve livelihoods and iii) improve resilience (both communities and environment). However, most of the IWM interventions in the basin are not implemented with full knowledge of the above by all actors. If we have to minimize the impact of land degradation (both on-site and off-site) to acceptable level in the basin and thereby improve livelihoods and ensure sustainability of GERD, proper understanding and awareness of the purpose of IWM and its end results by communities and all actors involved should be a precondition. This requires proper awareness creation at all levels and preparation for implementation.
- *Strengthen the IWM Initiative with improved quality and magnitude*: .
- IWM is seen only from the perspectives of constructing physical SWC structures and applying biological treatments on the land. The impact of these isolated interventions both on the environment and livelihoods is only visible on long time horizon. If we want to get the required positive impacts of IWM quickly, which is very much needed for GERD, we need to integrate other technologies like soil fertility management, soil moisture management, introduction of improved crop varieties animal breeds and most importantly introduction of improved farm mechanization implements and use of fuel saving stoves.

- *In* Abbay River Basin there are many institutes working on the broader aspects of IWM. Form the government the following offices such as Bureau of Agriculture, Bureau Environmental Protection, Bureau of Water Resources, Forestry Agency, Livestock Agency and Abbay Basin Authority are directly involved on managing the landscape in different forms. There are also different Development Partners, Research Institutes and NGOs do the same in collaboration with the government or directly by themselves. While having many players is very much needed to address the challenge, there is very big gap in integrating themselves. At the end it will be difficult to get the required result as efficiency and effectiveness are lost in between. It is thus very important that real integration among key institutes is achieved at all levels (planning, implementation and ME) for better results.
- Emphasis on Sustainability of the integrated watershed management works rather than the quantity.
- ***Mobilize Resources for IWM****:* all the above suggested improved interventions require availability of adequate resource. If we want to make various physical SWC measures implemented on farmlands gullies and degraded hills productive and sustainable we have to enrich them with biological planting materials. The same is true for homesteads and plantation sites. This requires establishment of nurseries in every corner of the basin (at least one within medium size watershed ˜1000ha at least within major hotspot areas. Every homestead should be converted into a productive land as it has immediate impact on livelihoods of rural communities, food security and enhance their confidence and trust on IWM. Improved technologies, including those farm implements that save time and energy, should be extensively disseminated and used. Improved crop varieties and livestock breeds should be an integral part of the IWM intervention in every community watershed. Social services such as water supply, flour mills, animal health clinics, feeder roads, small-scale irrigation| schemes and market Infrastructure should also be an integral part of the IWM intervention. All these and others required financial resources. The question is how to get this resource?
- ***Soil Conservation****:* This activity needs to target degraded, cultivable areas and closed areas. The degraded areas have been depleted so much that cultivation has ceased to be viable. However, these areas can be rehabilitated considering enabling moisture levels in

the Basin. The more they are rehabilitated the less the onset of problems like gully formation, soil removal and siltation in downstream Dams and forms. Most of these areas need to be at rest to bring out their own inner forces of rejuvenation. But considering barrenness, work such as terracing and the planting of trees and shrubs need to happen. The banked seeds in the soil will regenerate when the favorable conditions facilitate such development and the biodiversity will be enhanced. Some of recommended activities those should be implemented accordingly are listed as follows:

- ✓ Physical Controls: Gabions, Stone and Soil Bunds, and Terracing
- ✓ Biological Controls: Grasses, Fruit and non-fruit trees, Forest and biodiversity Development, Conservation and Utilization, Tree Planting in Closed Settings, Mixed Use Forestry, Commercial Forests, Nurseries, and so on.

- ***Monitoring and Evaluation:*** The development of the Abbay Basin Watershed is going to require massive resources. The fact of the matter is that resources are not enough to get desired outputs and outcomes. The organization and utilization of the resource matters also. Unless value of long-term impact is added from the resources invested there is a risk that the whole thing might be difficult leading to sour taste and retreat in public support. To enable ongoing efficiency and effectiveness and public acceptance, there has to sustained, transparent, open and active monitoring and evaluation. To help in the objectivity of such functions, dear indicators of performance and impact dovetailed to desired results need to be in place and internalized by all involved. The monitoring and evaluation should target both individuals and organizations that are engaged in the work. Evaluating systems alone would not be of effect as systems are molded and shaped by individuals. Evaluating individuals alone will not do as systems have a way of becoming ends in themselves. Both have to be evaluated to locate the problems and opportunities and work for change from that grounding.
- ***With the dependence of Ethiopia on natural resources, conservation must be a top government commitment.*** With an estimated 85 percent of the population dependent directly on the land for their livelihoods, and with increasing trends toward and acknowledgement of land degradation in Ethiopia, it is critical that conservation become a top commitment of the government of Ethiopia. Although there is an extensive and progressive framework of policies and agencies, management of natural resources is continually hampered by unclear and contradictory policies, a lack of clear authority between regional and federal bodies, and

poor enforcement. With the firm commitment of the government, these issues can be addressed; however, as long as people feel that policies are on paper only, they will never realize their objectives. With the recent re-elevation of the Wildlife Conservation Organization to an autonomous authority under the Ministry of Tourism and Culture, the federal government has shown signs of taking conservation more seriously. This development must be supported if degradation of the land and biological systems is to be reversed.

- ***Communities need direct economic returns to support protected areas and conservation programs.*** Without revenues from conservation activities equal to or greater than forgone benefits from previously utilized resources (whether decreased use or a complete cessation of use), local support for conservation activities will be unattainable or short-lived. However, programs with clear and substantial returns from conservation activities should be successful and sustainable as communities will support them. Whether through ecotourism, pastureland improvements, or watershed protection, the same principle is critical: Revenues need to be sufficient (although not necessarily cash) and tied directly to conservation.

  - ✓ To take forward the study of wetlands in the Basin and improve their management and contribution to development, it is necessary to make an inventory of the wetlands in other sub basins with special emphasis on their extent and nature.
  - ✓ This assessment of wetlands in this Basin has indicated that the absence of clear and exact data that indicate the location, area coverage and types of wetlands that the Basin exactly endowed from nature and human made activities. Hence, detailed inventory of wetlands has to be performed to know and conserve it.
  - ✓ At the national and regional level there is wetland conservation and management policy and legal frameworks. In spite of this fact the Authority has to push and coordinate the relevant organization to formulate the desired legislations.
  - ✓ Awareness creation workshops and brochures has to be made at the community level wherever the wetland exist in order to avoid the deliberate destruction of wetlands.
  - ✓ Ecotourism and carbon trading has to be developed in the sub basins that centered wetlands in order to facilitate the conservation of wetlands and decrease the threats.
  - ✓ Some wetlands can lose their vigour at an alarming rate due to unwise management. The problem needs integrated problem solving approach through realizing the

collaboration of relevant stakeholders from policy level down to grassroots community. Decision makers, communities, private sectors and all others who have stake in wetlands.

- ✓ Decision makers at all governmental and NGOs organizations especially Woreda level have significant role in ensuring wise use of wetlands in their jurisdiction. Through coordinating Woreda level stakeholders and assisting kebele administration they can halt wetland degradation and improve its situation.
- ✓ Decision makers at higher levels are required to strengthen sustainable wetland management efforts through effecting legislation, improving institutional arrangements and supporting capacity building initiatives.
- ✓ It is appropriate to assess the significance of wetlands and their environs for national development, and also the consequences of wetland degradation.
- ✓ Perform participatory watershed management practices at the upper catchment of wetlands that will help them self-protection from recession agriculture.
- ✓ Devise self-reliance programs for the communities settle around threatened wetlands in order to cover the food shortages occur after post harvesting seasons since wetlands are encroached by farmers for the purpose of producing food crops that will transit them to the main harvesting season.
- ✓ Differentiate wetlands that will serve for agriculture, eco-tourism purposes and ecological functions.

- Alien Species problem is one of the causes of biodiversity loss. Although no detailed studies have been available on their impact, they are causing enormous problems in the various ecosystems and the economy. The ecosystem diversity loss is increased time to time in alarming rate in the basin. This tragedy is happened due to many reasons which could be tackled immediately before it reaches on the point of impossible to avert the problem. these causes may direct or indirect. The direct threats and root causes of ecosystem biodiversity loss are: clearing for agriculture, over-cutting and unsustainable levels of harvest, overuse of park resource, over-grazing, poaching and hunting, alien invasive species, uncontrolled fire, climate change/drought, replacement of local varieties and breeds. On the other hand the loss may aggravated due to the following indirect causes like, demographic change, poverty, low level of awareness and lack of coordination**.** Alternative energy sources had better be accessible to minimise the pressures exerted on forests for the purpose of cooking.

- Establishment of conservation sites in the basin by systematic prioritization is necessary to mitigate developments. Biodiversity loss must be stopped or otherwise our future generations will find it extremely hard to survive. Here are some possible recommendations on how to halt biodiversity loss.
- ▪ First of all there is a habitat loss issue. Human population is constantly growing, needing new areas to live in which reduces the animal habitats. Many animals are going extinct because their habitats are constantly shrinking (for instance Bengal tiger). World needs to establish more protected areas free of humans because this is the only way to stop further decline of many animal species.
- ▪ Stop climate change from running out of control. Many plants and animals are finding it very hard to cope with the changes in climate, and many of them will forever perish from the face of our planet unless we stop climate change from becoming worse. In order to tackle climate change world needs international climate deal that would reduce greenhouse gas emissions on global level.
- ▪ Stop deforestation. Tropical rainforests are the areas of the richest biodiversity in our planet, providing living environment for millions of different species. Rainforests also play important role in sinking carbon dioxide (CO2) from the atmosphere which is extremely helpful in fight against climate change.
    - ✓ Reduce environmental pollution. Many plants and animals are finding it extremely hard to survive in polluted environment. Pollution is not only happening in land but also in our oceans having very negative impact on marine biodiversity. Animals and plants can't thrive in polluted environment.
    - ✓ Protect native ecosystems from invasive species. Invasive species more often than not do serious damage to native ecosystems, and reduce the success rate of conservation efforts.
    - ✓ Biodiversity also needs to be more studied in order to give us the necessary knowledge needed to protect animal and plant species from going extinct.
- The greatest threat to most wild species is reduction of habitats as we increasingly occupy or degrade more of the planet earth. Because of the increasing population pressure there are

frequent encroachments by man that resulted in widespread destruction of wildlife and their habitats. As a result of intensive human pressure most of the faunal and floral resources are now at risk. In areas like BGRS where the ecological processes are complex and poorly understood, conservation targeted to plant communities is the most recommended option.

- National Parks and Wild Life Conservation Areas are home of precious wildlife: Lion, Buffalo, and Elephant. Investment, wildfire outbreak, illegal hunting for wildlife meat and ivory are potential threats of wildlife conservation and sustainable utilization. Therefore law enforcement and advanced wildlife conservation measures are strongly recommended to sustain our precious natural ecosystem with precious wildlife diversity and population.
- Wildlife diversity in all localities is magnetic international tourists attraction. Despite taking long duration to establish National Parks, like Alatish, decisions on legalization and development activities are still going in time to maintain natural status. Indeed, it is a responsible decision on designation of parks for conservation, sustainable use, ecological and economical services for present and future generation. Study, boundary demarcation, legalization, organization of manpower and facilities and infrastructure development requested strong commitment and endeavor, as seen, still many of management activities going on in the same way. Moreover, another biodiversity and water source areas like Mount Guna requires demarcation and gazettes as a park and reservation areas.
- The large livestock population and declining pasture and animal feed in the basin are threats to the environment. However, the livestock sub sectors suffer from low productivity, poor genetic makeup of indigenous breeds, diseases and critical shortage of pasture. Breed improvement program was not effective to address the rising demands of farmers for improved breed of animals. Degradation and critical shortage of pasture resulted in severe shortage of animal forage and feed. Efforts made to improve availability of animal feeds in the watershed are not to expectations. Communal grazing lands are shrinking with land registration and certification. In order to solve the shortage of animal feed, significant number of households adopted backyard, cut and carry system. Absence of central or basin wide water laboratory can be mentioned as a core issue contributing for lack of regular water quality monitoring in the basin. The basin lab should have to be well staffed and equipped with sophisticated equipment. At this level it is expected to conduct applied research on the basin WQ problems, training of staff at all levels in the basin

- In Abbay Basin there is a need to conduct regular water quality monitoring program to characterize the water quality, understand the general condition of the water, and determine if degraded water quality exists.
- In order to address the water quality monitoring program in the basin the existing regional institutional frameworks with basic laboratories should be expanded and capacitated to produce a more comprehensive and coherent information on water pollution
- Implement polluters pay principles
- ABA should be responsible for the organization of the project in terms of standardized sampling and testing methods carried out by different regions as well as data collection, compilation, analysis and report writing at basin level.
- The ABA and EPA should be actively involved in the basin to implement the ambient water quality standard and standard for industrial pollution control. Proper solid and wastewater management practice should be exercised through community, NGO, CBO participation.
- Information and education are important tools to create awareness on prevention of water pollution and maintaining of water quality and its relation to negative environmental impacts. Such awareness could lead to improved behavioral change in preventing the contamination of surface and groundwater of the basin. The information and education program should create an appreciation to the rights of the people to safe water and their responsibility to use and maintain it wisely.
- Industries have to build their own or common waste treatment plant or the government may built common waste treatment plant to motivate investors and can collect the building cost from industries by the amount of effluent they discharge and the degree of pollution that the effluent contribute.
- There is a need of strong coordination of local government, environment and protection and land use planning, and health organizations to work together to ensure that sanitary disposal of municipal waste in the basin.
- The municipal sanitation, beautification and park offices should have to be equipped with appropriate experts and required equipments to develop and implement effective program of both solid and liquid waste disposal and sanitation system.

- It was found that one of the reason for the poor waste management in the towns of the basin was due to weak reinforcement of the law so that there is a need of strict enforcement of the law and progressively provide for continuous reviews and updates of legislation so as to tailor it to suit, as well as enable it to attain the vital coping mechanisms to deal with new developments and future challenges of wastes and adopt the principle of extended producer responsibility as it is increasingly practiced in several industrialized countries.

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ANNEX I: COMPARISON OF WATER QUALITY DATA WITH WHO, AND ETHIOPIAN STANDARD

No.	Parameters	Unit	Measured Result	WHO standard	Ethiopian Standard	Remark
1	pH	pH unit	5.3-11.6	6.5-8.5	6-9	Alkaline
2	Temperature	^{O}C	13.7 -25.8	25		
3	Electrical conductivity	µS/cm	68 -750	1000	1000	
4	Total Dissolved solids	mg/l	44 -441	1000		
5	Salinity	mg/l	0.03 -0.16			
6	Turbidity	NTU	1.98 -1016	<5		Critically high
7	Alkalinity	mg/l	35 -2700	400		Critically high
8	Hardness	mg/l	65 -2050			Elevated value recorded
9	Iron	mg/l	0.01-8.6	2	1	High iron conc.
10	Nitrate	mg/l	0 -25.8		50	
11	Nitrite	mg/l	0 -0.98	0.03	0.1	
12	Ammonia	mg/l	0.01-2.9	1.5	0.25	
13	Phosphate	mg/l	0.11 -25.2	0.7		High phosphate Record
14	Sulfate	mg/l	2 -950	250	200	Critically high
15	Sulfide	mg/l	0 -1.7			

ANNEX II: IDENTIFIED AND PROPOSED ENVIRONMENTAL ISSUES

Three broad major Environmental Issues were identified based on the environmental assessment of the river basin that had to be considered in Basin Planning. These are:-

1). Environmental Pollution arises from point and non-point sources as a result of poor waste management practices

2). Deforestation and land degradation mainly caused by anthropogenic activities

3). Incidence and spread of invasive species especially water hyacinth on Lake Tana and Abbay River