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Nile Trans-boundary Environmental Action Project (NTEAP)
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Foreword

The Nile Basin Initiative (NBI) is a partnership between riparian countries of the Nile; namely Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, and Uganda. The NBI's shared vision is to "achieve sustainable socioeconomic development through the equitable utilization of, and benefit from the common Nile Basin water resources". To translate this shared vision into action, there are two complimentary programs: the Shared Vision Program (SVP) which creates a basin wide enabling environment for sustainable development; and the Subsidiary Action Programs (SAPs) engaged in concrete activities for long term sustainable development, economic growth and regional integration of the Nile Basin countries.

The Nile Transboundary Environmental Action Project (NTEAP), one of the projects under the Nile Basin Initiative's (NBI) Shared Vision Program, was mandated to provide a strategic environmental framework for the management of the transboundary waters and environmental challenges in the Nile River Basin. One of the ways NTEAP met this objective was to document the national available information on wetlands and biodiversity in the Nile Ethiopia so as improve their understanding and plan for their management.

This report has been prepared from contributions by national experts who appraised information by deskwork to come up with a situational analysis and description of the status of wetlands and biodiversity in the Nile Ethiopia. Gaps have been identified in the information and recommendations have been made to involve as many stakeholders and possible in order to enrich the gaps through research. It is hoped that this report will promote a regional approach to the conservation of wetlands and biodiversity and will enhance documenting ad enriching our understanding in the management of wetlands and their biodiversity.

We hope that the report will be useful to managers, instructors, educators, tour agencies and all stakeholders wishing to contribute to conserve Wetlands in the Nile Basin..

Gedion Asfaw
Regional Project Manager
Nile Transboundary Environmental Action Project

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The Nile Transboundary Environmental Action Project

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Acronyms and Abbreviations

CAFF	Conservation of Arctic Flora and Fauna
CBO	Community based Organization
EPA	Environmental Protection Authority
EWHNS	Ethiopian Wildlife Natural History Society
FWL	Fish and Wildlife
MoWR	Ministry of Water Resources
NEDECO	Netherlands Engineering Consultants
NGO	Non Governmental Organizations
NTEAP	Nile Transboundary Environmental Action Project
UN/ECE	United Nations Economic Commission for Europe
USBR	United States Bureau of Reclamation
US EPA	United State Environment Protection Agency

Executive Summary

i) Water quality profile in the Ethiopian Nile Basin

More than 91% of the population in the Nile Basin within lives in rural areas (Fitsum Merid, 2006). The economy is dominated by agriculture with very little of other services in terms of small scale industries. In the rural part of the highland, mixed farming is practiced. Production of cereals, pulses as well as rearing of livestock is common. The majority of the population in the basin within Ethiopia could be categorized as very poor. This is reflected in poor nutrition, short life expectancy, low access to potable water and sanitation etc. The Basin's population in general is expected to triple in the next 50 years (Fitsum Merid, 2006) this) which will place enormous pressure on the land based economy. Given the current trends, the land in the basin cannot absorb the projected population (BCEOM).

The Nile basin portion of Ethiopia is generally characterized by steep slopes and erodible soils (Fitsum Merdi, 2006). It has high intensity, short duration rainfall confined to a four month period (July to October). During the wet seasons, the rivers are full of suspended soils. Deforestation and population on the marginal highland areas are major threats of the basin. Thus far no regular water quality monitoring programs are in place in the sub-basins. The limited intermittent efforts by Federal and Regional Governments bureaus focus on quality control of water supply. The awareness and participation of communities, CBOs, NGOs regarding water quality monitoring is almost none existent.

Ethiopia has twelve major river basins. The Nile basin within Ethiopia is the largest one consisting of four major river sub-basins including, Baro- Akobo, which originates from south western, Abbay (Blue Nile) that originates from north western part of the country and Tekeze river basins originating from central highlands of the country covering six regional states (RNS) viz, Amhara, Tigray, Oromiya, SNNP, Gambella and Benshangul-Gumuz with varying proportions covering a total area of 358,889 km. Among the sub basins, Baro-Akobo, Abbay (Blue Nile), and Tekeze within Ethiopia Contribute 66% of the total average annual runoff, and the Nile basin in Ethiopia is home to about 40% of its population with various development potentials including contributions to development of irrigation based agriculture. An estimated 2 million ha of land could be irrigated and be utilized for agricultural purposes. Similarly, the basin has the potential to hydro-power generation capacity of up to around 98,831 GWH/y (Fitsum Merid, 2006). An equally important issue as far the Nile Basin parts in Ethiopia is concerned, the continuous deteriorating natural resources within the basin as the result of enormous upstream degradation has effects on people in the downstream countries, reflecting significant trans-boundary impacts.

Unfortunately, except limited intermittent efforts by Federal and Regional Government bureaus focusing on quality control of water supply schemes, there is no systematically set regular water quality monitoring program in place thus far in the sub-basins. Similarly, an effort towards awareness creation and participation of communities, CBOs and NGO in relation to water quality monitoring are next to none and remains a waiting call for coordinated and integrated sustainable efforts by stakeholders.

ii) The status of wetlands and aquatic biodiversity in the Nile Basin:

In Ethiopia, the Ministry of Water Resource is responsible for protecting and utilizing wetlands through study and implementation of sustainable projects. Efforts aimed at increasing the size of agricultural land through minimizing the effects of flooding, and assisting traditional drainage efforts through appropriate drainage packages incorporated in the ministry's strategic planning are being exerted. Recently, the society at large has begun to appreciate the benefits of wetland as the result of the loss of services rendered by wetlands as the consequences of the disappearance of more wetlands in different parts of the country. The present situations hence call for an urgent need for a coherent guiding national policy to steer the management and distribution of Ethiopia's water resources and, in particular, its wetlands as vital components in the water cycle

iii) Wetland plant biodiversity within the Ethiopian Nile Basin

Human activities such as direct harvesting of species, introduction of alien species, habitat destruction, and various forms of habitat degradation (including environmental pollution) have caused dramatic losses of biodiversity; but because it is salient, only few people give it the attention that it derives. Approximately, half of the highlands 270, 000km^2 are thought to be significantly eroded, with additional 20, 000 km^2 unlikely to sustain future cropping (Zerihun Woldu, 2000). Population pressure leading to, inappropriate agricultural practices, such as deforestation, cultivation on steep slope lands and overgrazing is to be blamed for 80% of the erosion. The fact that 85% of the population in Ethiopia is rural and will remain so in the years to come implies that the rural areas will carry an even greater demographic burden than at present. This will be reflected in the rapid rate of deforestation of the limited forest resources of the country.

According to Sutcliffe (2006), the potential annual supply of woody biomass in 2000 was 77 million tons while the annual consumption (including wood for charcoal) was 54 million tons. This is unsustainable resource extraction .There is an annual loss of 65, 540 ha of high forest, 91,400 ha of woodland and 76,400 ha of shrub land due to land clearing for agriculture and settlement which amounts to woody biomass losses of approximately 3.5 million tons (Sutcliffe, 2006). As a result, ecosystem functions which encompass biodiversity , hydrological regulation, carbon sequestration, soil fertility loss will continue impinging on the biodiversity and lead to the extinction of many unique flora and fauna of the country and the world at large.

iv) Invertebrates as bio-indicators of ecosystem conditions

Invertebrates are the most successful and prolific animals on the planet. They have been around for over 400 million years and dominate the animal kingdom in terms of numbers of species and numbers of individuals (Hanson and Swanson, 1989). Invertebrates have also adapted to occupy practically every ecological niche. So really, when we talk about 'biodiversity' we are talking about invertebrates. The aim of any biodiversity monitoring is to track changes in the biological integrity of ecosystems. Given the overwhelmingly dominant contribution of invertebrates to biodiversity, no biodiversity monitoring program can be considered credible if invertebrates are not addressed effectively

Variability spanning several orders of magnitude of invertebrates is often strongly linked to long-term wet-dry cycles and associated vegetation changes in individual ecosystems (terrestrial, aquatic, wetland etc). Creating awareness about the ecological and economic roles invertebrates play is fundamental to use these organisms as indicators ecosystem status and for sustainable biodiversity management. Capacity for collection, identification and preservation of invertebrates is also fundamental for which the existence (establishment) of museums and/ or mandated and actively functioning institution working on invertebrates is also of paramount importance. Management that takes a broad multi-species and systems perspective may be essential to the conservation of invertebrate species and the ecosystems of which they are part. Currently, we are hampered by our lack of information about the various ecosystem functions of terrestrial, aquatic, wetland and riparian invertebrates. Efforts to develop holistic and adaptive ecosystem-based management of the countries biodiversity in general and invertebrates in particular in order to maintain functioning landscapes and natural communities are of paramount importance.

***v) An overview on mammals and birds of the Ethiopian Nile basin*:**

Wildlife in Ethiopia, like many other African Countries is still a public good. It should bee seen as an economic resource as it can ably justify its existence if opportunities are made conducive. At preset its total economic value (TEV) is not yet known. The direct uses (e.g. meat, tourism, hides, medicine etc), indirect use values (e.g. ecosystem stability, watershed protection, species diversity, water quality etc) are slowly being realized**.** Ethiopia has for instance over 280 million mammalian species and has the highest mammalian endemism, on the African continent (31 species =10.9%). There are six endemic genera of mammals of which four are monotypic (three rodent genera), one primate, and the other two genera are *Desmomys* and *Stenocephalemy*s represented by two species each (Henry *et al.*, 2088). These resources could if managed properly contribute significantly to the national economy. Similarly like many African countries, Ethiopia is also believed to have a large species birds which requires further baseline surveys that would provide baseline conservation data on the distribution of key species, the richness of sites, threats to allow comparisons and a monitoring programme to be made between and within sites over time

vi) The socio-economic significance of wetlands in the Ethiopian portion of the Nile Basin.

Although wetlands and wetland biodiversity of Ethiopia have not yet been investigated in depth, wetlands have different socio-economic values in the country. These include food crops supply through agriculture by draining and recession , important sites for dry season grazing, resources extraction , raw materials 9reeds for thatching purposes, papyrus) supply, fish harvesting, source of medicinal plants and sites for tourist attraction and various traditional ceremonies. Wetlands serve communities as sources of water, both for humans and animals. In wetlands such as Abaya and Chamo lakes, crocodile farming is yielding economic benefits. Some studies show that some wetlands such as Lake Tana, Fogera, Chefa, and the Rift Valley wetlands are resting and nesting sites for inter-Africa and Europe migratory birds and add to their tourist attraction significance.

Highlights on the water quality profile of the Nile Basin in Ethiopia

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Introduction

The Nile Basin within Ethiopia consists of Abbay (Blue Nile), Baro-Akobo (Sobat) and Tekeze (Atbara) river sub-basins which fall within five regional sates viz Amhara, Tigray, Oromia, and Gambella & Benshangul-Gumuz. These rivers are the major tributaries contributing more than three quarter of the main Nile annual average flow.

The part of Nile basin in Ethiopia is generally characterized by steep slopes and hence subject to continuous soil erosions over years. The basin also experiences high intensity, rainfall lasting for about four months (July to October). During wet seasons, the rivers are turbid and full of suspended solids. Deforestation and population pressure on the marginal highland area are major threats of the basin.

The basin wide water quality monitoring component is one of the six components of the NTEAP. This component initiates basin-based dialogues on water quality and improves understanding of trans-boundary water quality issues, improve capacities for monitoring and management of water quality and initiate exchange and disseminate information on key parameters.

Trans-boundary cooperation will be increasingly important to maintain appropriate water quality for drinking water, irrigation, and industry and to support human health and livelihoods and ecosystem functions in the Nile Basin

Basin wide water quality assessment program

Except limited intermittent efforts by Federal and Regional Government bureaus focusing on quality control of water supply schemes, there is no systematically set regular water quality monitoring program in place thus far in the sub-basin although some basin wide protocols are being discussed recently. Similarly, efforts towards awareness creation and participation of communities, CBOs and NGO in relation to water quality monitoring are next to none and remains as a waiting call for coordinated and integrated sustainable efforts by stakeholders.

Water quality profile summary of the Nile basin within Ethiopia

Available information on water quality data indicates inadequately spatial and temporal conditions of the basin. However, based on available sources an overview of water quality of the basin taking into account Lake Tana and three sub-basin rivers, has been summarized as follows (for details please refer to Tables-1-8).

Brief overview on water quality of Lake Tana and other smaller lakes (reservoirs) of the basin

The chemical composition of Lake Tana is characterized as Oligomesotrophic (BCEOM,1998, EPA, 2003)). The Lake Tana water is slightly alkaline of acceptable pH range, low TDS and EC values. The EC value is associated with low fish productivity of the lake. The average 6.5 mg-DO/l can drop down to nil without anoxic layer. Due to high suspended solids of the tributary rivers, the effective storage capacity of Lake Tana is being reduced by 6% per100 year.

Table 1. Chemical Composition of Lake Tana River mouths and Bahr Dar area

Chemical Parameters	Zeghe Giorgis	Ambo Bahr	Gilgel Abay Pelagial	G.A. river mouth	Egashu R. mouth	prison	Tana Hotel	Hosp. effluent
Depth (m)	9.3	0.6	9.7	2.5	0.60	1.05	2.30	-
pH	6.88	6.98	7.02	-	7.33	6.57	ND	7.27
Turbidity as NTU	21.99	81	3.42	55	12.19	0.00	11.73	0.00
Copper as Cu, mg/l	0.021	0.0091	<0.001	0.0249	<0.001	<0.001	<0.001	0.01
Lead as Pb, mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	0.0007	<0.001	<0.001
Zinc as Zn, mg/l	0.0289	0.0254	<0.001	0.0072	<0.001	0.0056	<0.001	0.015
Chromium as Cr, mg/l	<0.001	0.0263	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Calcium as Ca, mg/l	2.45	9.29	10.5	3.11	ND	ND	ND	ND
Magnesium as Mg, mg/	0.47	1.84	2.21	0.56	4.18	ND	ND	4.49
Ammonia as N, mg/l	0.2	0.2	0.11	0.25	0.21	0	0	0.45
Nitrate as N, mg/l	6.7	10.2	5.2	5.9	3.3	7.1	4.9	6.6
Phosphate as PO_4, mg/l	1.03	1.03	2.00	0.69	0.12	2.01	1.96	2.13
Iron as Fe, mg/l	0.001	0.0077	0.017	0.024	0.0932	0.0583	0.181	0.187
Potassium as K, mg/l	0.40	1.79	ND	0.56	3.00	ND	ND	ND

Sources: Busulwa *et al*, 2008

Table 2. Chemical Composition of Upper Lake Tana catchment sites

Chemical parameters	Woreta	Aykel	Debre Tabor	Nefas Mewcha	Chagni	Bure	Dejen
PH	7.5	7.0	8.0	8.5	6.95	6.8	8.06
Color as Pt-Co units	11	113	-	-	79	5	-
Turbidity as FTV	3	21	2	1	12	8	-
Conductivity, ms/cm	0.47	0.09	0.20	0.26	0.27	4.26	0.39
Total Alkalinity,	240	40	150	110	70	2920	200
$CaCO_3$, mg/l							
Carbonate Alkalinity, CaCO3, mg/l	80	40	100	140	80	2800	200
Total hardness, $CaCO_3$, mg/l	80	40	100	140	80	2800	200
Calcium as Ca, mg/l	28	16	20	28	1	200	49
Magnesium as Mg, mg/l	2.4	2.4	11.9	16.8	1.24	551	19.5
Manganese as Mn, mg/l	-	0.05	0.01	0.02	-	0.02	-
Copper as Cu, mg/l	0.01	0.27	0.04	0.12	0.16	0.152	0.02
Nitrate as N, mg/l	1.18	4.20	3.6	3.7	19.36	31.6	5.72
Phosphate as PO_4, mg/l	0.44	0.23	0.34	1.07	0.42	2.39	0.96
Fluoride as F, mg/l	0.21	0.53	0.57	0.33	0.15	0.22	0.50
Chloride as Cl, mg/l	10	5	5	5	10	15	10
Iron as Fe, mg/l	0.16	0.41	0.02	0.01	0.10	0.30	0.01

Source: Busulwa *et al*, 2008

In contrast, the upper catchments of the LTSB had lower phosphate levels, except Bure town, which may reflect the high degree of urbanization of this town. Nitrate levels were however higher in some areas such as Aykel, Degen, and Chagni. These could be due to livestock and domestic wastes, or other local factors in these areas. Otherwise nitrate values appear to be lower in the upper catchments than in the lake catchments, indicating some degree of mobilization of these nutrients from the rivers or urban sources. Nitrate concentration above 10 mg/l not only contributes to eutrophication, but can cause blood disorder in infants (blue baby disease) and was recorded only from Chagni in the upper catchments previously. Elevated levels indicate that manure, sewage, or nitrogen fertilizers are reaching the water source, with no chance of being modified through wetlands. As far as the water quality of other smaller lakes is concerned, the test for physico-chemical parameters of the remaining smaller lakes and reservoirs is within the acceptable range of ambient water quality standard set by EPA (2003) for aquatic species.

Summaries of the surface and ground water quality profiles of three sub-basins of the Nile basin within Ethiopia.

The water quality profile of the three main sub basins of the Ethiopia section of Nile basin has been presented in summarized forms in tables 3-8.

Table 3. Summary of Abbay sub-basin surface water quality profile

Well Code/Name	EC	TDS	pH	Na+	k+	T. Hard	T. Alk	Ca++	Mg++	Cl-	PO4--
	(µs/cm)	mg/l		mg/l	mg/l	mg/l Ca CO3		mg/l	mg/l	mg/l	mg/l
No of Tests	37	36	36	31	32	19	19	34	34	25	16
Mean	176	108	7	8	5	45	36	19	6	4	2
Median	105.0	78.0	7.2	4.0	2.5	24.0	22.0	14.0	3.1	4.0	2.5
Min	25.0	10.0	5.5	0.9	1.0	6.0	4.1	1.5	0.9	0.0	0.2
Max	846.0	550.0	8.7	55.0	45.0	238.0	120.0	100.8	58.3	28.0	2.8
Ambient Surface water Standard	1000		6 to 9							250	
No. of Tests Exceed Guideline			1	0		0				0	

(Source: UN/ECE, 1996)

NB: "0" at Min value represent "less than detection limit"

Table 3 show that the most of the values the tests on surface water quality of the Abbay sub-basin fall below the national guidelines for each component except values for the PH. This may indicate that the water quality is good conditions and that micronutrients such as No_3 have been utilized for photosynthesis due to the availability of light the surface water.

Table 4. Abbay sub-basin ground water quality profile summary

	Color	EC	Har total	Alk total	pH	TDS	NO_3^-	NO_2^-	Cl^-	F^-	$SO4^{--}$	$PO4^{---}$	Na+	Fe tot	Mn
	TCU	S/cm	mg/l $CaCO_3$			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
No of Tests	414	539	649	578	641	464	538	484	532	442	468	470	189	380	448
Mean	128	377	149	176	7	215	8	0	16	1	10	1	32	1	0
Median	2	295	112	129	7.4	167	3.04	0.02	7.1	0.32	1	0.265	18.7	0.06	0
Min	0	6	2	0	4.1	9	0	0	0	0	0	0	0	0	0
Max	12250	4260	2800	3000	10.2	2933	145	6.72	535	10.4	318	27.5	489	32	20.2
Guideline Value	22		392		6.5-8.5	1776	50	6	533	3			358	0.3	0.13
No. of Tests Exceed Guidelin	121		24		70	3	13	2	1	7			3	96	69
(%) of Tests Exceed Guidelin	29.23	0	3.7	0	10.92	0.65	2.42	0.41	0.2	1.58	0	0	1.59	25.3	15.4

(Source: USBR,1964, BCECOM,1998)
NB: "0" at Min value represent "less than detection limit"

The test results in Table 4 for the Abbay ground water quality show that there is high iron content exceeding the national guideline limit (25.3%) This may indicate that the ground water compared to the surface water of the sub basin contains more deposited micronutrients for instance the exceeding NO_3 percentage value compared with the national guidelines limit by 2.42c% percent (Table 4) may indicate that micronutrient has not been fully utilized for phothosynthesis due to shortage of light. Similarly the excess Mn may also show that there was leaching and deposition of Mn from underground rock.

Table 5. Tekeze sub-basin surface water quality profile summary

	Tur	EC	TDS	pH	NO3	NO2	Cl	CO3-	HCO3-	SO4--	PO4---	Na+	K+	Ca++	Mg++
	FTU	S/cm	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
No. of Samples	11	15	8	25	15	20	25	19	21	21	13	20	14	27	27
Mean	36	622	388	7.8	2.632	0.21	28.1	2.8	196.7	60.9	0.2	27.5	20.2	56.1	18.3
Median	18	417	284.5	8	1.2	0.02	15	0	195.2	2	0.04	13.5	2.5	40	16.32
Min	0	96	88	6.6	0	0	0.07	0	48.8	0	0	0.57	0.05	10	2.4
Max	118	2029	1015	8.6	11.2	2.8	190	28.8	537	450	1	119	252	252	67.2
Guideline	7		1776	6.5-8.5	50	6	533			483		358			
No. of Sample Exceed Guideline	6		0	1	0	0	0			0		0			

(Source: NEDECO, 1998)
NB: "0" at Min value represent "less than detection limit"

The above figures (Table 5) similar to that for the Abbay surface water quality figures (Table 4) shows that the Tekeze surface water quality is in good condition as most of the values for the different parameters fall bellow those values indicated in the national. These contrary to the ground waters may imply that there is less deposition of essential micronutrients such as No_3 at the surface as the result of photosynthesis in the presence of light.

Table 6. Summary for Tekeze sub-basin ground water quality profile

	TDS mg/l	pH	NH4+ mg/l	Na+ mg/l	K+ mg/l	Fe++ mg/l	Mn++ mg/l	Cl- mg/l	NO2 mg/l	NO3 mg/l	F mg/l	HCO3 mg/l	CO3 mg/l	SO4 mg/l	PO4 mg/l	HARDN mg/l as CaCO3
Eth Guideline Value	1776	6.5 to 8.5	2	358		0.4	0.13	533	6	50	3			483		392
No. of Parameters Exceeding Guideline	7	41	5	1.0		7	61	1	0	17	0			8		45
No. of Tests	336	335	213	282	281	94	108	264	72	247	272	281	75	205	236	282
Median	312	7.2	0.21	21.5	2	0.02	0.2	13.3	0.02	7.5	0.33	241.6	9.6	15	0.17	223
Min	32	4.9	0	2.4	0.09	0	0	1	0	0	0.03	20.3	0	0	0	16
Max	2750	9.8	7.42	650	24	2.03	3	890	4.05	261	1.88	734.4	34	1700	231	2780

(Source: NEDECO, 1998)); NB: "0" at Min value represent "less than detection limit"
Table 6 shows that values for some of the parameters such as iron content, values for No_3 and manganese exceed that of the values in the national guideline , 45, 17 and 61, respectively. These values are also higher than those recorded for Abbay sub-basin ground water (Table 4) and may indicate that there is more leaching and deposition of Mn as well as less utilization of micronutrients such as No_3 for photosynthesis by green algae, bacteria etc owing to lack of light beneath the surface (underground)

Table.7 . Summary of Baro-Akobo sub-basin surface water quality

	Color	Turb	EC	Hard	Alk total	pH	TDS	NO3	NO2	Cl	F	SO4	**PO4**	**Na**	Fe (total)	Mn
	TCU	FTU	S/cm	**mg/l CaCO3**			Mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
No of Tests	16	18	13	22	21	25	13	24	23	22	17	21	15	12	13	21
Mean	119	23	139	31	31	7	112	1	0	8	0	8	0	5	1	0
Median	55	18	93	25.75	30	7.2	60	1	0.02	5	0.15	3	0.1	3.05	0.61	0
Min	0	0	22	7.2	0.16	6.3	25	0	0	0	0	0	0	1.2	0	0
Max	342	64	450	90	60	8	457	10.12	0.4	35	2.1	46.1	0.55	30.9	1.33	0.5
Guideline Value	22	7		392		6.5-8.5	1776	50	6	533	3	483		358	0.3	0.13
No. of Tests Exceed Guideline	12	12		0		3		0	0	0	0	0		0	10	3

(Source: Source: Fitsum Merid, 2006)
NB: "0" at Min value represent "less than detection limit"

Although the values for total Fe and Mn exceed the value for the same in the national guidelines by 10%, 3%, respectively, as indicated in Table 7, the over all water quality for the Baro-Akob sub-basin is to the large extent similar to that of the Abbbay and Takeze sub-basins surface water quality test results.

Table 8. Summary of Baro-Akobo sub-basin ground water quality profile

	Color	**Turb**	**EC**	**Hard**	**Alk total**	**pH**	**TDS**	**NO3**	**N02**	**Cl**	**F**	**SO4**	**PO4**	**Na**	**Fe total**	**Mn**
	TCU	FTU	S/cm	**mg/l CaCO3**			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
	25	30	29	30	34	30	24	32	30	32	30	31	26	8	22	27
Mean	102	20	389	148	222	7	219	17	0	28	1	6	0	73	2	1
median	12	1	270	78	81	7.17	202.5	3.31	0.04	4.985	0.3	0.7	0.26	12	0.095	0.04
Min	0	0	20	10	0.2	5.35	10	0	0	0	0	0	0	1	0	0
Max	990	198	1344	1560	2640	8.74	655	2123	6.72	280	9.8	37	3.6	489	32	12
Guideline Value	22	7		392		6.5-8.5	1776	50	6	533	3	483		358	0.3	0.13
No of tests Exceed	10	9				7		4	2		4				13	13

Guideline																	

(Source: Source: Fitsum Merid, 2006)
NB: "0" at Min value represent "less than detection limit"

Similar to the ground water quality test result figures for Abbay and Tekeze sub-basins, the test result figures for Baro-Akobo sub-basin ground water (Table 8) shows exceeding values from that of the national guidelines values for all parameters which may be indicatives of more deposits and less utilization of micronutrients such as NO_3 for photosynthesis as compared with the preceding two sub-basins ground water test results (Tables 4 and 6)

Proposed water quality monitoring

A simple, affordable and basic monitoring system is proposed. The anticipated monitoring should function using the existing Governmental structure and able to generate a consistent and reliable data that can comprehensively characterize and helps to evaluate the basin. The establishment and strengthening of federal, regional, zonal and basic laboratories is paramount importance for the implementation of the program. Type of sampling sites, sampling site location, monitoring media and parameters as well as frequency of sampling are proposed on the basis of objectives set. This study proposes 68 surface and 21 groundwater sampling sites (macro-location) of trend and/Baseline stations type. The sampling station (micro-location) should be determined after proper field assessment of the sub-basins. Among these, five (5) geo-referenced & trans-boundary important, sampling stations are selected.

MoWR and other concerned Federal and Regional line bureaus in carrying out their responsibilities by strengthening their analytical capacity. In addition to that, the study will provide a framework for cooperative efforts between various stakeholders in the basin towards a common goal of protecting the basin's water resource while accommodating reasonable economic growth.

To address the current data management challenges and future information demand, web-based database systems is recommended for the development of spatial decision support system. Tailor-made software is recommended to achieve standard automated data analysis, (UN/ECE, 1996). As the tailor-made WQ database, developed in 2002 for MoWR, has included most of the requirements, still has an advantage if it can be improved and updated by the help of the state of the art technology. This database should also be transformed to a web-based Spatial Decision Support System (SDSS).

There is a chance for proper data management and sharing using web-based geographic information systems (GIS) and tailor-made database. The recent development of Wide Area Network (WAN) infrastructure in Regional Administrations is an opportunity for the SDSS in the filed of water quality application. The system will facilitate the situation by which, all stakeholders, riparian actors, the general public, decision makers and regulatory authorities will be provided with information to visualize different management options.

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The status of wetlands and aquatic biodiversity in the Nile Basin: *an overview*

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Introduction

Ethiopia is endowed with a wide variety of landforms and climatic conditions, creating an extensive wetland system throughout the country. Against this background, however, the frequency of drought has increased over the past three decades, resulting in significant social, economic and environmental imbalances. There are also growing constraints to water supplies in Ethiopian dry lands. Other issues compounding water supply include, watershed degradation and poorly managed wetlands. This imbalance is one of the issues that the Ethiopian Water Resources Management Policy attempts to address in its formulation.

The present situations hence call for an urgent need for a coherent guiding national policy to steer the management and distribution of Ethiopia's water resources and, in particular, its wetlands as vital components in the water cycle. The Ministry of Water Resource is responsible for protecting and utilizing these resources through study and implementation of sustainable projects. Efforts aimed at increasing the size of agricultural land through minimizing the effects of flooding, and assisting traditional drainage efforts through appropriate drainage packages incorporated in the ministry's strategic planning are being exerted. Recently, the society at large has begun to appreciate the benefits of wetland as the result of the loss of services rendered by wetlands as the consequences of the disappearance of more wetlands in different parts of the country due to above factors

There is now a growing awareness that many wetlands are more valuable in their natural or only slightly modified state. Conservation of wetland has long been a world wide concern ever since the Ramsar Convention appeared in 1971 and recently became a hot issue in Ethiopia in relation to the efforts made to ratify the convention. Although accepted and signed the convention, several countries have lost a number of important registered wetland sites because governments still give priorities to short term socio-economic benefits over conservation based long term sustainable developments. Water resource and wetland development need environmentally sound planning systems in order to sustain and enhance long-term ecological productivity and to improve the welfare of local communities. It is therefore crucial to develop strategies for national wetland programs so that wetland values can be accrued. The rivalry interventions are basically between those seeking to develop these wetland areas for agricultural production and those who believe that wetlands must be preserved as much as possible in a pristine state to maintain their ecological contributions to the global environmental system. Hence the Ministry needs to provide equal attention to conservation as it does to development.

General profile of Ethiopian wetlands

In this section, information compiled from different literature references, informants are summarized to show the general profile Ethiopian wetlands and their conditions including, wetland coverage, types, classification and distribution, benefits and threats and other relevant aspects.

Definition

Wetlands are ecosystems or units of the landscape that are found on the interface between land and water. While water is a major factor of wetland definition (Ramsar Convention Bureau, 1997) soils, vegetation and animal life also contribute to their unique characteristics (Roggeri, 1995). As a result, it has proved to be difficult to define wetlands, and many descriptions exist. However the general guiding definition by the Ramsar Convention (1997: 2) reads as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters".

W*etland coverage*

According to available sources, wetlands are distributed all over the globe and are estimated to cover about 6% of the earth's surface covering ca.5.7 million km^2 (Maltby, 1986) Despite the fact that Africa is rather best perceived as a continent with more of savannahs and hot deserts, evidences show that 1% of the continent's surface area (345,000 km^2) is covered by wetlands (Finlayson, 1991). These ecosystems range from the Senegal River and the inner Niger Deltas in the west, to the Sudan floodplains and the Ethiopian wetlands in the East. Southwards, important wetlands include the Zaire Basin swamps, the Okavango Inland Delta, the Kafue Flats, the African Great Lakes and the extensive Malagarasi-Moyovosi Wetlands in Tanzania. Wetland characteristics will also vary with altitude, with high ground wetlands, such as those found in the Ethiopian and Kenyan mountain systems, complementing lowland types found in the semi-desert.

Ethiopia has 5,311 km of frontiers that it shares with Djibouti, Eritrea, Kenya, Somalia and Sudan. About 7,444 km^2 is covered by water bodies, including swamps, marsh and floodplains. About 1.14% of the country landmass is covered with wetlands (Hillman and Abebe, 1993). Tesfaye (1990) listed 58 major lakes and marshes in Ethiopia (including, Eritrea). (Hillman, 1993) listed a total of 77 wetlands in Ethiopia and Eritrea, together with locations. Hillman (1993) estimated that Ethiopian wetlands covered an area of 13,699 km^2 or 1.14% of the country's land surface. At the macro level, wetlands may be classified according to biomes. At the local and more specific level, wetlands may be grouped according to their habitat type, physical and biological characteristics.

Ethiopia's ecological diversity and climatic variation is to a large extent explained by its highly variable topography. Altitudes range from 125 m below sea level in the Dallol Depression, to

4,620 m above sea level at Ras Dashen. These altitudinal extremes mean that Ethiopia is a country of enormous habitat diversity, which is also influenced by the country's climate. The tropical monsoon rainfall pattern is influenced by moisture-laden winds from the Atlantic and the Indian Oceans and also by the Inter-tropical Convergence Zone and variations in altitude.

Forms of wetlands

The major groupings of wetlands according to Ramsar are:-

- marine (coastal wetlands);
- estuarine (deltas, tidal marshes, and mangroves);
- lacustrine (lakes and associated wetlands);
- Riverine (rivers, streams and associated wetlands);
- palustrine (marshes, swamps and bogs).

With the exception of coastal and marine-related wetlands and extensive swamp-forest complexes**,** all forms of wetlands are represented in Ethiopia. These include alpine formations, riverine, lacustrine, palustrine and floodplain wetlands. Floodplains are found both in Ethiopia's highlands and lowlands, although they are most common in the North-Western and Western Highlands, Rift Valley and Eastern Highlands.

Classification of Ethiopian wetlands

Biome based classification of Ethiopian wetlands

Ethiopian wetlands could be grouped into four major categories based on ecological zones, hydrological functions, geomorphologic formations and climatic conditions. These categories interlink to form four major biomes, which also describe climatic conditions in Ethiopia.

These biomes include:

I) The Afro-tropical Highlands,
II) The Somali-Masai,
III) The Sudan-Guinea and,
IV) The Sahelian Transition Zone groups (Tilahun *et al.*, 1996).

*Group I***: The Afro-tropical wetland system**

The Afro-Tropical Highlands are composed of the Central, Western and Eastern Highlands of Ethiopia that serve as the prime water catchments and sources of its major rivers. The average annual rainfall is more than 2,000 mm. Rains are bimodal, with the long rains extending from June to September and short rains between February and May (Tilahun *et al*, 1996).

These areas include most of Ethiopia's alpine and fresh water wetland ecosystems. The wetlands in this biome include Lakes Tana, Hayk, Ashange, Wonchi and, in the Western Highlands, Gojjeb and Ghibe.

Floodplains associated with the biome's lakes and rivers are the Fogera and Dembia on the shores of Lake Tana. Some of the important wetlands of the Central Highlands are the Chomoga-Yeda floodplains around Debre Markos, and the Borkena and Dillu swamps in the Upper Awash Basin. The numerous alpine lakes of the Bale Mountains and the swamps of Arsi and Alemaya are important wetlands in the Eastern Highlands.

*Group II***: Somali-Masai wetland system**

This biome also exists, in large measure, due to the formation of the Great Rift Valley. Its wetlands include the southern group of the Great Rift Valley Lakes and the northern group of the Awash Basin together with their associated swamps and marshlands. The water-divide of these two wetland complexes is near Meki town. The Awash Basin wetland complex is to the north of the water divide and includes the wetlands of Bishoftu, the Kesem-Meteka complex and Lake Abe complex. The southern group comprises three separate and closed drainage systems. The first system comprises lakes including, Langano, Abijatta and Shalla**.** The second drainage system comprises Lake Awassa and Chelekleka, while the third comprises the rivers Abaya, Chamo and Chew Bahir together with their associated floodplains. The rainfall distribution under this biome is bimodal, with peaks between September and November, and March and May (Tilahun *et al.*, 1996).

Group III: **Sudano-Guinean wetland system**

The Sudano-Guinean wetland system is found in the western lowlands of Ethiopia. The wetlands in this group stretch from the Turkana delta in the south-west of Ethiopia, north along the Ethio-Sudanese border, the Baro-Akobo floodplains in Gambella Region, the Dabus and Beles floodplains in the Benshangul-Gumuz Region and the Metema and Tekeze floodplains in Amhara and Tigray Regions. Rainfall is unimodal lasting from March to September (Tilahun *et al*, 1996).

Group IV **: Sahelian transitional wetland system**

The Sahelian Transitional Zone Biome is that found in the extreme north-eastern part of Ethiopia. This area is the hottest and driest part of the country and is where the Dallol depression is located – at its lowest point and is 116m below sea level (Tilahun *et al*., 1996). The area comprises semi-desert steppe, and the evapo-transpiration exceeds mean annual precipitation by over ten times (Messele Fisseha, pers. comm.). The biome contains a number of fresh and saline wetlands, including Lakes Afambo, Afdera, Gamari and Asali. The water volume of these lakes is dependent on the rainfall from the highlands during the wet season. In the dry season, most of the water in these wetlands evaporates leaving large salt pans behind. Rainfall is unimodal and unreliable, with a small amount received mainly between November and February (Tilahun *et al.*, 1996).

Habitat, physical and biological characteristics based classification of Ethiopian wetlands .

According to the directory of African Wetlands as a basis, Ethiopian wetlands are classified into nine major groups in which lakes are also included (Hughes and Hughes, 1992). This classification is based mainly on river and lake drainage systems. The classification is not complete yet and no wetlands in the country are listed. The present classification scheme shows the diversity of wetland types in the country although not all wetlands have been listed mainly owing to the presence many and fragmented wetlands all over the country. The scheme does not however show the many different forms of wetlands e.g. alkaline, fresh or seasonal. The classification includes those wetlands which were previously excluded by Hughes and Hughes (1992), but excludes tidal and coastal wetlands because Ethiopia has no access to the sea now. The major wetland groups and associated lakes, rivers, swampy and marshy plains etc include:

i) ***The Lake Tana and associated wetlands:*** Lake Tana, Fogera floodplains,Dembia floodplains

ii) ***Western River floodplains:*** Alwero, Baro, Akobo, Gilo, Chomen, Fincha Swamps, Dabus Swamp, and Beles floodplain

iii) ***Wetlands of the Western Highlands:*** Ghibe and Gojeb (Keffa Zone)

The Ashenge and Hayk Lakes Wetlands of the Bale Mountains: Numerous alpine lakes including Garba Guracha, Swamps and floodplains (Illubabur Zone)

iv) ***Lakes of Bishoftu****:* Crater Lakes: Hora, Bishoftu Guda and Zukala, Green, Babogaya, Bishoftu Lakes, etc.

v) ***Lakes and the associated wetlands of the SW Rift Valley:*** Lakes Ziway, Langano, Abjiyata, Shalla, Lakes Awassa and Chelekleka, Lakes Abaya, Chamo, Chew Bahir, Lake Turkana

vi) ***Lakes and Swamps of the Awash River System:*** The upper Awash Valley- Dillu Meda, Aba Samuel, The Lake Beda Sector, The Gewane Lakes/Swamp Complex,The Dubti, Afambo and Gemari Lakes/Swamp complex, Lake Abe and delta.

vii) ***Lakes of the Afar Depression:*** Lake Afrera, Lake Asale, Dallol Depression

viii) ***Artificial Impoundments and Micro Dams:*** Koka, Fincha, Melka-Wakana and other hydropwer dams, municipal and other reservoirs like dams, aquifers, and wells

Importance, threats & wise use of wetlands

Importance of wetlands

The complex interactions between biotic (fauna and flora) and abiotic (soil, water and topography) components of wetland systems make them amongst the earth’s most productive ecosystems. Wetlands are very important for the multifarious values that they provide free of charge. They constitute a resource of great economic, cultural, scientific and recreational value. Wetlands are the most productive ecosystems in the world, by far outstripping some of the alternative uses to which they are subjected. The annual primary production of herbaceous swamps, for example, is impressive. Papyrus in tropical Africa can produce up to 143 tones per hectare, while production rates for *Typha* range from 30 to 70 tones per hectare. Conversely, highly productive crops such as sugar cane and maize produce just 63 tones and 60 tones per hectare respectively (Finlayson and Moser, 1991 cited in Eshete Dejen, 2003).

They are described both as ‘the kidneys of the landscape’ because of the functions they perform in the hydrological and chemical cycles, and as ‘biological supermarkets’ because of the extensive food webs and rich biodiversity that they support (Mitsch and Gosselink, 2000). The values and services that wetlands provide can be broadly categorized as:

- **Functions:** flood alleviation, erosion control, stream flow regulation, water storage, ground water recharge, retention of pollutants, water purification, nutrient cycling, exchange of water between the surface and the groundwater and the surface and the atmosphere.
- **Products:** fish, fuel wood, timber, fodder for domestic animals, habitat for wetland dependant species, rich sediments used for agriculture in the floodplains, fiber for thatching roofs and handicrafts.
- **Attributes:** diversity of species, aesthetic beauty, cultural heritage, tourist attractions, and recreation such as bird watching, sailing, educational and archaeological.

The indirect uses of wetlands include, hydrological and ecological functions, which support various economic activities, life support systems and human welfare. These are manifested in the forms of ground water recharge, flood control, nutrient cycling, erosion control and sediment traps, climate regulation, habitats for migratory wildlife and pest control (de Graaf, M.,2003). As such, wetlands produce an ecological equilibrium in the environment by maintaining the integrity of life support systems for sustainable socio-economic development. Yet, many wetland ecosystems – particularly floodplains and swamps - are regarded as wastelands and continue to be depleted at an alarming rate throughout Ethiopia. Moreover, national economic policies that priorities crop production, severely affects sensitive ecosystems including wetlands through extensive land development schemes that have no concern for environmental costs.

Assessment of aquatic biodiversity in the Nile basin

Amphibians, reptiles & other invertebrates

According to Arjo-Dedessa irrigation project feasibility study report, February, 2007 by Water works design and supervision enterprise in association with intercontinental Consultants and technocrats India PVT. LTD). Lake Tana and its tributary rivers are also said to be poor in diversity of aquatic fauna. As a result Lake Tana is home only to a dozen of endemic fish species (24), few large animals such as Hippopotamus, Otters, Nile Monitor Lizard, a number of aquatic birds, Crocodile near Tis Issat water falls and in the surroundings. Lake Tana is also home to a number of Zooplankton and benthos organisms and insect larvae like midges, mosquitoes, stone flies, dragon flies, etc.

According to the Karadobi multi purpose project, prefeasibility study, final report NORPLAN-NORCONSULT-LAHMEYER in association with Shebelle Engineering and WWDSE, May 2006, one endemic Cricket is reported in the Abay Gorge. The above document also indicates cites some data collected by the British expedition in 1960s and Ethiopian-Russian Biological expedition in 1994 (JERBE,1996 cited in Eshete Dejen, 2003) Mrris et al,1970 cited in Eshete Dejen, 2003) refers to the observation of a “Pale golden colored frog” during the British expedition in 1964-66 which latter was identified as Ptychadena huguettae (Morris.et al 1976 cited in Eshete Dejen, 2003).

Brief profile of aquatic fauna

According to: Appendix 4.3-4.7, page 13-17 in the Eastern Nile power trade program prefeasibility study of Border Hydropower project, Ethiopia, July 2007, available baseline data for aquatic biota other than fishes is desperately poor. The data for fish is comparatively better.

i) Zooplankton and Benthos

Due to the rocky and turbulent nature of the Abbay River, it is unlikely that a population of zooplankton is established in a considerable proportion of the river. The benthos of the Abbay is generally believed to be poor mainly because of the drastic changes in flow rates and water level.

Samples taken in March 2007 from Abbay river at an island between Boka and Abagole, located some 37 km upstream of the uppermost end of the potential border reservoir, and some 15 km downstream of the Mandaya dam site, as well as samples from the Mandaya dam site, indicated the presence of two zooplankton species, namely, Mesocyclops sp. and Cyclopoid nauplii.

In a recent survey conducted on Beles river at Babizenda, Diaphinosoma and Thermocyclops of the zooplankton community and Chironomids, mayflies,beetles, dragonflies, water penny and stoneflies of the Arthropod community have been recorded. Sample taken from under the Bure-Nekemte Bridge, further upstream, revealed the presence of no group of zooplankton. Due to the rocky and turbulent nature of the river, there is little probability of the presence of established communities of zooplankton. The benthos of the Abbay, likewise, is believed to be generally poor because of the steep river bed and banks in places and the drastic changes of water level**.**

ii) Aquatic fauna-Lake Tana

Lake Tana and its tributary rivers are also said to be poor in diversity of aquatic fauna. As a result Lake Tana is home only to a dozen of endemic fish species (24), few large animals such as Hippopotamus, Otters, Nile Monitor Lizard, a number of aquatic birds, Crocodile near Tis Issat water fails and the like. Lake Tana is also home to a number of Zooplankton and benthos organisms and insect larvae like midges, mosquitoes, stone flies, and dragon flies..

Table 1. List of aquatic fauna in Lake Tana

S/N	Family	Genus name	Species name	Remarks
1	Cladoceras	Bosominia	B. longrostris	Most abundant ZP
		Ceriodophnia	C. cornuta	Benthos
		“	C.dubia	“
		Daphnia	D. similis	“
		“	D. longispina	“
		Diaphanosoma	D.excisum	Most abundant ZP
		Juvenile	J. cladocera	Benthos
		Monia	M. micrara	“
2	Cyclops	Copepodite	Copepodite spp.	“
		Mesocylop	Mesocylop spp.	“
		Naupli	Naupli spp.	Common Zooplankton
		Thermocyclop	Thermocyclop spp.	“ “
		Thermodiptmous	T. galbei	“ “
3	Rotifers	Brachionus	B. caudatus	“ “
		Filina	F. terminalis	“ “
		Keratella	K. crassa	“ “
		“	K. quadrata	“ “
		Lecane	Lecane spp.	“ “
		Trichocerca	Trichocerca spp.	“ “
4	Bivalve	Aspatharia	A. rubens	Benthos
		Corbicula	C. fluminalis	“
		Unio	U. abyssinica	“
5	Chironomidae	Chironomus	Chironomus spp.	“
6	Ephemeroptera	May flies	Fly spp.	Insect larvae
7	Gastropods	Bellamya unicolor	B. abyssinica	Endemic subspecies
		Lymnaea	L. natalensis	Intermediate host of Fascioliasis
		Lymnaeidae	Lymnaeidae spp.	
8	Mosquitoes	Viviparidae	Viviparidae spp.	
		Anopheles	Anopheles spp.	Vector of Malaria
		Chaoborus	Chaoborus spp.	
		Lulex	Lulex spp.	
		Chaoboridae	Chaoboridae spp.	
9	Planorbidae	Anisus	A. natalensis	Host of Schistosoma haematobium
		Bulinus	Bulinus spp.	
10	Plecoptera	Stone flies	Fly spp.	Insect larvae
11	Trichoptera	Caddis flies	Fly species	Most abundant insect larvae
		Dragon flies	“ “	
		Odonata	14 species	

Sources: (1) Gumara irrigation project feasibility study report, June 2007 (Water works design and supervision enterprise in association with Intercontinental Consultants and technocrats India PVT. LTD). and (2) Baro 1 and 2 Hydropower projects, including Genji Diversion Scheme, Feasibility study report, Volume 5(EIA), May 2006. Norplan-Norconsult , Lahmeyer International.

iii) Aquatic habitat-* River *Baro

The Baro River as well as the Genji river tributary, is generally a substratum of rocks and bedrock. Some sections of the river have a very high gradient (more than 4% on the section from Baro 2 to the Fani river confluence). The river runs through forest, and terrestrial organic material is an important input to the productivity of the aquatic ecosystem.

iv) The status of Non-fish Aquatic Biodiversity*-River *Baro

According to local informants, crocodiles do occur in the low-gradient sections of Baro River, e.g. upstream of the Baro 2 dam site. The monitor lizard probably also occurs along the river. Locals also refer to an animal called “hola bishani” (meaning literally “sheep of the water” in Oromigna). It is said to feed on the head of fish in nets set overnight. This would probably be the African clawless otter (Aonyx capensis), which also fits with the observation of remains from mussel meals left by some mammals on the river bank.

Hippos are not recorded in the Baro River in the DIZ. The possible occurrence of smaller mammals associated with water is not known. During the fish survey tadpoles of amphibians, as well as shells of bivalves and snails were observed.

The status of fish biodiversity

Fish and fisheries-Lake Tana

Lake Tana’s hydrological characteristics such as high flushing time (6.2 years residence time), small mean depth (8-9m), high seasonal changes in water level (1-1.5m) and year round mixed water columns, categories it as a seasonally pulsed system, an allotropic riverine lake where biological productivity is expected to be highly variable by nature and dominated by unspecialized species with selected life histories (Martin de Graaf, 2003).

However, in Lake Tana the variation of the annual influx of nutrients and the timing is highly predictable. Lake levels and sediment inflows achieve their peak values during October and July-August, respectively. And hence nutrients also achieve peak values during this period. Lake Tana can, therefore, be considered as seemingly stable environment despite the fact that nutrient influx is externally driven.

As a result, fish fauna of Lake Tana consists partly of resilient, flexible species like *O. niloticus* and short lived, small-sized diploid Barbus (African Barbus) as well as a species – rich, endemic and ecologically specialized group of fish (hexaploid large Barbus, now renamed as Labeobarbus by Wassie Anteneh (2005). In general, three fish families occur in Lake Tana ; Cichlidae, Clariidae and Cyprinidae giving a total of 24 fish species. The largest fish family in the lake is however, Cyprinidae, represented by 1,3 and 18(15 large and 3 small barbus) species. Fish species available in Lake Tana are given in Table 2.

Lake Tana endowed with 24 fish species grouped under 6 genera and 3 families all together estimated to yield 14,000-16,000 Tons/year. Until recently (2006), out of the known 24 fish species, 8 are riverine spawners, mainly using Gumera and Dirma Rivers (Martin de Graaf, 2003).These piscivorous fish species form congregation around river mouths before they migrate up until 40-50 km along the river courses in the period of June/July-October/November each year.

Table 1(a). List of fish species collected from Abbay River on 21 and 22 March 2007 at Abagole, downstream of Mandaya dam site

Family	Species
	Labeo cylindricus
	Labeo forskalii
	Labeobarbus sp.
	Raiamas laoti
Bagridae	*Bagrus docmak*
	Bagrus bajad
Claridae	*Clarias gariepinus*
Cichlidae	*Oreochromis niloticus*
Mormyridae	*Mormyrus kannume*
Alestidae	*Hydrocynus forskalii*

Table 1(b). Fishes of the Beles river at Babizenda

Family	Species name	Common name
Cyprinidae	*Labeo coubie*	Tsemebebella
	Labeo cylindricus	Tseya
	Labeo horie	Tsemebebella
	Labeo forskalii	Tseya
	Labeo niloticus	Tsemebebella
	Labeobarbus bynni	Goshe
	Labeobarbus intermedius	Goshe
	Labeobarbus nedgia	Goshe
	Labeobarbus degeni	Goshe
	Raiamas loati	Abella
	Varicorhinus beso	Abella
Bagridae	*Bagrus bajad*	
	Bagrus docmak	
	Clarias gariepinus	

Claridae	*Heterobranchus longifilis*	
	Auchenoglanis occidentalis	Jajuma
Mochokidae	*Synodontis serratus*	
	Synodontis schall	Buwa
Characidae	*Hydrocynus forskalii*	
	Brycinus macrolepidotus	Yechacheya
	Brycinus nurse	Lekewar
Mormyridae	*Mormyrus kannume*	Bebela
Cichlidae	Oreochromis niloticus	Begebella

Source: Eshete Dejen,2003

Table 1©. Fishes of the Abbay River at a location 35 km SWW Mankush (11^0 14'N 34^0 59'E

Mormyrops anguilloides (Linnaeus, 1758)
Mormyrus cashive(Linnaeus, 1758)
M. hasselquistii (Valenciennes, 1846)
M. kannume(Forskal,1775)
Pollimyrus petherici(Boulenger,1898)
Alestes sp.
Brycinus macrolepidotus (Valenciennes, 1852)
Brycinus nurse (Ruppell, 1832)
Hydrocynus forskalii(Cuvier,1819)
Micralestes acutidens(Peters,1852)
Nannocharax sp.
Garra sp.
Leptocypris niloticus (de Joannis, 1835)
Labeo cubie (Ruppell, 1832)
Labeo cylindricus (Peters, 1852)
Labeo niloticus (Forsskal, 1775)
Bagrus docmak (Forsskal, 1775)
Schilbe mystus (Linnaeus, 1758)
S. uranoscopus (Ruppell, 1832)
Synodontis frontosus (Vaillant, 1859)
S. schal (Bolch & Schneider, 1801)
S. serratus (Ruppell, 1829)
S.sorex (Gunther, 1864)
Oreochromis niloticus (Linnaeus, 1758)

Source: Eshete Dejen (2003)

Table 1(d). Fishes of the Dabus River at the bridge along Nekempt-Assosa road (9^0 46'N 34^0 48' 30"E)

Labeo forskalii (Ruppell)
Clarias gariepinus (Burchell)
Oreochromis niloticus (Linnaeus)
Barbus intermedius (Ruppell)
B. paludinosus (Peters)
Garra sp.
Varicorhinus beso (Ruppell)

Source: Eastern Nile power trade program pre-feasibility study of Border Hydropower project, Ethiopia, July 2007

Previous works have studied the ecology of Lake Tana in general and the fish species and their stocking status in particular (Martin de Graaf and Eshete Dejene, 1999-2001. Lake Tana's hydrological characteristics such as high flushing time (6.2 years residence time), small mean depth (8-9m), high seasonal changes in water level (1-1.5m) and year round mixed water columns, place it as a seasonally pulsed system, an allotropic riverine lake where biological productivity is expected to be highly variable by nature and dominated by unspecialized species with selected life histories (Martin de Graaf, 2003).

However in Lake Tana, the variation of the annual influx of nutrients and the timing is highly predictable. Lake levels and sediment inflows achieve their peak values during October and July-August, respectively. And hence nutrients also achieve peak values during this period. Lake Tana can, therefore, be considered as seemingly stable environment despite the fact that nutrient influx is externally driven. As a result, fish fauna of Lake Tana consists partly of resilient, flexible species like *O. niloticus* and short lived, small-sized diploid Barbus (African Barbus) as well as species that are endemic and ecologically specialized group of fish (hexaploid large Barbus, now renamed as Labeobarbus by Wassie Anteneh (2005).In general, three fish families occur in Lake Tana; Cichlidae, Clariidae and Cyprinidae giving a total of 24 fish species. The largest fish family in the lake is however, Cyprinidae, represented by 1, 3 and 18(15 large and 3 small barbus) species. Fish species recorded in Lake Tana are presented in Table 2.

Lake Tana is endowed with 24 fish species grouped under 6 genera and 3 families all together expected to yield 14,000-16,000 tons/year. Until recently (2006), out of the known 24 fish species 8 of them are riverine spawners, mainly using Gumera and Dirma Rivers (Martin de Graaf, 2003).These piscivorous fish species form congregation around river mouths before they migrate up until 40-50 km along the river courses in the period of June/July-October/November each year.

Table 2. Recorded fish species in Lake Tana and Gumera river

Family	Genera	Species	Remarks
1. Cyprinidae	I. Varicorhinus	V. beso	
	II. Garra	G. quaddrima culata	
		G. dembeensis	
		G. microstoma and tana	
	III. Labeobarbus	B. acutirostris	Endemic and Piscivorous [1]
		B. dainellii	“ “
		B. gorguari	“ “
		B. longissimus	“ “
		B. macraphtalmus	“
		B. megastoma	“ “
		B. platydorsus	“ “
		B. truttiformis	“ “
		B. brevicephalus	“ “
		B.crasibarbis	Endemic and non-Piscivorous [2]
		B. gorgorensis	“ “
		B. nedgia	“ “
		B. surkis	“ “
		B. tsanensis	“ “
		B.intermedius	“ “
	African Barbus	B. humilis	Common pry for large Barbus
		B. pleurogramma	“ “
		B. tanapelagius	“ “
2. Clariidae	Clarias	C. garepinus(African catfish)	Omnivore and moderately resilient to fishing pressure
3. Cichlidae	Oreochromis	O. niloticus(Tiliapia)	Planktivore(opportunist) and most resilient to fishing pressure

Sources: (a) Water works design and supervision enterprise in association with Intercontinental Consultants and technocrats India PVT. LTD(2007)

(b) Eshetie Dejen (2003)

1. Food specialists (narrow preferences) and riverine spawners, highly vulnerable to fishing pressure, especially when targeted during spawning periods.
2. Highly vulnerable to fishing and are locustrine spawners.

Fisheries in the Gambela plains (*river*- Baro, Alwero and Gilo)

The fisheries on the Gambela plains are the most important river fishery in Ethiopia in terms of yield. The recorded catch in this area, which is fed by several rivers in addition to the Baro, varied from nearly 8900 kg to more than 25000kg in the period 1988 to 1995. An estimated 12400 fishermen participated in this fishery (Ministry of Water Resources, 1999)

The available fishery statistics are specifically associated with the Baro River obtained from the fishery cooperative in Itang. According to this, recorded catches in the Itang fishery have exceeded 17000 tones, but the information seems quite erratic, with recorded catches going from more than 10000 to 30 tons in one year. The fishing activities on the plains are largely restricted to the dry season (October to April), as the flooding in the wet season render many fishing sites inaccessible. The catches in 1994 were dominated by Nile perch, with *Polypterus* bichir also being important (Table 2).

Table 2: Species composition of fish caught from Baro River by the fishery cooperative

Distichodus	Puro		164	5.6
Niloticus				
Lates niloticus	Gur	Nile perch	1209	41.4
Hydrocynus	Weiry		33	1.1
Forskahlii				
Clarias gariepinus	Agwella	Catfish	190	6.5
Gymnarchus	Weet		132	4.5
Heterotis niloticus	Ullawak		207	7.1
Citharinus	Ujaka		27	0.9
Bagrus	Udwara		209	7.2
Barbus spp.	Ukura/Jara	Barbs	135	4.6
Tilapia	Urwedo	Tilapia	13	0.4
Synodontis	Ukok		50	1.7
Polypterus bichir	Udwella	African Bichir	402	13.8
Others			149	5.1
Total			2920	

Sources: MoWR (1999)

Table3. List of fish species in the Baro/ Gilo rivers on the Gambela plains

S/N	Family	Species name	Local name	Frequency
1	Lepidosirenidae	*Protopterus annectens*		+
2	Polypteridae	*Polypterus bichir*	Udwella	+++
3		*P. senegalus*		+
4	Osteoglossidae	*Heterotis niloticus*	Ullawak	+++
5	Mormyridae	*Mormyrus cashive*		+++
6		*M. hasselquistii*		++
7		*Mormyrops sp.*		++
8		*Marcusenius isidori*		++
9		*M. harringtoni*		+
10		*Petrocephalus bane*		+
11		*Petrocephalus sp.*		+
12		*Gnathonemus niger*		+
13		*G. cyprinoides*		+
14		*G. pictus*		+
15		*Hyperopisus bebe*		+
16		*Pollimyrus petherici*		+
17	Gymnarchidae	*Gymnarchus niloticus*	Weet	+++
18	Alestidae	*Hydrocynus forskalii*		+++
19		*H.vittatus*		++
20		*Brycinus nurse*		+
21		*Brycinus macrolepidotus*		+
22		*Micralestes sp.*		+
23	Citharinidae	*Citharinus latus*	Ukaka	+++
24		*Distichodus engycephalus*	Puro	+++
25		*D.brevipinnis*	"	++
26		*Neolebias sp.*		+
27		*Nannocharax sp.*		+
28		*Ichtyoborus besse*		+
29	Cyprinidae	*Labeo forskalii*		+++
30		*Labeo horie*		++
31		*Labeo niloticus*		++
32		*Labeo neumanni*		++
33		*Labeo coubie*		++
34		*Barbus bynni*	Ukura/Jary	+++
35		*B. prince*	"	++
36		*B. anema*	"	+
37		*Barilius loati*		+
38		*Chelaetiops bibie*		+?
39	Bagridae	*Bagrus bayad*	Udwara	+++
40		*Bagrus docmak*	"	+++
41		*Auchenoglanis occidentalis*		+?

42		*Chrysichtys auratus*		+?
43	Mochokidae	*Chiloglanis niloticus*		++
44		*Mochocus niloticus*		++
45		*Andersonia leptura*		+
46		*Synodontis nigrita*	Ukok	++
47		*S. cupterus*	"	+
48		*S. caudovittatus*	"	+
49		*S. frontosus*	"	+
50		*S. schall*	"	+
51		*S. filamentosus*	"	+
52		*S. sorex*	"	+
53		*S. clarias*	"	+
54		*Brachysynodontis batensoda*		+
55	Schilbeidae	*Schilbe mystus*		+
56		*Eutropius niloticus*		+
57		*Siluranodon auritus*		+
58	Claridae	*Clarias gariepinus*	Agwella	++
59		*C. anguillaris*		+
60		*Heterobranchus longifilis*		+
61		*H. bidorsalis*		+
62	Malapteruridae	*Malapterurus electricus*		+
63	Cyprinodontidae	*Haplochilus marni*		+
64		*Haplochilus sp.*		+
65	Cichlidae	*Tilapia zillii*	Urwedo	++
66		*Oreochromis niloticus*	"	++
67		*Sarotherodon galilaeus*	"	+
68	Anabantidae	*Anabas petherici*		+
69		*A. murici*		+
70	Tetraodontidae	*Tetraodon fahaka*		+
71	Centropomidae	*Lates niloticus*	Gur	+?

Sources: MoWR (1999)

+++ Prevailing commercial fishes, ++ unimportant commercial fishes, + local fishes,+? not recorded in commercial catches

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An overview of wetland plant biodiversity in five regional states of Ethiopia in the Nile Basin.

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Introduction

Ethiopia has variable topography and altitude range, from 126 m below sea level in the Dallol depression to 4, 620 m above sea level at Ras Dashen, and this confers enormous ecological diversity, which is also influenced by the climate in the country. With the exception of coastal and marine–related wetlands and extensive swamp forest complexes, all forms of wetlands are represented in Ethiopia (Yilma Abebe, 2003, cited in Henry *et al*, 2008). These wetland resources include lakes, marshes, and swamps, in various parts of the country from low lands to high lands. However their area coverage has not yet been determined exactly. However, Hillman (1993) estimated that Ethiopian wetlands cover a total area of 13, 699km^2 which is 1.4% of the country's land surface. It is also estimated that only 9% of the total annual discharge from 12 river basins (120x10^{6}m^3 of water) remains in the country in the various water forms including lakes, bogs, swamps springs and marshes. The water retained in wetland formation is estimated to cover 18, 587 km^2 which is 1.5% of the total land area of Ethiopia (EPA, 2003).

The fact trees have been cut down (deforestation) and grass have been overgrazed (de-vegetation) are among the threats that promote increased erosion to the remaining patches of wetlands in Ethiopia. Accordingly, sedimentation of the water bodies is becoming a major problem as wetlands that are major habitats for birds and other wild animals are threatened. In depth study findings on Ethiopian wetlands are lacking. Some of the previous efforts are those carried out by the Ethiopian Wetland Research Program in Illuababora zone, Ethio Wetlands and Natural Resources Association in Oromia and Amhara zones, Addis Ababa University and its partners, the Federal Environment Authority (2003) financial assistance) and Ethiopian Wildlife and Natural History Society.

Human activities such as direct harvesting of species, introduction of alien species, habitat destruction, and various forms of habitat degradation (including environmental pollution) have caused dramatic losses of biodiversity; but because it is salient, only few people give it the attention that it derives. Approximately, half of the highlands 270, 000km^2 are thought to be significantly eroded, with additional 20, 000 km^2 unlikely to sustain future cropping. Population pressure leading to, inappropriate agricultural practices, such as deforestation, cultivation on steep slope lands and overgrazing is to be blamed for 80% of the erosion. The fact that 85% of the population in Ethiopia is rural and will remain so in the years to come implies that the rural areas will carry an even greater demographic burden than at present. This will be reflected in the rapid rate of deforestation of the limited forest resources of the country

According to Sutcliffe (2006), the potential annual supply of woody biomass in 2000 was 77 million tons while the annual consumption (including wood for charcoal) was 54 million tons. This is unsustainable resource extraction .There is an annual loss of 65, 540 ha of high forest, 91,400 ha of woodland and 76,400 ha of shrub land due to land clearing for agriculture and settlement which amounts to woody biomass losses of approximately 3.5 million tons (Sutcliffe, 2006). As a result, ecosystem functions which encompass biodiversity , hydrological regulation, carbon sequestration, soil fertility loss will continue impinging on the biodiversity and lead to the extinction of many unique flora and fauna of the country and the world at large. All physical and economic evidences show that loss of land resource productivity is an important problem in Ethiopia and that with continued population growth; the problem is likely to be even more important in the future

This document based on different previous wetland assessment reports, attempts to show plant biodiversity of wetlands in five regions of Ethiopia, namely, Amhara, Tigray, Oromia, Beneshangule-Gumuz and Gambella

Amhara Regional State

a).Gojam and Awi zones

These two zones have several small wetlands that provide socioeconomic and environmental services to the people in the area. Major wetland plant species recorded from the wetlands of these areas include,*Phoenix recilinata, Cyperus* spp and Z*ypha* sp (EPA, 2003).

b) Fogera Wetland

Fogera wetland together with Lake Tana makes the largest wetland system in the Amhara regional state, probably in the country. This wetland system is very important when we see its position in the Nile Basin as headwater ecosystem.

Table 1. Shows permanent and season swam plant species of Fogera wetland.

Permanent swamp	Seasonal swamp

Centrostachyus aquatica *Cyperus rotundus* *Echinochloa colona* *Echinochloa stagnina* *Ipomoea aquatica* *Lagarosiphon sp.* *Nymphaea nouchali* *Persicaria glabra* *Persicaria senegalensis* *Ranunculus sp.* *Sacciolepis africana*	Aerva sp. *Aeschynomene schimperi* *Centrostachyus aquatica* *Cyperus distans* *Cyperus flavesens* *Cyperus mundtii* *Cyperus polystachyos* *Cyperus rotundus* Digitaria sp. *Echinochloa colona* *Echinochloa haploclada* *Echinochloa stagnina* *Hygrophila schulli* *Ipomea aquatica* *Otetelia ulvifolia* *Panicum coloratum* *Persicaria senegalensis* *Ranunculus sp.* *Sacciolepis africana* *Sesbania sp.* *Vigna vexillata* *Zannichellia palustris*

Source: Getachew Tesfaye & Kagnew H/Selassie, 2004

c) Cheffa wetland

According to the National Report on the Surveyed Wetlands (EPA, 2004) the plant species in this wetland are *Cyperus digitatus* and *Typha domingensis*. However, more plant species (Table 2) were recorded latter in 2006.

Table2. Wetland plant species recorded in the Cheffa Wetland

Species	Family
Cynodon dactylon	Poaceae
Cyperus rigidifolius	Cyperaceae
Nymphaea nouchali	Nymphaceae
Typha domingensis	Typhaceae
Cyperus latifolius	Cyperaceae
Sporobolus pyramidalis	Poaceae
Parthenium hysterophorus	Asteraceae
Ipomoea aquatica	Convolvulaceae
Sphaeranthus saveolens	Asteraceae
Sesbania sesban	Fabaceae
Paspalum scrobiculatum	Paoceae
Eriochloa fatmensis	Poaceae
Echinochloa pyramidalis	Poaceae
Hygrophila auricuata	Acanthaceae

Sida rhomboidifolia	Malvaceae
Juncus effusus	Juncaceae

(Cheffa Management Plan, EPA 2006)

d) Lakes Ardibo and Lego-Wollo: The dominant plant species around Lakes Ardibo and Lego-Wollo according to National Report on the Surveyed Wetlands (EPA, 2004) was found to be *Nymphaea* sp. The EWNHS (1996) survey shows that in Jema and Jara valleys and Mid –Abay (Blue Nile) River, plant species including, *Typha* spp. *Sterculia African, Tamarindus indica and Ficus thonningii* were encountered. The same survey report shows that the Mid –Abay (Blue Nile) River Basin [Riverine Forest of Didessa River] is home for plant species including, *Ficus vallis-choudae, Mimusops kummel, Tichilia emetica,Phoenix reclinata, Sapium ellipticum and Dracaena steudneri*

e) Lake Tana . Plant species recorded during the EWNHS (1996) survey around Lake Tana also included, C*yperus papyrus, Typha* (bullrush), *Echinochloa spp. and* Blue Water Lilly

Tigray regional state:

Waja Timuga wetland: The major and dominating plant species in this wetland according to the National Report on the Surveyed Wetlands (EPA 2004) was *Cyperus papyrus.*

Oromia Regional State

a) Lake Zeway: In lake zeway areas plant species including, *Phragmites* (reed), *Nymphaea* (water lilly),*Typha* (bullrush),C*yperus papyrus*, *Jancus* sp.,*Panicum repens*,C*yperus papyrus* (EWNHS, 1996), *Paspalidium geminatum, Nymphaea coerulea, Eicchornia crassipes(*Invasive Alien Species*) and Aeschynomeneelaphroxylon have been encountered ((*Makin *et al*, 1974, EWNHS, 1996)

Table 3. Plant Biodiversity in the wetlands of Illubabor Zone.

SPECIES	FAMILY
Aeschynomene schimperi	FABACEAE
Cyperus elegantulus	CYPERACEAE
Cyperus flavescens	CYPERACEAE
Cyperus latifolius	CYPERACEAE
Cyperus mundtii	CYPERACEAE
Cyperus platycaulis	CYPERACEAE
Echinochloa ugandensis	POACEAE
Eragrostis botryodes	POACEAE
Fimbristylis dichotoma	CYPERACEAE
Floscopa glomerata	COMMELINACEAE
Fuirena stricta	CYPERACEAE
Hydrocotyle sibthorpioides	APIACEAE
Impatiens ethiopica	BALSAMINACAEAE
Jussiaea abyssinica	ONAGRACEAE
Leersia hexandra	POACEAE
Oldenlania goreensis	RUBIACEAE
Oldenlandia lancifolia	RUBIACEAE
Ottelia ulvifolia	HYDROCHARITACEAE
Panicum hymeniochilum	POACEAE
Panicum subalbidum	POACEAE
Persicaria glabra	POLYGONACEAE
Phyllanthus boehmii	EUPHORBIACEAE
Sacciolepis africana	POACEAE
Schenoplectus corymbosus	CYPERACEAE
Sesbania dummeri	FABACEAE
Smithia elliotii	FABACEAE
Thelypteris confluens	THELYPTERIDACEAE

Species	Family
Acanthus arboreus	ACANTHACEAE
Achyranthes aspera	AMARANTHACEAE
Aeschynomene abyssinica	FABACEAE
Ageratum conizoides	ASTERACEAE
Ajuga remota	LAMIACEAE
Alchemilla cryptantha	EUPHORBIACEAE
Alchemilla pedata	EUPHORBIACEAE
Anagallis serpens	PRIMULACEAE
Arthraxon prinoides	POACEAE
Celosia schweinfurthiana	AMARANTHACEAE
Commelina africana	COMMELINACEAE
Commelina diffusa	COMMELINACEAE

Cyperus brevifolius	CYPERACEAE
Cyperus dichroöstachys	CYPERACEAE
Cyperus distans	CYPERACEAE
Cyperus microstylis	CYPERACEAE
Cyperus rigidifolius	CYPERACEAE
Cyperus weitsciii	CYPERACEAE
Digitaria ternata	POACEAE
Dissotis canescens	MELASTOMATACEAE
Dissotis princeps	MELASTOMATACEAE
Drymari acordata	CARYOPHYLLACEAE
Geranium aculeoidea	GERANACEAE
Guizotia scarba	ASTERACEAE
Hydrocotyl emanniii	APIACEAE
Hygrophil aauriculata	ACANTHACEAE
Leucas deflexa	LAMIACEAE
Paspalum scrobiculatom	POACEAE
Pennisetum thunbergii	POACEAE
Persicaria senegalensis	POLYGONACEAE
Plectranthus plunctatus	LAMIACEAE
Pycnostachy seminniii	LAMIACEAE
Ranunculus multifidus	RANUNCULACEAE
Ricinus communis	EUPHORBIACEAE
Satureja paradoxa	LAMIACEAE
Scleria lagensis	CYPERACEAE
Snowdenia petitiana	POACEAE
Solenostemon porepeodon	LAMIACEAE
Sphaeranthus lexuosus	ASTERACEAE
Spilanthes mauritiana	ASTERACEAE
Thunbergia alata	ACANTHACEAE
Triestemma mauritanum	MELASTOMATACEAE
Trium tapilosa	TILIACEAE
Triumfetta rhomboidea	TILIACEAE
Veronica abyssinica	SCROPHULARIACEAE
Vigna parkerii	FABACEAE

Sources: Zerihun Woldu, 2000

b). **Fincha and Chomen swamps**: According to the EWNHS, (1996) host plant species including, *Panicum hygrocharis, Nymphaea coerulea,Persicaria* spp.*, Phoenix reclinata and* Qetema or Sedges. Similarly, the Koffe swamp within Kitto-Koffe wetland in the Jimma area is home for two major plant species *Alisma plantago-aquaticaand Persicaria* sp. (EWNHS, 1996). Table 4 however indicates more plant species Kitto-Koffe wetland.

Table 4. Shows plant species encountered in Kitto-Koffe Wetland

Fuirena pubescens	*Lobelia welwitschii*
Lindernia whytei	*Sida schimperiana*
Eleocharis acutangula	*Maesa lanceolata*
Platycoryne corcea	*Psidium guajava*
Alistma plantago-aquatica	*Syzygium guineense*
Schoenoplectuscorymbosus	*Platycoryne corcea*
Typha latifolia	*Acroceras macrum*

Alisma plantago-aquatica	*Digitaria ternata*
Carissa spinarum	*Echinochlo acolona*
Cyperus aethiops	*Echinochlo pyramidalis*
Cyperus denudatus	*Hyparrhenia hirta*
Cyperus dichroostachyus	*Potamogeton lucens*
Cyperus latifolius	*Anagalis tenuicaulis*
Cyperus nitidus	*Dodonea angustifolia*
Cyperus pectinatus	*Buchnera capitata*
Eleocharis acutangula	*Lindernia oliveriana*
Lipocarpha chinensis	*Lindernia whytei*
Brideliamtha	*Thelypteris palustris*
Phyllanthus boehmii	*Typha latifolia*
Cadia pupurea	*Gnidia glauca*
Pterolobium stellatum	*Lantana camara*
Senna didymobotrya	*Xyris capensis*
Neohyptis paniculata	

efa and Melaku Wondafrash, 2004

Plants in wetlands around Gambela regional state

Wild rice, *Echinochloa* spp*. And Panicum maxicum were recorded during the* (EWNHS (1996)

Benshngule Gumuz regional state

a) Plants in Abay and Beles basin: Plants recorded in Abay and Beles basin of the Benshangul regional state during the EWNHS, (1996) included, *Borassus aethiopum, Hyphaena thebaica,Oxytenanthra abyssinica*

b) Plants in Reverine forest. Similarly, plants in Reverine forest of the Benshangul Regioanl state wetlands included, *Ficus vallis-choudae, Tamarindus indica,Mimusops kummel, Trichilea emetica and Phoenix reclinata (*Zembaba)

Conclusion

The above finding shows the scarcity of data on wetlands and wetland biodiversity in Ethiopia. This scarcity can be the result of either that wetlands/wetland biodiversity is not adequately investigated in the country or wetland data management and dissemination mechanism is not developed. Since Ethiopia lacks wetland focused legal framework and institutional arrangement that efficiently coordinate wetland management and wetland related information nationally, it is difficult to locate individual efforts made so far. Different organizations carry out activities in wetland areas from their own perspective individually. The efforts are not integrated and as a result it is difficult to get information. Moreover, it is also challenging to foster initiatives jointly for common goal and promote capacity building.

Thus it is crucial to build capacity and develop wetland and wetland biodiversity database for Ethiopia through conducting extensive wetland assessment in the country. To bring this issue in to effect the role of key national wetland affiliated organizations such as the

AAU,EPA, IBC, EWNRA, EWNHS and others Regional initiatives such as the Nile Basin Initiative and international bodies such as the Ramsar Secretariat, Wetlands International, etc is vital.

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Invertebrates as key components of biodiversity and as bio-indictors for sustainable ecosystems management: A review

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Introduction

Invertebrate biodiversity and abundance

Invertebrates are animals such as corals, shellfish, insects, worms, spiders, jellyfish, starfish, crabs etc. The invertebrates provide the highest number of individuals and species, biomass and production in most ecosystems. Over 95% of animal species are invertebrates (Fig.1) out of which insects alone constitute >85% of the animal kingdom with an estimated existing spp of more than 80 million ((in the planet) of which 1million have already been identified and catalogued (*U.S. EPA* (220).

Invertebrates are the most successful and prolific animals on the planet. They have been around for over 400 million years and dominate the animal kingdom in terms of numbers of species and numbers of individuals. Invertebrates have also adapted to occupy practically every ecological niche. So really, when we talk about 'biodiversity' we are talking about invertebrates.

The vertebrates - mammals (such as us), birds, reptiles, frogs and fish are only one group of thirty that make up the animal kingdom. Therefore all the vertebrates put together are only a tiny proportion of the species of animals on earth.

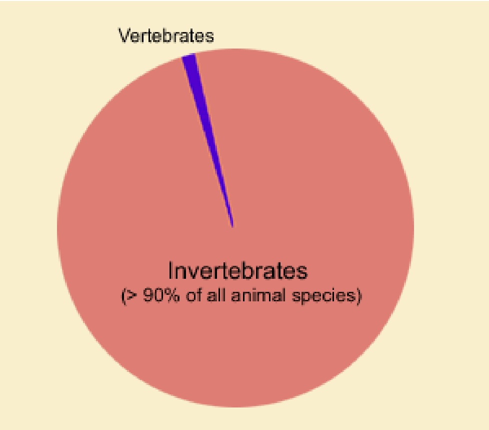

Fig1. The percentage proportion of invertebrates to vertebrates globally (Hanson and Swanson, 1989).

Estimates of invertebrate densities in localized areas have found invertebrates are so abundant that it is difficult to even approximate global numbers let alone count them (note figures in Fig.2). For example, an area the size of an Olympic swimming pool in a rainforest may contain three million insects. Termites alone can reach abundances of up to 10,000 individuals per meter square.

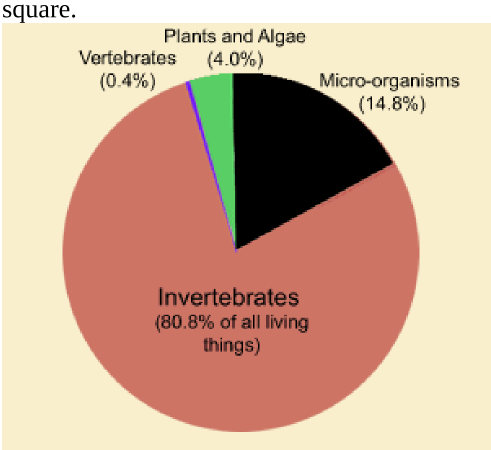

Fig2. The percentage proportion of invertebrates to other living organisms globally (Hanson and Swanson, 1989).

Discovery of invertebrates-the unfinished task

Even when we include plants, algae and micro-organisms, invertebrate animals are the dominant life on earth. The number of invertebrate species is staggering and new species are being discovered all the time. To date, scientists have only documented 1.7 million invertebrate species but they estimate numbers could range from 5 - 30 million. At this rate, it will take scientists over a thousand years to identify all invertebrate species. Unfortunately, species numbers are declining faster than we can record their existence. Although invertebrates occur in wetlands everywhere, prairie wetlands support notably great numbers. This is attributed to that prairie wetlands have especially rich soils, slow water turnover times, and seasonally fluctuating water tables , all of which support high levels of algal production and spatially complex vegetative stands that are important to invertebrates.

Within invertebrates, insects dominate freshwater aquatic systems where their species numbers, biomass and productivity are the highest. Aquatic macro-invertebrates including insects, crustaceans, mollusks and worms inhabit a river channel, pond, lake, wetland or ocean. Their abundance and diversity have been used as an indicator of ecosystem, health and of local biodiversity. Macro-invertebrates are categorized as being pollution sensitive and as being pollution tolerant. Water flow, food, habitat and water quality are the primary determinants of macro-invertebrate abundance and diversity. Any activity which alters these factors affects the normal functioning of invertebrate ecosystem. Food sources include phytoplankton, biofilms and terrestrial organic material that enter the water from the riparian vegetation. Major predation occurs from other macro-invertebrates and fish. The key habitats for macro-invertebrates are the benthic sediments, aquatic vegetation and woody debris. Salinity, temperature, dissolved oxygen, and turbidity have a significant impact on the survival and diversity of invertebrates in wetlands (Adamus, 1996).

Sustainable management of our ecosystems and the rich life within them remains to be one of the key natural resource management challenges in the world where rivers and other water bodies remain at risk and many species are facing risk of extinction or have already disappeared as the result of unwise/greedy human nature. Sustainable development requires sustainable biodiversity and natural resources management strategies. This is because biodiversity is the basis for natural products (food, medicines, timber etc), while ecosystem underpins many natural resources and services (clean water, healthy soils, pollination of crops, leisure thereby employment, etc).

Understanding the complex processes involved in biodiversity and conservation requires mechanisms and systems to evaluate the processes at all levels and time. Invertebrates play paramount roles in discovering, conserving, and identifying native and alien species.
The cost caused by invasive alien species globally is estimated to be around US350 Billion. Invasive species are second only to habitat destruction as a major cause of biodiversity loss. The impact of alien invasive species on biodiversity is best evaluated using invertebrates as experimental animals (bio-indicators)

Knowledge about invertebrates' biodiversity hence remains to be fundamental to evaluating (analysis) managing ecosystems, both natural and man made, urban and rural. On the other hand, invertebrates remain as key bio-indicators in waste and contaminant risk assessment (understanding contaminants) endeavors. Knowledge about hazard identification and risk assessment are used to generate decision support systems and risk (impact) assessment tools for the protection and maintenance of ecosystem health (USDI-FWL, 13, 1988)

In general, invertebrates are often key components of the habitats and ecosystem of the more familiar vertebrate species that we value. In many ecosystems, large populations of mites, collembolans (springtails), enchytraed worms, and insect larvae assist in decomposition by breaking down plant and animal material (CAFF, 2001). Decomposition helps determine the amount of organic matter accumulated in the soil. Thus, it is essential to soil fertility and plant growth upon which all terrestrial animals depend (CAFF, 2001). What is often immediately apparent for many is the role of bees, which are known to pollinate a wide diversity of domestic and wild plants. In the late 1980s for instance, the value of insect (that is mostly bee) pollinated crops in the USA was estimated as ranging between $4.6 billion and $18.9 Billion (Daily and Ellison, 2002)

Characteristics (attributes) of invertebrates that make them favorable for use in monitoring ecosystem integrity.

Sustainable wetland biodiversity, bio-security, and ecosystem management requires reliable biological analysis based on proper Index of biological Integrity (IBI) modules for which invertebrates remain to be central (*U.S. EPA* (220)

- Characteristic responses to all major wetland stressors (hydroperiod, sediment, nutrients, and contaminants), increased turbidity, loss or implication of vegetation, siltation, rearing of bait or game fish, input of storm water or wastewater runoff, introduction of exotic species, or alterations of the landscape around the wet land have been documented; many "indicator taxa" have been identified.

- Toxicological/laboratory based information (analysis) is extensive. Invertebrates are used for a large variety of experimental approaches at different ecosystems (terrestrial, aquatic, wetlands riparian etc).

- Decay-resistant remains (e.g. shells) provide a means for establishing historical reference conditions in a wetland.

- Invertebrates can be confined for whole-effluent bioassay or *in situ* assessments

- There is an extensive history of analysis of aquatic invertebrates in biological monitoring approaches for streams

- Invertebrates are used for testing bioaccumulation of contaminants to analyze effects of pollutants in food webs

- Invertebrates are important in food webs of fish, waterfowl, and predatory invertebrates.
- Many invertebrates are tightly linked to wetland conditions, completing their life cycles within the wetlands and hence are exposed to site-specific conditions

- Many invertebrates depend on diverse wetland vegetation; some depend on particular types of vegetation for reproduction.

- Invertebrates have short life cycles and they integrate stresses to wetlands often within 1-year time frame.

- Invertebrates can be sampled with standard methods and can be sampled once during the year, if the best index period is selected for optimal development of invertebrates

- Invertebrates can be identified using available taxonomic keys within labs of the entities doing the monitoring

- High numbers of taxa and individual counts permits the use of statistical ordination techniques that might be more difficult with just a few species e.g. amphibian. Citizens are often excited to see the richness of wetland invertebrates and hence can be trained to identify wetland invertebrates and become interested and involved in wetland assessment and monitoring programs

Invertebrates response to stressors in wetland management

In recent years, one of the most exciting new developments in the understanding of functional wetlands has been the high level recognition of the important roles of invertebrates in aquatic ecosystems. These roles include trophic linkage from primary production to secondary consumers such as waterfowl, packaging of specific nutritional components such as amino-acids, and micronutrients for vertebrate predators, and detrital processing of wetland organic material (Swanson, 1984). Enhanced understanding about biodiversity, bio-security and ecosystems management have sparked new interest decision makers from wetland management point of view and the vital roles of invertebrates in relation to:

3.1. Water birds (invertebrates as Indicators of Water bird Stressors).

Invertebrates are the vital link that makes algal production and emergent plant material available as an energy source for water birds. Much of the energy for some birds (ducks, for instance) that comes from plants is initially transferred to the primary consumers which include a diverse group of invertebrate species (fig.1). A variety of invertebrates are, for example consumed by water birds such as waterfowl. Similarly, ducks rely heavily on invertebrates as major food sources throughout the year (USDI-FWL. 13, 1988)

Invertebrates do this by consuming algal production and decaying plant material and then being consumed by higher order animals (Driver et al, 1974). Invertebrates represent grazing, filtering, detritivore, and predator trophic pathways of energy flow, and thus should reflect the status of these fundamental processes in wetlands.

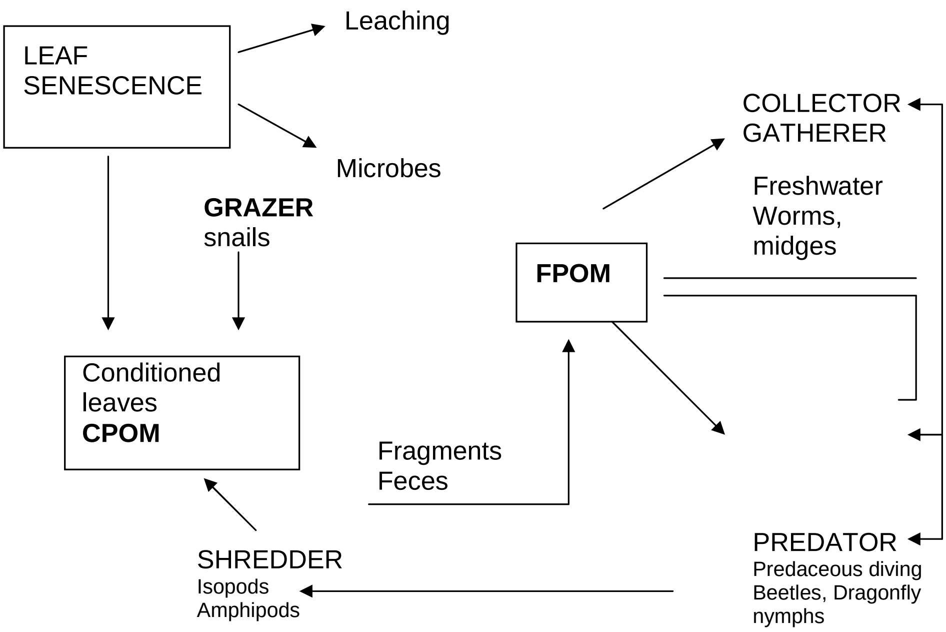

Fig.3. Invertebrate detritivore community, CPOM=coarse particulate organic matter: FPOM =Fine particulate organic matter (Swanson, 1984).

In some cases water birds appear to select wetland having the greatest densities of invertebrates (Talent et al. 1982). Water birds spend more time foraging in wetlands that have greater abundance of macro- invertebrates (Kaminski and Prince, 1981 a, b, 1984). Whereas larvae are eaten mainly by ducks, emerging insects are consumed by many songbird species. Soil macro invertebrates (such as earthworms and certain midge larvae, for instance) dominate the diet of several shorebird species that stop to feed in prairie wetlands during migration. Nematodes are one abundant, diverse, and sensitive assemblage which are useful indicators of soil conditions.

3.2. Water regimes (invertebrates as Indicators of Hydrologic Stressors).

Species composition: Long-term hydrologic cycles have shaped the life history strategies of wetland invertebrates (Swanson, 1984). These organisms have developed many adaptations, including:

- Egg or pupa stages which can tolerate drought periods,
- Initiation of egg development only after specific water/oxygen levels have been reached marked seasonality in life cycle,
- Rapid development,
- Large number of offspring (high reproductive potential),
- Obligate diapauses tied to seasonal flooding,

- Parthenogenetic reproduction

While long-term hydrologic cycles have shaped the life history strategies of wetland invertebrates, short-term hydrologic regimes may determine the actual occurrence and abundance of invertebrates. Flooding affects wetland invertebrate occurrence, growth, survival and reproduction. Entirely different invertebrate communities are present in wetland basis with differing hydrological regimes (timing, depth, and duration of flooding) (USDI-FWL. 13, 1988)

As litter is flooded, nutrients and detrital material (as coarse particulate organic matter) are released for a host of aquatic invertebrates. In general, wetlands can be cautiously deduced to be of greater hydrologic permanence when they contains a higher density of and richness of longer-lived and /or relatively immobile species (snails, mollusks, amphipods, worms, leeches, crayfish) as compared with the density and richness of short-lived species (Anostracans, Conchostracans), species that survive the winter as drought –resistant eggs (e.g. Daphnia) , and /or species that are relatively mobile (e.g. Chironomid midges)

This is probably due to the likelihood that drought and drawdown renders the less mobile species more vulnerable to predations as well as causing their direct loss due to desiccation and salinity toxicity. The response of nekton (swimming) and benthos (bottom dwelling) invertebrate herbivores/detritivore and predators to water level manipulation in prairie wetlands has been well established (Swanson, 1984). Long-term changes in wetland hydrology might be inferred by collecting decay-resistant remains of invertebrates from sediment cores or settling traps and determining if the species present are the ones that occur mostly in semi-permanent, seasonal, or temporary wetlands

Species richness: Previous workers (Euliss et al, 1989) have indicated that even wetlands that are flooded only temporarily have many more species than non-wetland areas

Density and biomass: Flooding generally increases invertebrate densities in wetlands, but perhaps only for about a year after initiation of flooding. On year round basis, invertebrate biomass and production is probably greatest in semi-permanent wetlands

3.3 Invertebrates as Indicators of changes in vegetation cover.

Species composition: The composition of invertebrate population is associated with plant succession. Invertebrate associations with plants are influenced by the leaf shape, structure, and surface area of aquatic vegetation. An increase in ratio of algae-consuming species (certain mayflies) to detrivorous species (e.g. certain worms, amphipods) and in the ratio of open-water forms (e.g. Water strider, midges) to vegetation dwelling forms (snails, some mayflies) is expected if an ecosystem has been exposed to herbicides, grazing, fire, flooding, or other vegetation removal processes. The ratio of predatory to herbivorous-detrivorous invertebrates might be used to indicate changes in vegetation cover conditions (Murkin et al, 1991).

Species richness: High invertebrate richness in wetlands is associated with presence of vegetation although beyond some points, vegetation stands can become too dense that invertebrate richness declines (Broschart and Linder, 1986; Kaminiski and Prince, 1981a, b). The variety of invertebrate families, especially of macro-invertebrates, can be greater in wetlands that have been mowed than in otherwise similar wetlands that have not, particularly if the hay has not been removed (Kaminiski and Prince, 1981a, b).

Density and Biomass: Invertebrate biomass in prairie wetlands is strongly linked to plant biomass and thus to aerial cover of vegetation (McCrady et al, 1986). This is because vegetation provides submerged habitat space that macro-invertebrates colonize at a far greater density than open water (Engel, 1990). Beyond some point, however, vegetation stands in prairie wetlands can become so dense that invertebrate density and biomass decline (Broschart and Linder, 1986)

3 4. Invertebrates as Indicators of Wetland salinity

Species composition: Certain invertebrates such as the Anostracan brine shrimp (Artenia), brine flies (Ephydra), ostracods, some midges and aquatic worms are characteristic of hyper-saline prairie wetlands while other taxa (e.g. some spp. Of midges, mosquitoes, aquatic worms, dragonflies, water beetles etc) are known to be relatively tolerant (up to < 30,000mg/L salt) (Swanson, 1984).

Species richness: The variety of invertebrate species within major taxonomic assemblages generally decline in prairie wetlands with increasing salinity and /or with increasing specific conductance, in part because the biomass of most submerged plants decreases and in part because fewer taxa are physiologically adapted to higher salinity levels.

Density and Biomass: The few species that tolerate saline conditions often occur at very great densities in prairie wetlands. This is partly attributable to reduced pressures from completion and predation (Lancaster and Scudder, 1987).

3 5. Invertebrates as Indicators of Sedimentation and Turbidity

Species composition: A shift from herbivorous and filter-feeding species (many midges, zooplankter, and mayflies) to sediments-burrowing species (many aquatic worms) can indicate that major turbidity and sedimentation incidents have occurred or are continuing.

This is because a reduction in light penetration kills submerged plants and attached algae and the plants contain a characteristic assemblage of herbivorous species. Burrowing species meanwhile can continue to exploit soft sediments Excessive sedimentation might be expected to have different effects on species that over winter (season) in wetland sediments as eggs, as opposed to over wintering (seasoning) as diapausing adults.

Species richness: A diminished variety of invertebrates is also a sign that turbidity and sedimentation conditions have been severe. Species richness is particularly likely to decline in semi-permanent and permanent wetlands, where sediments are most likely to become anoxic mainly in marine wetlands.

Density and Biomass: Total density or biomass of invertebrates is a poor indicator of sedimentation, because their increases or decreases can occur in response to increased sedimentation. Increases often occur when some species of burrowing aquatic worms that tolerate oxygen conditions are able to proliferate and, in the absence of intense predation, come to dominate the aquatic community (Adamus, 1996)

3. 6. Invertebrates as Indicators of Excessive Nutrient Loads and Anoxia

(i) Species composition: Particular assemblages of invertebrate species have commonly been reported to be useful indicators of lake trophic status (Adamus, 1996) and might be similarly useful for signaling wetlands that have received excessive nutrients. In general, the proportion of "scrapers" (species that characteristically graze on algae) increase with eutrophication at least at the early stages of enrichment. Specifically increases in the ratios of:

(a) Tubificid worms to sedentary insects;

(b) The midge subfamilies Tanypodinae and/or Chironomini to the subfamily Orthocladinae;

© Non-burrowing mayflies to burrowing invertebrate and;

(d) Cladocerans to rotifers have been reported to indicate excessive nutrient loading of wetlands or other water bodies

(ii) ***Species richness***: species richness can decrease or increase in response to enrichment in
In lakes zooplankton richness initially increases with increasing phytoplankton production, then it decreases as production continues to rises.

(iii) Density and biomass- Density and biomass of invertebrates, especially midges, increase with larger increases in wetland fertility. As the result, the density of midges has been recommended as an efficient indicator in some situations of secondary production in lakes At some point, the response of the whole invertebrate community changes from an increase to a decrease in density when plant litter accumulates faster than it can be processed effectively and oxygen is depleted from sediments and water column causing a reduction in densities of many invertebrates (Wiederholm, 1980).

3.6. Invertebrates as Indicators of Pesticide and Heavy Metal Contamination

(ii) ***Species richness***: Among insecticides, the synthetic pyrethroids (specifically deltamethrin) are generally more toxic to invertebrates than organochlorine, organophosphates, and carbamate pesticides. Mayflies and amphipods tend to be more sensitive to most insecticides than are midges and adult water beetles. In general, herbicides are not as acutely lethal to invertebrates as are insecticides. Within herbicides, the most toxic herbicides are probably the triazines, including the widely used herbicide atrazine as it has been shown to cause shifts in community composition and emergence times of aquatic insects at a concentration of 2 mg/L, and as little as 0.230 mg/L reduced the development of midges (Sheehan et al, 1987).

The use of the herbicide triallate is also quite toxic to prairie invertebrates. On the other hand, other herbicides used in wetland have been shown to increase the dominance of invertebrates (e.g. many aquatic worms) that are tolerant of low dissolved oxygen, a result related to the large oxygen deficit caused by decay of massive amounts of plants. Herbicides can also increase the dominance of open-water forms (e.g. Cladocerans) as their algal food base blooms after the reduction of shading aquatic vegetation.

A host of factors influence toxicity and mortality, and sufficient to change the generic rankings of insecticide toxicity as well as lethal thresholds. These include:

(a) Environmental factors: water temperature, organic content, pH, alkalinity, suspended solids
(b) Dose factors: concentration, the specific formulation (inert ingredients), frequency of application, duration of exposure, and

© *Basic factors:* *the* invertebrate species, its life stage, proximity of unexposed microhabitat patches, degree of simultaneous stress from other factors that may be related (e.g. oxygen stress and enrichment from plant decomposition and photosynthetic inhibition for 1-2 weeks after herbicide application) or unrelated (e.g. drought)

The availability of vegetation can be particularly important to invertebrate’s survival in wetlands having sediments that are contaminated chemically or that are persistently anoxic or saline. In such situations, vegetation provides a colonization of surface isolated from the sediments, where contaminants often are concentrated. Richness and abundance of epiphytic and nektonic (swimming) invertebrates can thus remain high in some contaminated but well-vegetated wetlands (McLachlan, 1975). In other regions and in sediments exposed to some herbicides or severely contaminated by heavy metals, a shift from a community of aquatic insects and toward a community dominated by certain oligochaetes (aquatic worms) has been noted

In non-wetland water bodies, areas that are at least moderately contaminated often are dominated by chironomid midges and other aquatic invertebrate species whose adults have wings and short life cycles (e.g. water bugs, Hemiptera and water beetles (Coleoptera). Wetland amphipods (*Gammarus*, *Hyallea*), clam shrimp (*Lynceus brachyurus*), and many zooplankton species, appear to be very sensitive to certain pesticides, whereas most aquatic snails and worms are less sensitive. Amphipods are specially useful as indicators of contamination because they bare relatively stationary (i.e because they do not emerge and fly away like aquatic insects, their presence can be more indicative of longer-term conditions of a wetland)

In wetlands that lack surface water, nematodes can be particularly resistive indicators of contaminant toxicity. Under such conditions, different nematode suborders and subclasses respond differently to contaminant toxicity. Apparently, the least sensitive organisms in such habitats are the soft-bodied invertebrates such as earthworms, terrestrial herbivores such as ants, and weevils, and invertebrates that inhabit the upper soil layers, such as springtail (Collembola).

Bioaccumulation: bioaccumulation of some substances appears to be greater among sand dwelling invertebrates than mud-dwelling invertebrates. Several aquatic invertebrate taxa effectively accumulate certain heavy metals in lakes and probably wetlands (Adamus, 1996).

Conclusion

The aim of biodiversity monitoring is to track changes in the biological integrity of ecosystems. Given the overwhelmingly dominant contribution of invertebrates to biodiversity, no biodiversity monitoring program can be considered credible if invertebrates are not addressed effectively. The species composition of invertebrate communities and to a lesser degree their species richness, demonstrates diagnostic responses to changes in terrestrial human and natural induced factors, wetland salinity, water regime, and sedimentation/turbidity. Invertebrates also sensitively respond to changing vegetative cover, nutrient levels, and presence of some contaminants. Invertebrate communities are monitored with increasing frequency in wetlands partly because of their recognized importance as food for water birds.

Because of their high dispersal abilities and reproductive capacity wetland invertebrate communities tend to recover quickly (within weeks or months) from the direct effects of acute non-persistent stressors. Results of decay-resistant remains can help establishes conditions for development of water quality standards and biodiversity monitoring systems in general. But further information is first required on the tolerance thresholds of the taxa most commonly found decay-resultantly and factors such as pesticides as contaminants. Studies show that individual wetlands that are semi-permanently flooded generally contain about 20-40 invertebrate families, at densities of 1-20,000 organisms /m^2. Estimates of species composition, richness, and density are strongly influenced by the type of sampling gear and sampling design. Variability spanning several orders of magnitude is often strongly linked to long-term wet-dry cycles and associated vegetation changes in individual ecosystems (terrestrial, aquatic, wetland etc).

Coordinated and sustainable research, follow- ups, is needed to document and analyze temporal and spatial invertebrate response thresholds to all stressors. Before bio-criteria can be fully

developed, information is needed on the potential loss or gain of information resulting from various levels of specimen identification and use of sampling protocols.
Determining the ecological integrity of biological entities in terrestrial, aquatic, riparian and wetland ecosystems and diagnosing possible causes of impairment should involve monitoring of multiple indicators. In most eco-systems, the possibility of ongoing or recent past exposure to excessive sedimentation, pesticide use, deforestation and overgrazing are probably best indicated by species composition of algae and invertebrates, with emphasis on the epibenthic form (taxa that live on the top surface of the sediment).

Epibenthic and epiphytic algae and invertebrates are also useful indicators of excessive enrichment, removal of vegetative cover, and turbidity that is occurring either currently or during past years as determined by analysis of decay-resistant remains. Ongoing or recent past changes of water regime salinity, as well as over-grazing; individual ecosystems are perhaps best indicated by vascular plant species composition. Longer-term changes in these factors can be inferred by examining seed banks and decay-resistant remains of invertebrates. Exposure to pesticides and heavy metal contaminants can be inferred from species composition of invertebrates and from various biomarkers in amphibians and birds. For bio-accumulative contaminants, tissues of individual plants and birds can also be examined.

The restoration of disturbed wetlands has its greatest potential in areas of marginal agricultural lands. Pesticide use should be eliminated on all refuge areas, regardless of proximity to urban sites where vector (e.g. mosquito) control is a concern, or the quality of such wildlife areas will be reduced. Inflow waters must be monitored for pollutants and pesticides. The timing of water movements should coincide with the exploitation of leaf litter by invertebrates. Waters should not be drained when nutrient export may be high, such as in early stages of leaf litter decomposition.

On the other hand, the decline of native plant pollinators and natural enemies of pests in many areas (ecosystems) leads to significant economic loss. Therefore, measures towards biodiversity conservation need to be incorporated, including:

- Protecting natural habitat where native bees and other beneficial insects can, thrive; leaving enough wild land to provide a functional habitat,
- Buffering these important areas from areas where pesticides are used,
- Mixing crops where possible and maintaining weedy borders , ground cover, and hedge-rows, and
- Introducing other feasible practices to sustain beneficial insects

Management that takes a broad multi-species and systems perspective may be essential to the conservation of invertebrate species and the ecosystems of which they are part. Currently, we are hampered by our lack of information about the various ecosystem functions of terrestrial, aquatic, wetland and riparian invertebrates. Efforts to develop holistic and adaptive ecosystem-based management of the countries biodiversity in general and invertebrates in particular in order to maintain functioning landscapes and natural communities are of paramount importance.

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Mammals and birds of the Ethiopian Nile basin: *a brief overview*

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Introduction

The economic significance of the Nile basin and a profile of the Nile sub basins in Ethiopia

Ethiopia has twelve major river basins. The Nile basin within Ethiopia is the largest one consisting three major river sub-basins including, Baro- Akobo, which originates from south western, Abbay (Blue Nile) that originates from north western, and the Tekeze river basins originating from central highlands of the country covering six regional states (RNS) viz, Amhara, Tigray, Oromiya, SNNP, Gambella and Benshangul-Gumuz with varying proportions covering a total area of 358,889 km. The Amhara RNS has the largest share (38%) followed by Oromiya (24%) while remaining 38% of the Nile Basin part in Ethiopia is distributed among Benshangul – Gumuz, Tigray, Gambella and SNNP regional states which share 15%, 11%, 7% and 5%, respectively. Regional states, Gambella and Benshangule-Gumz are situated entirely within the Nile basin (Table 1)

Table 1. Areas and relative percentage share of Nile Basin within Ethiopia by regional states.

	Regional State	Baro-Akobo basin		Abbay Basin		Tekeze Basin		Total (Nile in Ethiopia)	
		Area (km^2)	% (Basin)	Area (km^2)	% Basin	Area (km^2)	% (Basin)	Area (km^2)	%
1	Gambella	26,062	34	-		-	-	26,062	7%
2	SNNPR	18,668	25	-		-	-	18,668	5%
3	Bansangul-Gumuz	7,412	10	44,699	22.37	-	-	52,111	15%
4	Oromyia	23,770	31	62,474	31.27	-	-	86,244	24%
5	Amhara	-	-	92,639	46.36	45,237	54.39	137,876	38%
6	Tigray	-	-	-	-	37,928	45.61	37,928	11%
	Total	75,912	100	199,812	100	83,165	100	358,889	100%

Sources: EPA, 2003

The significance of the Nile Basin to Ethiopia

Among the sub basins, Baro-Akobo, Abbay (Blue Nile), and Tekeze within Ethiopia Contribute 66% of the total average annual runoff, and the Nile basin in Ethiopia is home to about 40% of its population with various development potentials including contributions to development of irrigation based agriculture. An estimated 2 Million ha of land could be irrigated and be utilized for agricultural purposes. Similarly, the basin has the potential to hydro-power generation capacity of up to around 98,831 GWH/yr (EPA, 2003, UN/CEF, 200). An equally important issue as far the Nile Basin parts in Ethiopia is concerned, the continuous deteriorating natural resources within the basin as the result of enormous upstream degradation has off-site effects on people in the downstream countries, reflecting significant transboundary impacts.

The two tributaries of the Nile, the Abbay (Blue Nile) and the Tekeze (Atbara)) rivers, contribute about 86% of the total annual supply of water to the lower Nile. The authors also estimated that the Atbara (Tekeze) and the Blue Nile (Abbay) as established conveyors of the seasonal flood from the Ethiopian highlands with a catchments area of only 332,000 kM^2 (16% of the entire Nile basin) contribute over 90% of the Nile sediment. In this regards, Hurni (1996; Cassells 1994 cited in EWNHS, 1996) have calculated the magnitude of annual economic looses in the range of 10 to 3,000 million Ethiopian Birr for soil erosion, and 600 to 8,000 Million Birr for nutrient removals.

Highlights on Ethiopian wildlife resources

Wildlife in Ethiopia, like many other African Countries is still a public good. It should bee seen as an economic resource as it can ably justify its existence if opportunities are made conducive. At preset its total economic value (TEV) is not yet known. The direct uses (e.g. meat, tourism, hides, medicine etc), indirect use values (e.g. ecosystem stability, watershed protection, species diversity, water quality etc) are slowly being realized**.** Ethiopia has for instance over 280 million mammalian species and has the highest mammalian endemism, on the African continent (31 species =10.9%). There are six endemic genera of mammals of which four are monotypic (three rodent genera), one primate, and the other two genera are *Desmomys* and *Stenocephalemy*s represented by two species each (Henry *et al.*, 2008). These resources could if managed properly contribute significantly to the national economy. Similarly like many African countries, Ethiopia is also believed to have large species birds which require further baseline surveys that would provide baseline conservation data on the distribution of key species, the richness of sites, threats to allow comparisons and a monitoring programme to be made between and within sites over time.

Present evidence suggests that the extensive and unique conditions in the highlands, together with their isolation, led to the development of a large number of endemic wildlife species in Ethiopia (Table 2)

Table 2.Shows the summary of the wildlife profile of Ethiopia

Group	No. of Species	No. of Endemic Species	Total
Mammals (terrestrial)	277	31	11.2
Birds	861	28	3.3
Reptiles	201	9	4.5
Amphibians	63	24	38.1
Freshwater fish	150	4	2.7

Butterflies	324	7	2.2
Plants	5,712-6,034	-1,150	-20.0

Source: EPA, 2003

Highlights on vegetation cover in Ethiopia

Owing to the long period of modification /interference by man, it has now become difficult to discern the natural vegetation of the Ethiopian highlands.

2. An over view of summary of wildlife and natural renounces profile by region. An attempt was made to highlight the major aspects of the status of vegetation, birds and wildlife by region as follows:

2.1. Tigray regional national state

The Tigray regional state is located in the northern part of Ethiopia. The most important habitats in the region with respect to wildlife include, broken up and often forested or at least wooded escarpments, lakes (both artificial and natural), defrosted high mountains, cultivated areas, and river valleys, especially the Tekeze Valley.

2.1.1. Profile of vegetation cover in the region

Most areas in the region are mostly deforested and overgrazed. Currently however, the people have fully realized the importance of conserving nature and are exerting considerable efforts towards conservation. As the result, many areas are being closed off i.e are protected from human and animal interference so that the lost vegetation would revive (recover) and wildlife would return, too.

Profile on the status of birds in the region

According to available information the Shire lowland and the central part of the region fall within the Nile basin catchments (EWNHS, 1996). According to the same study, there are about 500 bird species in Tigray representing birds from three biomes viz highland, Somali-Masai and Sudan-Guinea. According to the same sources, the endemic birds in the region include, Rupell's Chat, Abyssinian Catbird, Black headed Siskin, and further five species that are endemic to Ethiopia and Eritrea. More over the Region has wetlands which hosts large numbers of palaerctic migrants during the winter months

The Shire low land areas of the Tekeze valley

The Shire lowland areas of the Tekeze valley are found in the western administrative zone of the Tigray Regional state. Altitudes range from about 600 m.a.s. at the Tekeze River to over 1,900 m.a.s at Enda Selassie (EWNHS 1996). The areas are moist and fertile. The flatter areas on both the plateau and the lowlands towards the Eritrean and Sudanese borders are extensively cultivated and used to grow different crops. The area is particularly suitable for cotton, sorghum and sesame. According to EWNHS (1996) inventory, 152 species of birds were recorded in the Shire low land of the Tekeze valley and the avifauna within the site according to this inventory contains the Sudan-Guinea biome species (Green-backed Eremomela,chestnut-crowned sparrow-weaver, black-rumped waxbill) and several Somali-Masai biome species (e.g. Purple Grenadir straw-tailed widow). Other birds that are recorded here are, Grey kestrel, stone partridge Egyptian plover, Pink-headed Dove, Little Green Bee-eater, Red –billed Wood Hoopoe and Black-headed Gonolek.

On the other hand, available sources show that the Shire lowland is home for different mammals including, Elephant Greater Kudu, Warthog, Ratel, Leopard, Gray, Duiker, klipspringer and Common Jackal. Similarly, other wildlife including, reptiles, African Rock Python and Egyptian Cobra (the first record for Ethiopia) have been recorded in the 1996 inventory by the Ethiopian wildlife and Natural History Society (EWNHS).

Amhara regional national state

The Amhara regional state is found in the North-western, center and northeast parts of Ethiopia at varying altitudes ranging from 1000 m.a.s. to 4,620 m.a.s. The region is endowed with natural and historical tourist attractions including (among others), the Semien Mountains National park which is recognized by UNESCO as a world heritage site, lake Tana which is the largest body of inland water in the country. The region has also the famous rock – hewn churches of Lalibela the castles of Gonder and the " Tis Isat" (lit.water that smokes) falls.

As far as major wildlife habitats in the region are concerned, the EWNH inventory (1996) shows that, the habitats could categorized as afro -alpine vegetation, wetlands, forest, and Vast cultivated lands. The same inventory results show that out of the 10 important bird areas (IBAS) identified for the region, seven are within the Nile basin catchments. These IBAS were identified on the presence of the restricted range species and include, Harwood's francolin, Rupell's Chat, and Ankober Serin and other eight endemic species found in the region and further 12 highland Biomic species restricted to Ethiopia and Eritrea.The Amhara regional state is divided into 10 zones which in terms of wild life and natural resources are diverse.

The Awi Zone is one of the administrative zones in the region and the zone is relatively flat and fertile with an altitudes ranging from 1800 to 3,100 m asl. There are about nine permanent rivers which drain into the Abbay (Blue Nile) River as tributaries. The zone has two crater lakes, Zengena and Tirba. In terms of climate, most of the areas in the zone fall into the WEINA DEGA agro-climate with average temperatures ranging between 16 and 21 ^{o}C and rainfall between 1,200 and 1,400 mm a year. The people in the zone are known as Agaws and have well established culture of communality as the result of which they have established systems to use their water and forest resources commonly. These practices have contributed to the sustain ability of the fertility of the soil and to minimize erosion as the result of which the area is recognized as one of the most productive areas in the Region. According to available information, the major wildlife habitats in the region include,wetlands (Zimbiri Marsh, for instance), forests (e.g. Dukima (Figs spp.), Apini and Goobil Forests), Lakes (Zengena Lake) and cultivated lands.

As far as birds fauna are concerned, a total of 214 species were recorded (EWNHS, 1996), out of which two were globally threatened species: Rouget's rail and the Ethiopian endemic, Abyssinian long claw. Other recorded Ethiopian endemics included, Abyssinian Woodpecker and Abyssinian catbird, both hghland biome species.Two Somali-Masai biome species, White rumped babbler and Bush petronia and Abyssinia ground trush and Abyssinian crimson wing as well as a number of Palaearctics birds were also recorded (Table 3).

Table 3. Shows number of bird species recorded from in sites in Awi Zone

Site	Total	HB	E
Zimbiri Marsh	96		
Zengena	28	8	1
Dukima & Apini forests	100	18	2
Goobil forest and pond	69	15	2

NB: HB = Highland biome, E = Endemic to Ethiopia
Source: EWNHS (1996)

The EWNHS (1996) inventory of wildlife (birds and others) included some selected areas such as the Lake Tana and its environs, Choke mountain and, Simien Mountains National park (SMNP). Accordingly, the bird fauna profile in Lake Tana and its surrounding showed that only in a days survey 217 species were recoded (EWNHS, 1996) as the result a recommendation has been made to recognize the site as an important bird area under three categories. First the areas that are homes for five globally threatened species: Wattled Crane, Lesser Flamingo, Rouget's Rail, Pallid Harrier, and Greater Spotted Eagle are housed, second, sites where the population of water birds around Lake Tana seasonally exceeds 20,000, and the third category includes area where 19 Highland Biome have been so far recorded which included, Abyssinian long-Eared, Owl, White-Backed Black Tit, White Throated Seedeater and Banded Barbat. In Addition , four Sudan-Guinea Biome species(Red Throated Bee Eater, Green Backed Eremomoela, Bush Pteronta and Chestunet-Crown Sparrow weaver), were also recorded

As far other wildlife in and around the lake are concerned, very little has been known although some available scanty sources indicate that wildlife such as Vervet Monkey, Anubis Babon, Hyaena, Mongoose and Rodents do exist in the area. Otter and Monitor Lizard were recorded from the lake (EWNHS, 1996).

Another site the EWNHS (1996) survey covered in the region was the Choke Mountains. The Choke Mountains are chains of large block of highland plateaus found south of Lake Tana in the center of east Gojam administrative zone. The Abbay River has cut a deep valley round the east of this mountain block. The highest peak of Mt Choke is 4,070 m a.s. The mountains sources for many small streams which originate from the mountains and flow into the valleys. There is also continuous and extensive agricultural activity with cultivation at up to 3,000 m a.s. high. In this area, 49 bird species were recorded during the 1996 by EWNHS survey group. The important species recorded included, Wattled lbis, spot-breasted plover, White-collared Pigeon, Abyssinian Long claw, Thick-billed Raven and Black-headed Sis kin all of which are characteristic of open highland habitats species.

The other site the EWNHS (1996) survey covered was also the Semien Mountains National park (SMNP) which is the only officially protected conservation area in the Region. Wildlife biodiversity conservation is given particular emphasis due to the endemic mammals like Gelada

Baboon co-exist with the local people, rare and precious animals like walia Ibex and Ethiopian Wolf which are now seriously threatened by the rapid deterioration in their natural habitat as the result of unabated agricultural encroachment timber extraction and abandonment of the major threats to the survival of birds and other wildlife in the Region. During the survey, the EWNHS team recoded 135 birds out of which 33 are highland species representatives, including; Chestnut napped Francolin, Black winged Love Bird, White Cheeked Turaco and White winged Cliff Chat. Recorded were also, Abyssinian Long Claw, Red-Billed Chough. The same survey team also recorded other animals including, Walia Ibex, Ethiopian Wolf, Kilif Springer Geleda Baboon, White and Black Columbus Monkeys in the area.

Benishangul-Gumuz regional national state

The Benishangul-Gumuz Region is stretched along the western escarpment of Ethiopia. Although it is assumed that this region is endowed with potential IBA sites, surveys have not been yet conducted in the region due to largely logistic related issues.

Gambella regional national state

The Gambella regional state is found within the basins of the Baro and Akobo rivers in western Ethiopia. Two important bird areas including Baro-river and Gambella National Park have been identified from which around 300 bird species have been recorded. Examples of bird species recorded include. Shoebill, Black winged pratincole, and Basra ried walbler. As far as mammals are concerned, 41 species have been recorded. Representative examples of the recorded mammals included, Giraffe, Lion, Leopard, Elephants, Lelwel hartebeest, Buffalo and Roan Antelope.

Oromia regional national state

The Oromia regional state has the largest share in the official protected areas system in the country. Accordingly, 70% of the national forest priority areas of the country are for instance located in this region. The region has three national parks viz Abijatta-Shalla, partly Awash and Bale Mountains, and also has more than eight conservation areas. The region is relatively rich in wildlife. Among the most notable wildlife in the region are, the Mountain Nyala (the last large mammal species to be named in 1919), and the Giant Mole rat which are found in the Bale mountains national park.

Further more, 11 of Ethiopia's endemic wildlife species and two endemic subspecies are recorded from the region. The Region also shares the two endemic mammals, Gelada Baboon and Ethiopian wolf with those recorded in the Amhara regional state. The Oromia regional national state holds the largest number of IBAs in the country. There are 29 IBAS confined to Oromia region and two others are shared with location within the city of Addis Ababa and the Afar regional state.

Moreover, some part of the South Ethiopian highlands endemic bird Area (EBA) is found in Oromia. Available sources show that there are 22 globally threatened species of birds in Oromia along with rare species such as Prince Ruspoli's Turaco which is the region’s most famous bird which is beautiful, rare and globally endangered. Many agree that this bird can claim to be the ornithological equivalent of Walia Ibex. Seven of the 22 globally threatened species are endemics with five of them being restricted range species among which the very rare species such as White-tailed Swallow, Abyssinian Bush crow etc. are found only in this region.

Conclusion

Most of the birds and mammals habitats within the Nile basin part of Ethiopia are highly affected by human intervention, eg. White winged flufftail’s habitat, the Sululta area is seriously affected by the intensively widening up of flower farms, while Harwood’s francolin habitat on the other hand is being diminishing due to agricultural expansion leading to continuous vegetation clearing and tree cutting for fuel wood purposes.

Recommendations

In order to maintain and enhance the dwindling wildlife resources situation in the country:
Community based eco-tourism should be initiated and encouraged
Site specific conservation efforts should be given due attention based on further well coordinated and designed study findings. Studies and actions should be sustainable with strategies for follow ups. Environmental insensitive practices should be halted, at all levels, all the time
Environmental education and awareness creation efforts ought to be in place at all levels of both formal and informal education set ups.

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Socioeconomic significance of some wetlands in the Amhara and Oromia regional states, Ethiopia

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Introduction

Wetlands are among the most productive and beneficial ecosystems for human needs in the world. The Millennium Ecosystem Assessment has clearly depicted the services that wetlands provide (directly and indirectly) for humans. They are source of food, fresh water, fiber, fuel, medicines, ornamental items, etc. Wetlands also benefit humankind through their regulatory role in that they mitigate climatic disturbances, purify water, maintain water balance, halt natural hazards such as flooding, and reduce downstream siltation by trapping sediments and host large array of biological diversity. In addition, they play important role in serving cultural values such religious needs, aesthetic, educational and recreational issues. They provide ground for spiritual and religious ceremonies and open opportunities for recreational activities. Moreover, they are site of beauty or aesthetic value for many people and serve as area of study for formal and informal education and training, and research.

1.1. Wetlands in the Ethiopian context

Although wetlands and wetland biodiversity of Ethiopia have not yet been investigated in depth, wetlands have different economic values in Ethiopia. These include food crops supply through agriculture by draining and recession, important sites for dry season grazing, resources extraction, raw materials (reeds for thatching purposes, papyrus) supply, fish harvesting, source of medicinal plants and sites for tourist attraction and various traditional ceremonies. Wetlands serve communities as sources of water, both for humans and animals. In wetlands such as Abaya and Chamo lakes, crocodile farming is yielding economic benefits. Some studies show that some wetlands such as Lake Tana, Fogera, Chefa, and the Rift Valley wetlands are resting and nesting sites for inter-Africa and Europe migratory birds and add to their tourist attraction significance.

Successive drainage of wetlands in Ethiopia for agricultural production has been undertaken for decades in the Southwestern part of the country, Jimma, wollega and Illubabur (Bognetten et al, 2003 cited in Fitsum Merid, 2006).Hence, the socioeconomic significance wetlands in Ethiopia are enormous and the significance is from grassroots community livelihood up to nation wide macroeconomic activities benefiting in one way or another. Major hydroelectric dams of the country are originated from natural wetlands in the upstream and they themselves are manmade wetlands. In this regard their role in maintaining underground and above ground water balance through recharging and discharging becomes more evident. They regulate overflow of rivers during rainy seasons by capturing excess water. As a result they allow year round flow of streams and avoid downstream hazards of flooding. In this regard wetlands such as Fogera plain, Lake Tana, Tefki-Teji plain, Cheffa wetland, wetlands in Baro-Akobo basin and wetlands in Didessa valley can be mentioned. Thus, wetlands are the source of energy that gears all socioeconomic endeavors towards sustainable development (poverty reduction, food security, industrial development).

Wetlands in the Amhara Regional State

a) Lake Tana

Lake Tana and other wetlands within the Amhara region state have multifaceted significance for the surrounding communities and several million people in the Nile Basin (Zerfu Hailu, 2004). For instance, Lake Tana and it's environ have local and overreaching contributions including:

i) Local contributions: Local contributions recognized by the community include, as source of food, feed, construction materials, etc,as livelihood base for large number of people (fisherpersons, handicrafts, sand producers, boatmen, tourism related bodies including hotels and their workers etc), as sources of water for humans and animals, have cultural and/or religious value, serve for transportation of people, goods and animals, generates of hydroelectric power, protect the local community and the surrounding infrastructure such as Bahir Dar city from hazards of flooding, and additional source of revenue for the country

ii) Over reaching (extend) contributions: Over reaching (extend) contributions include: (i) home for biological diversity (various fauna, flora and micro-biota), (ii) Provides attractive scenery that attracts tourists,(iii) regulates year-round flow of the Blue Nile and thereby secures life throughout its course in the downstream , and (iv) Ameliorate local climatic situation. The Fogera plain for instance serves (among others) as major area for seasonal agriculture and as grazing land for large number of livestock including the Fogera breed (known as best performing draught animals).

b) Socio-economic significance of Chefa Wetland

Chefa wetland is one of those wetlands that are agriculturally very productive and of great socioeconomic value (Annexes 1and 2). This land saves life of large herds of cattle from the surrounding Afar and Amhara Regions in dry season (EPA, 2006). During the harsh dry season, from January to March in particular, large numbers of cattle (as high as 120,000) come from Afar and Amhara Regions, in search for green herbage and water. Further more, the communities living in the proximity of the wetland depended on it for many of their livelihood related activities and for recreational purposes. The wetland is also a site where many ethnic groups come together to utilize the resources in common. The wetland a further has significance for Peace and Stability – For instance the pastoralists who come in dry seasons from Afar particularly the 'Wurene *Afar'* and the local people living around Chefa have agreement based on mutual benefit.

The pastoralists leave their livestock under custody of local communities; the latter benefit from milk and milk products of livestock under their custody. This has created some sort of peaceful coexistence between the Afar and individual member of the local communities. Like many other wetlands, Chefa wetland contributes towards personal hygiene and sanitation -besides providing water for keeping personal hygiene, the wetland has some hot spring sites that were used for treatment of all sorts of ailments, but primarily for skin diseases and muscular paralysis. There were however some negative aspects perceived by the community as the result of living in and around the wetland- various health hazards resulting from waterborne diseases such as malaria and livestock disease such as liver fluke.

Wetlands in Oromia Regional State

a) Socioeconomic functions of wetlands in Illubabor zone

Wetlands of Illubabor zone and the surrounding forested catchments are crucial in serving as source of headwater for the tributaries of the Nile (rivers like Baro). They are also vital in trapping sediment passing from the catchments to downstream (Afework Hailu et al, 2000). Thus they increase the life time and vitality of dams and reservoirs. Farmers in Illubabor zone (Oromia) cultivate wetlands in dry seasons and during grain deficit seasons in order to ensure food availability. Most cattle owners use the wetlands as water point and dry season grazing site for their stock. Further more, the inhabitants use sedges for thatching the roofs of traditional huts (about 85% of the inhabitants), for social or ceremonial use (100%), for handcrafts, for making traditional umbrella locally known as "Gessa", for mulching nursery sites etc. The traditional healers collect medicinal plants from wetlands. In dry season, people use wetland margins to raise seedling of various plants with economic and environmental significance

b) Socio-economic functions of Wetlands in the rift valley areas

The rift valley wetlands have several socio-economic benefits such as, water supply - springs which are found around the wetlands are indispensable for domestic water supply in the dry seasons when people and animals face serious water shortage, reeds for thatching, crafts or floor covering, animals obtain green fodder and water in the dry season, thus they are life saving centers, the local people collect medicinal plants both for human and animal health problems, supply aquatic resources such as fish as food and income source, store water for irrigation and hydropower generation, serve for cereal crop, vegetable and fruit production, and dependable sources of food during dry season, wetlands have been good recreation areas and tourist attraction sites that generating income in the rift valley areas (Siraj Bekeli, 2004).

In general, if wisely managed, wetlands that attribute the above mentioned socioeconomic contributions are essential ecosystems in poverty reduction and ensuring (sustaining) food security.

Conclusion

The functions of wetlands directly or indirectly contribute to socioeconomic vitality and human wellbeing from local or grassroots up to global level. So wisely harnessing the potential of wetlands shall enhance benefits for generations and minimize resource use conflicts between upstream and downstream users, thus create conducive situation for sustainable development. The aforementioned socioeconomic contributions of wetlands could be are summarized as in such a way that at community level the contribution of wetlands is related mainly with livelihood and basic needs of daily life. This includes providing material for food, feed, construction, income, freshwater, decorative, medicine etc and services such site for cultural or religious ceremonies and protection from flooding while at national level, wetlands play key roles in contributing to nationwide socioeconomic performance through generating revenue from sectors such as tourism, job creation, generating hydroelectric power, providing water for irrigated state or large-scale farms.

Improve longevity of dams by trapping silt and maintain smooth river flows through their recharging and discharging role and global level, carbon sequestering role of wetlands is vital for the survival of humankind as it contributes to global climatic stability or reducing global warming. They are also home for biological diversity of global significance (various fauna, flora and micro-biota), and particularly important in sheltering transcontinental migratory waterfowl. They are also important in creating harmonious ecological setup through forming and regulating year-round trans-boundary river flows such as the Nile and reduce conflicts.

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Annexes

Annex 1 -Type of Economic link with wetland around Chefa wetland [Chefa Management Plan, EPA (2006)]

Type of economic link	Frequency	Percent
Only cultivation	72.0	13.6
Cultivation, fishing, and grazing	3.0	0.6
Cultivation, fishing, grazing fuel wood and cutting grasses	2.0	0.4
Cultivation, fishing, grazing and construction	1.0	0.2
Cultivation, fishing, grazing and cutting grasses	4.0	0.8
cultivation and grazing	79.0	14.9
cultivation, grazing and fuel wood	14.0	2.6
cultivation, grazing, fuel wood, construction and cutting grasses	10.0	1.9
cultivation, grazing, fuel wood and cutting grasses	15.0	2.8
cultivation, grazing and construction	3.0	0.6
cultivation, grazing, construction and cutting grasses	7.0	1.3
cultivation, grazing and cutting grasses	66.0	12.5
Cultivation and fuel wood	5.0	0.9
cultivation, fuel wood, construction, and cutting grasses	1.0	0.2
cultivation, fuel wood and cutting grasses	8.0	1.5
cultivation and construction	1.0	0.2
cultivation and cutting grasses	25.0	4.7
Only fishing	4.0	0.8
fishing and grazing	2.0	0.4
fishing, grazing and cutting grasses	4.0	0.8
Only grazing	19.0	3.6
grazing and fuel wood	2	.4
grazing, fuel wood, construction and cutting grasses	1	.2
grazing, construction and cutting grasses	4	.8
grazing and cutting grasses	36	6.8
Only fuel wood	2	.4
fuel wood and cutting grasses	4	.8
construction and cutting grasses	5	.9
Only cutting grasses	21	4.0
Not mentioned	7	1.3
No economic link	102	19.3
Total	529	100.0

Annex 2 - Type of Non Economic link with the wetland around Chefa wetland [Chefa Management Plan, EPA (2006)]

Type of non Economic link	Frequency	Percent
Only recreation	23.0	4.3
recreation and enjoy the view	9.0	1.7
Recreation, enjoy the view and identity	1.0	0.2
Recreation, enjoy the view, identity, sanitation and water	13.0	2.5
Recreation, enjoy the view and water	1.0	0.2
Recreation, enjoy the view and sanitation	5.0	0.9
Recreation, enjoy the view, sanitation and water	40.0	7.6
Recreation, enjoy the view and water	6.0	1.1
Recreation and sanitation	8.0	1.5
Recreation, Sanitation and water	33.0	6.2
Recreation and water	24.0	4.5
Only enjoy the view	28.0	5.3
Enjoy the view, identity, sanitation and water	1.0	0.2
Enjoy the view and rituals	1.0	0.2
Enjoy the view and sanitation	7.0	1.3
Enjoy the view, sanitation and water	17.0	3.2
Enjoy the view and water	21.0	4.0
Rituals and water	3.0	0.6
Only sanitation	25.0	4.7
Sanitation and water	72.0	13.6
Only Water	82.0	15.5
Not mentioned	21.0	4.0
No link	88.0	16.6
Total	529.0	100.0

Annex 3 Pictures showing socioeconomic contributions of wetlands

Fig 1.-Fishing on Lake Tana

Fig.2 Grazing and wetland cultivation

Fig 3.-Water for Personal hygiene and household consumption

Fig 4.-Wetland materials for income and construction

Fig 5.-Wetland biodiversity and scenery for tourism