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Research Article

THE WEALTH OF LAKE TANA

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1. INTRODUCTION

Lake Tana, the source of the Blue Nile River, is geographically located in the north-western part of Ethiopia, between latitude 10°58`–12°47`N and longitude 36°45`-38°14`E. It has a surface area of 3,200 sq km, a mean depth of 8 meters and maximum depth of 14 meters with fluctuations due to increasing siltation levels. It is the largest freshwater body in the country, contributing about 50% of the water resource of the nation. The lake lies at higher altitude in the range of 1,840 meter above sea level compared to Lake Victoria at 1,134 meters above sea level and is considered the highest lake in Africa. Due its altitude it is characterized by cold waters with mean temperature of 21.7°C. The Lake Tana watershed consists of 347 Kebeles (the lowest administrative units) and 21 Woredas (districts) in four administrative zones. The lake catchment covers an area of 16,500 sq km. Altitude variations in the Lake Tana watershed range from > 3000 m (Guna Mountains) to 1800 m (bordering floodplains). This altitudinal variation coupled with high habitat heterogeneity possibly has made the region rich in biodiversity and endemism. From more than five million lakes on the planet, Lake Tana has emerged as one of the global top 250 lake regions most important for biological diversity conservation in the LakeNet framework. Lake Tana is a multi-use water body where many millions of people in the region depend on its ecological and socio-economical values. In addition to its use for agricultural activities for the local inhabitants, the lake is used for transportation. In particular, Lake Tana has 37 islands that are scattered about the surface of the lake and this islands shelter fascinating churches and monasteries, some of which have histories dating back to the 13th and 14th Century. With varieties of attractions in the nearby Lake Tana and Blue Nile River, make the Lake Tana region, particularly Bahir Dar City, as one of the leading tourist destinations in Ethiopia.

Fig. 1: The view of Lake Tana.

1.1. Baseline of the Lake Tana Region

The Lake Tana region is situated in the northern part of the Ethiopian Highlands in Amhara National Regional State. The Lake Tana Region is not a clearly demarcated area but it lies within the Lake Tana watershed (LTW) and includes those areas around the lake with strong ecological, socioeconomic but also cultural linkages to the lake itself. Geographically situated between latitude 10°58`–12°47`N and longitude 36°45`-38°14`E, the watershed consists of 347 Kebeles and 21 Woredas (districts) in four administrative zones. With a surface of 3156 km^2 stretching approximately 84 km north-south and 66 km east-west, Lake Tana is the largest lake of Ethiopia and one of the largest in Africa. Located at an elevation of 1840 masl it is also the highest lake in Africa. Its maximum depth is 14m with a decreasing trend due to siltation and lowering water level. As the main source of the Blue Nile at its upper course, the Lake Tana Basin accounts for 50 % of the inland water amount, draining a

long way through Khartoum in Sudan to the Mediterranean Sea. The LTW has a drainage area of 15,096 km^2. The lake is surrounded by lagoons and wetlands and has 40 tributaries (rivers and streams), on which Gilgel Abay, Ribb, Gumara and Megech account for 93 % of the total inflow. The lake was formed 20 million years ago by a lava extrusion that functions as a natural dam. Note: For the feasibility study the whole catchment has been taken into consideration, even though the actual outer boundaries of a potential biosphere reserve still need to be defined and are part of a negotiation process.

The climate around the lake is a warm-temperate tropical highland monsoon with a mean temperature of 21.7°C, large diurnal but small seasonal changes of 5°C and two temperature peaks around May/June and October/November. Rainfall is strongly Feasibility study for a potential biosphere reserve Lake Tana – Michael Succow Foundation 2012 seasonal with a dry season between October/November and May/June and a pronounced rainy season (kiremt) between July and September. Due to its high altitudinal variations within the whole basin of Lake Tana, it covers eight agroecological zones. Accordingly, mean annual rainfall ranges from 800 to 2000 mm. Major soils in the basin are Chromic Luvisols, Eutric Cambisols, Eutric Fluvisols, Eutric Leptosols, Eutric Regosols, Eutric Vertisols, Haplic Alisols, Haplic Luvisols, Haplic Nitisols and Lithic Leptosols (see annex IV – map 13). The majority of the land area, 51 % of the Lake Tana Basin is used for agriculture, 29 % is agropastoral area, 20 % of the basin is covered by the lake´s water. The LTR is of national and international importance in many ways: it is rich in biodiversity with many endemic plant species and cattle breeds; it contains largest areas of wetlands; and it is home to many endemic birds and cultural and archaeological sites. In particular, Lake Tana has 37 islands of which 20 have Ethiopian Orthodox churches and monasteries with an enormous historical and cultural value, dating back up to the 14^{th} century. The basin is also critical for the national economy, as it has great potentials for irrigation, hydroelectric power, water supply, high value crops and livestock production, transportation, (eco-) tourism attractions and others. With 85 % of the Nile water originating from Ethiopia and most of it being precipitated in the LTW, the area has undoubtedly enormous international importance for the Blue Nile River and water supply in all the downstream regions and countries, Sudan and Egypt.

1.2. Biodiversity hotspots

Ethiopia has the fifth largest flora in tropical Africa and is one of the 8 centres of origin of crops on the global level. The flora of the country is estimated that 6,500-7,000 species of higher plants occur, of which 12 % are endemic. Ethiopia as a centre of fauna diversity: of the 277 mammals, 862 birds, 201 reptiles and 63 amphibians, 29, 16, 10 and 34 species are endemic to Ethiopia, respectively (IBC 2009). The LTR is part of the Eastern Afromontane Hotspot and comprises four terrestrial and three freshwater (one highpriority) Key Biodiversity Areas. It is home of important flora and fauna:

- Aquatic biodiversity: endemic fish species and other important species with the last flocks of Barbus; habitats for hippopotamus and reptiles like the Nile crocodile; rich in invertebrate diversity;
- Habitat of the Fogera cattle breed: one of the best native Ethiopian milk cow breeds which is at risk of genetic dilution;
- Important bird nesting and sanctuary areas of global importance : 500,000 ha are For further information on the Eastern Afromontane and the Horn of Africa Hotspots
- Many indigenous medicinal plants such as endod (Phytolacca dodecandra), kosso (Hagyinia abyssinica), gesho (Rhamnus prinoides), wanza (Cordia africana) and girawa (Vernonia amygdalina) are also found in the watershed and with 67 documented plants from the natural forest of Zegie Peninsula only ;
- Church forests as islands of biodiversity, Zegie peninsula with 113 documented woody plant species and the Bahir Dar Blue Nile River Millennium Park with 140 woody plant species identified.

1.3. Aquatic ecosystems

With its vast water resources, water plays a pivotal role for the ecosystems´ Constitution and ecological processes within the LTR. Lake Tana is considered as the water tower of Ethiopia because it accounts for 50 % of the total inland water of the country with 60 rivers and streams that flow into it. The four perennial rivers, Gilgel Abay, Gumara, Rib and Megech contribute 91 % to the inflow into the lake. The water of the lake comes from surface run-off, direct rainfall and groundwater recharge from its surrounding wetlands. The annual outflow from Lake Tana is $4km^3$, i.e. 7 % of the total Blue Nile water flow. The annual outflow for the period 1959 to 1995 as measured on the Abay River at Bahir Dar was 114 m/s, while the total flow in the Abay River at Tis Abay (Nile Falls) was 126m/s.

2. PHYSICAL FEATURE OF LAKE TANA

Lake Tana occupies a wide depression in the Ethiopian plateau. The lake is shallow, oligotrophic, and freshwater, with weak seasonal stratification. At 3156 km in area, it is the largest lake in Ethiopia and the third largest in the Nile Basin. Of more than 40 rivers feeding the lake, Gilgel-Abay, Gumera and Magetch contribute more than 93%of the inflow. The only surface outflow is the Blue Nile, which comprises 7% of the Blue Nile flow at the Ethio-Sudanese border. The lake is believed to have been formed due to damming by lava flow during the Pliocene, but the formation of the depression itself started in the Miocene. The temperature of the lake surface is about 38C greater than mean air temperature, perhaps related to the above one year residence time of lake water and the consequent heat storage. The mean annual humidity (1961–2002) at Bahr Dar (the closest station to the Lake) is 0.65 and it varies between 0.50 and 0.80. The area has a unique

cultural, historical and aesthetic value with numerous monasteries and churches dating back to the 13th century. Culturally, the Biosphere Reserve is very important as it is home to many unique churches and monasteries of the Ethiopian Orthodox Tewahedo Church; some date back to the 13th century. These churches and monasteries contain valuable treasures of the Ethiopian Christian faith.

2.1. Water Inflow and Out Flow

At 1,830 m altitude, Lake Tana is situated on the basaltic Plateau of the north-western highlands of Ethiopia covering an area of 3,050 km^2. It is poor in nutrients and the source of the Blue Nile River (Great Abbay), with a catchment area of 16,500 km^2. The Lake has been formed by volcanic activity, blocking the course of inflowing rivers in the early Pleistocene times 5 million years ago. The lava also separated the Lake and its headwaters from the lower Blue Nile basin by 40 m high falls at Tissisat, 30 km downstream from the Blue Nile outflow. Terraces suggest that the Lake was originally much larger than it is today. Seven large permanent rivers feed the lake as well as ca 40 small seasonal rivers. The main tributaries to the lake are Gilgel Abbay (Little Nile River), Megech River, Gumara River and the Rib River. Together they contribute more than 95% of the total annual inflow. The Blue Nile is the only outflowing river. The shallow lake (average depth 8 m, max. Depth 14 m) is Ethiopia's largest lake, containing half the country's freshwater resources, and the third largest in the Nile Basin. In the main rainy season (July—August) the inflowing rivers carry heavy load of suspended silt into the lake, thereby increasing the turbidity of the lake water. The suspended sediments reduce the underwater light intensity and as such the primary production, the basis of the food web. The fish community of the Lake is dominated by cyprinid fishes, 20 of the 27 fish species (e.g. *Labeobarbus* spp., *Barbus* spp., *Garra* spp.) are endemics to the Lake catchment. This speciation was possible because the incipient Lake offered new habitats for adaptive radiation and maintained its isolation for millions of years from the lower Blue Nile. Wetlands are located all around the lake, with the exception of the Northeast. Together they are the largest in the country and integral parts of the complex Tana-ecosystem. They consist of permanent swamps, seasonal swamps, and areas subjected to regular inundation. During the raining period these wetlands are connected with the lake. They act as nurseries for most of the fish populations in the lake, and serve as breeding ground for water fowl and mammals. Around the lake and its catchment, including the town of Bahir Dar, live about 2 million people. This lake and adjacent wetlands provide directly and indirectly a livelihood for more than 500,000 people. The Blue Nile drains the NE Ethiopian Plateau (total catchment: 324,000 km^2). Already in ancient Egypt civilization this river was of key importance to early agriculture and today the river is still of critical importance for the economies of Sudan and Egypt.

2.2. Climate

The climate of the region is 'tropical highland monsoon' with one rainy season between June and September. The air temperature shows large diurnal but small seasonal changes with an annual average of 208C. The seasonal distribution of rainfall is controlled by the northward and southward movement of the inter-tropical convergence zone (ITCZ). Moist air masses are driven from the Atlantic and Indian Oceans during summer (June–September). During the rest of the year the ITCZ shifts southwards and dry conditions persists in the region between October and May. Generally, the southern part of the Lake Tana basin is wetter than the western and the northern parts. At least seven irrigation schemes with an overall water demand greater than 600 million m/year have been proposed within the watershed of Lake Tana. However, no major water resources development implementation has so far been done in the Lake Basin.

2.3. Water Resources Development around Lake Tana

The two important water resources development around Lake Tana include the water level regulation weir constructed at the mouth of the lake in 1996 and the TisIsat hydropower development 35 km downstream of the Location of Lake Tana. The four large rivers account for 95% of surface water flow to Lake Tana. The TisIsat fall and the hydropower plant is located 35 km downstream of Lake Tana outflow. The construction of the weir, which was completed in 1996, was intended to augment the dry season outflow to supply water regularly to the Hydropower Plant (TisIsat Hydropower). The lowlevel water development activities, however, does not mean a low level of environmental impact. The few activities such as the diversion of the water for hydropower generation have significantly reduced the volume of water available for the 35 m waterfall. This natural waterfall was the second most frequently visited tourist destination in the region.

2.4. Wetlands around Lake Tana

Wetland ecosystems have a high local and global significance as natural and economic resource. They provide a wide set of environmental services, such as flood control and biodiversity maintenance, and socioeconomic services for production and use, such as plants, crops, and fish and grazing and thus are important for human use as well as for plants and animals. Therefore they are recognized as extremely valuable and the protection of wetland ecosystems has become highly important all over the world. Wetlands can be defined as, "areas where water is the primary factor controlling the environment and the associated plant and animal life. They occur where the water table is at or near the surface of the land, or where the land is covered by shallow water. "Wetlands are 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 metres."

2.4.1. Major Wetlands

The Lake Tana Region is endowed with a large number of wetlands that are among the largest and ecologically most important ones of the country and the Horn of Africa. They surround the whole Lake and are flooded during the rainy season. Lake Tana and its associated wetlands are part of the Central Ethiopian Highland Wetland Complex including

- Lake Tana;
- Fogera Floodplain to the east;
- Dembia Floodplain to the north;
- Dangela and the surrounding Wetlands;
- Bahir Dar Zuria;
- Kunzula to the southwest.

Wetlands account for 13,699 km^2 (i.e. 1.14 %) of land surface in Ethiopia. Of this 1,803km^2 (0.16 %) of Ethiopia is covered by marshes and swamps. If water bodies are included, in ANRS 3.7 % is covered by wetlands, with 288,744 ha covered by swamps and marshes, and 316,609 ha by water bodies. Wetland ecosystems support a diverse flora and fauna, high diversity in habitat types dependent on altitude, rainfall, temperature and geographic location.
More than 60 seasonal and perennial rivers that are equipped with distinct riparian and wetland vegetation can be found in the Lake Tana region. But the vast majority of thisvegetation type is concentrated in the flat plains of Lake Tana.

2.5. Islads in Lake Tana

Lake Tana has a number of islands, whose number varies depending on the level of the lake. It has fallen about 6 feet (1.8 m) in the last 400 years. According to Manoel de Almeida (a Portuguese missionary in the early 17th century), there were 21 islands, seven to eight of which had monasteries on them "formerly large, but now much diminished. When James Bruce visited the area in the later 18th century, he noted that the locals counted 45 inhabited islands, but stated he believed that "the number may be about eleven. A 20th-century geographer named 37 islands, of which he believed 19 have or had monasteries or churches on them. Remains of ancient Ethiopian emperors and treasures of the Ethiopian Church are kept in the isolated island monasteries (including Kebran Gabriel, Ura Kidane Mehret, Narga Selassie, Daga Estifanos, Medhane Alem of Rema, Kota Maryam, and Mertola Maryam). On the island of Tana Qirqos is a rock shown to Paul B. Henze, on which he was told the Virgin Mary had rested on her journey back from Egypt; he was also told that Frumentius, who introduced Christianity to Ethiopia, is "allegedly buried on Tana Cherqos. The body of Yekuno Amlak is interred in the monastery of St. Stephen on Daga Island. Emperors whose tombs are also on Daga include Dawit I, Zara Yaqob, Za Dengel, and Fasilides. Other important islands in Lake Tana include Dek, Mitraha, Gelila Zakarias, Halimun and Briguida.

Fig. 2: The Island Church on Lake Tana.

The monasteries are believed to have been built over earlier religious sites. They include the fourteenth-century Debre Maryam, and the eighteenth-century Narga Selassie, Tana Qirqos (said to have housed the Ark of the Covenant before it was moved to Axum), and Ura Kidane Mehret, known for its regalia. A ferry service links Bahir Dar with Gorgora via Dek Island and various lakeshore villages. There is also Zege Peninsula on the southwest portion of the lake. Zege is the site of the Azwa Maryam monastery.

3. BIODIVERSITY IN LAKE TANA

Lake Tana is the largest national freshwater body, accounting for 50 % of the total inland waters of the country, and is the source of the Abbay of Blue Nile River. The Biosphere Reserve is an important fish resource and is home to up to 67 different species of fish of which 70% are endemic. The barbus species of Lake Tana constitute the only remaining intact species of large cyprinid fish in the world. A large number of wetlands are located all around

Lake Tana, some of them being the largest and ecologically most important units in Ethiopia and in the Horn of Africa, and also form part of the Central Ethiopian Wetland Complex. These wetlands, dominated by papyrus and typha stands, are breeding, nesting and feeding grounds for very large bird populations, and provide a source of animal feed, domestic water supply, building material, fuel, food, etc. forlocalcommunities.

At Lake Tana more than 217 different bird species have been recorded. The area is internationally renowned as Important Bird Area and the high abundances qualify areas around the lake as Ramsar site. Many Palaearctic migrant water birds depend on the lake as feeding and resting grounds, including the common crane (*Grus grus*), Northern shoveller (*Anas acuta*), Black-tailed godwit (*Limosa limosa*), and ruff (*Philomachus pugnax*). Few patches of original forest vegetation and mountain ecosystem remain that have high plant end emism of globa limportance.

Indigenous trees include: Sesa (*Albizia gummifera*), Birbira (*Millettia ferryginea*), Wanza (*Cordia Africana*). The region is a gene centre for indigenous agricultural crops such as noug (*Guizotia abyssinica*), teff (*Eragrostis tef*). Wild coffee (Coffea arabica) occurs naturally in the area, especially in the Zegie Peninsula. Four major wetland ecosystem types have been identified: Riverine freshwater wetlands, lacustrine freshwater wetlands, palustrine freshwater wetlands and agricultural flooded freshwater wetlands.

About 70% of the fish species in the lake are endemic. This includes one of only two known cyprinid species flocks (the other, from Lake Lanao in the Philippines, has been decimated by introduced species), which consists of fifteen relatively large, up to 1 m (3 ft 3 in) long, *Labeobarbus* barbs. Eight of these are piscivorous and an important prey is the small *Barbus tanapelagius*, another endemic of the lake. (*B. humilis* and *B. pleurogramma* also occur in Lake Tana, but neither is endemic.). Other noteworthy endemic species are *Afronemacheilus abyssinicus*, which is one of only two African stone loaches, and the *tana* subspecies of the Nile tilapia.

Lake Tana supports a large fishing industry, mainly based on the *Labeobarbus* barbs (formerly in genus *Barbus*), Nile tilapia and sharptooth catfish (a large catfish that is widespread in Africa). According to the Ethiopian Department of Fisheries and Aquaculture, 1,454 tonnes of fish are landed each year at Bahir Dar, which the department estimates is 15% of its sustainable amount.

Among other fauna, the lake supports relatively few invertebrates: There are fifteen species of molluscs, including one endemic, and also an endemic freshwater sponge. Numerous wetland birds, such as the great white pelican and African darter, reside at Lake Tana. It is an important resting and feeding ground for many Palearctic migrant waterbirds. There are no crocodiles, but the African softshell turtle has been recorded near the Blue Nile outflow from the lake.

3.1. Church forests – islands of biodiversity

The high number of churches and monasteries with their culture to protect the surrounding environment and forest vegetation contributed to a high biodiversity in these so called church forests. Forests like Zegie Peninsula and Tara Gedam Monastery may be the only habitat patches with primary forests remaining locally. On Zegie peninsula alone 113 woody plant species were documented and 67 species were confirmed in one of the relatively undisturbed dry evergreen afromontane forests of Tara Gedam Monastery. They host several endemic and endangered species, which were destroyed completely in other places over the last decades. They are buffers against depletion of genetically adapted local species and biodiversity from deforestation and species loss. The church forests can serve as insitu conservation sites. They are also source of seeds for rehabilitating degraded areas. A high forest biodiversity is an insurance against various environmental risks. Continuance of natural forest life enables all elements of the system to permanently specialize and adapt. Natural regeneration occurs permanently whenever the conditions are favourable. Low entropy is a characteristic of primary forests. They are well organized as mainly self-sustaining systems with minimum imports from surrounding systems. Several scientific studies demonstrate that the consumption (and demand) of nearly all wooden products can be reduced by at least 50 % by substitution, economizing, recycling and technical improvements.

3.2. Shoreline vegetations and other communities

Three dominant plant communities were identified throughout the shore area of the Lake Trees (e.g. Syzgium guineense)and shrubs dominated in rocky shore areas, Scirpus and Polygonum species dominated in the north and east shore area, and Papyrus and Typhadominated in the southwestern gulf shore area of the lake. Characterization of Lake Tana shore area by their dominant vegetation communities. A total of over 50 macrophyte species belonging to over 15 families were recorded in Lake Tana shore area. Only 2 submerged and floating macrophytes and 15 emergent ones were recorded in the northern part of the lake. 3 and 10 more species of submerged and emergent species were recorded in the south westernzones, respectively. Therefore the southwestern zone is found to be in a better condition as compared to northeastern zone. This is because of population pressure and accessibility of infrastructures which results in overall degradation of the environment. Among environmental variables, water turbidity (clarity), lakewater level, turbulence and nitrogen concentration were the most important. In Lake Tana water level from the shore area declined during dry season exposing 0.5–1 km shoreline from the lake. During this season, exposed soils were cleared of emergent vegetation and used for agriculture.

In spite of their dynamics in abundance and diversity with seasonal changes, macrophytes are quite different in substratum selection. The survey indicated most submerged macrophytes grow in the south-western part of the lake where there is no wind current and urban fringes. Similarly in Lake George, papyrus formed large fringing floating swamps, and flourished in water with conductivity of 200 µS. In spite of the limited presence and number of the submerged and floating macrophytes recorded, they are quite different in their habitat selection. For example, *Ceratophyllum* species is found throughout the lake shore, as it has wide range of tolerance while Nymphea species grow best in habitats that are wind-protected (calm condition), shaded and higher clarity areas. In shallow calm parts in the shore area of the lake, especially at the river mouths, head of blue Nile river and pocket sites at the west zone, Pistia spp (water lettuce) and *Sagittaria* spp (common arrowhead) are common. The occurrence and abundance of *Scirpus* spp in the north and east habitats is because this species is known to be tolerant of shallow water and waterlogged soils as compared to *Typhaand Cyperus* sp. Water level fluctuation is considered by many authors ast the most important factor that controls the distribution of shoreline and aquatic vegetation. The present study also revealed that these same factors play, together with anthropogenic activities, an important role in governing the distribution of the shoreline vegetation. In Lake Tana aquatic ecosystem, it appears that stress to macrophytes is produced by high turbidity due to sedimentation process and direct conversion of shore areas to agricultural and other purposes. In addition, population pressure, low level of awareness, lack of wetland regulation and enforcement are othert important factors. Zonation varied both spatially and temporally. During dry season where water level declined and water clarity increased, the zonation from deep water was Nymphacae–Potomageton and Ceratophyllum– emergent vegetation (e.g. papyrus). Papyrus and other emergent plants are floating on the surface even in the deep-water zone.

3.3. The aquatic and terrestrial animals

Hippopotamus (Hippopotamus amphibius) as the most prominent large mammal can be found in the inlet and outlet of Lake Tana and Blue Nile River. Higher mammals are endangered by habitat fragmentation, overgrazing, farmland expansion, settlements, hunting and deforestation. Among the reptiles, particularly the python is critically endangered by habitat loss and hunting. The LT is also inhabited by globally threatened and biome-bound bird species and large numbers of waterfowls (as many as 20,000) including Palaearctic and intra-African migrants (the bird life of Lake Tana has been documented.

3.3.1. Birds (altogether 257 species were recorded, esp. Fogera Plains)

- Cormorant (*Phalacrocoraxm carbo*), Anhinga (*Anhinga rufa*), and intermediate Egret (*Mesophoyx intermedia*), Sacred Ibis (*Threskiornis aethiopicus*), Fulvous Whistling-Duck (*Dendrocygna bicolor*) and White-faced Whistling-Duck (*D. viduata*), Open-billed Stork (*Anastomus lamelligerus*) and Common Crane (*Grus grus*), Black-crowned Crane (*Grus pavonina*), Wattled Crane (*Grus carunculatus*), Great Blackheaded (*Gull Larus Ichthyaetus*), Yellow-legged Gull (*Larus cachinnans*) and Western Reef- Heron (*Egretta gularis*) occurin smaller numbers, Great Bittern (*Botaurus stellaris*) and African Finfoot (Podica senegalensis)
- Pelicans, eagles, Lesser Kestrel (*Falco naumanni*)
- Palaearctic migrant birds: Osprey (*Pandion halictus*), Great Black-headed Gull, Lesser-black headed Gull, Herring Gull, Whiskered Tern, White-winged Black Tern
- Globally threatened waterfowls (213 recorded species)

3.3.2. Mammals

- Hippopotamus (Hippopotamus amphibious), Black and White Colobus Monkeys (Colobus guereza), Aard Vark (Orycteropus afer), Crested Procupine (Hystrix cristata), Grimm's Duiker(Sylvicapra grimmia), Leopard (Panthera pardus), Ratel or honey badger (Mellivora capensis), African civet cat (Civettictus civetta), Bailey´s shrew (Crocidura baileyi)
- Foxes, highland hyenas, rabbits and other rodents.

3.3.3. Reptiles

- Crocodile (*Crocodyla niloticus*), Monitored Lizard (*Varanus niloticus*), water snake and python (*Python sebae*).

3.3.4. Fish (altogether 67 species)

- About 18 endemic Labeobarbus species (Cyprinidae family), including *Barbus tanapelagius* and *Barbus trispilopleura*
- *Garra regressus, Garra tana, Labeobarbus acutirostris, Labeobarbus gorgorensis, Labeobarbus gorguari, Labeobarbus macrophtalmus, Labeobarbus megastoma, Labeobarbus ossensis, Labeobarbus platydorsus,* tilapia and catfish.

3.3.5. Flora – key forest species

- *Coffea arabica, Justicia schimperiana, Syzygium, guineense, Mimusops kummel, Rothmannia urcelliformis, Juniperus procera, Ficus spp. Millettia ferruginea, Ehretia cymosa. Albizia schimperiana, Ritchiea albersii and rare species of Prunus Africana* and *Podocarpus falcatus*
- A large number of indigenous trees species, e.g. Dokma, Marents, Eshe, Kawot, Azamer, Chibha.

3.4. Lakeshore and riverine to upland vegetation

- Maytenus arbutifolia, Carissa edulis, Croton macrostachyus, Phoenix reclinata, Cordia africana, Acokanthera schimperi, Diospros mespiliformis, Ficus vasta, Celtis africana, Acacia abyssinica and Grewia bicolor

- The Lake Tana Region is endowed with a high number of valuable ecosystems and habitats which have a high potential for biodiversity conservation. UNESCO designation criterion Potential in the Lake Tana context “Major biogeographic regions (gradation of human interventions)”
- Dry evergreen montane forest and evergreen scrub ecosystem
- Aquatic ecosystems
- Wetland ecosystems On higher elevations
- Alpine/sub-afroalpine ecosystems
- Montane grassland ecosystem
- Vast areas of (agri) cultural landscapes “Significance for biodiversity conservation” Important ecosystems:
- Wetlands and papyrus stocks around Lake Tana
- Remnant (church) forests as islands of biodiversity and gene pools, wild coffee
- Aquatic ecosystems
- Freshwater of inter-regional importance (Blue Nile)
- Important Bird Areas of global significanceCultural “significance for biodiversity conservation”
- Church forests as a safeguard for conservation
- Indigenous knowledge
- Trad. Land-use practices with conservation benefits

4. CHEMICAL FEATURE

The lake is turbid and has an oligotrophic status. The Dembia Plain to the north, the Fogera to the east and the Kunzula Plains to the southwest are low areas with a dendritic drainage network. Major soils in the basin are Chromic Luvisols, Eutric Cambisols, Eutric Fluvisols, Eutric Leptosols, Eutric Regosols, Eutric Vertisols, Haplic Alisols. The seasonal rainfall fluctuations cause a lake level range of about 1.5 m. Due to the higher water turbidity caused by the large tributaries, the transparency of the lake (Secchi depth) varies from 1.3 m in the rainy season to 1.82 m in the dry season. Economically the water resources play a significant role because

a) It has significant share of the country’s` irrigation and hydropower potential
b) As the source of Blue Nile, it contributes a significant amount of water to Sudan and Egypt through the Nile system, on which their agricultural sectors are highly dependent (geopolitical relevance due to interregional dependence).
c) It is habitat for various fish species that makes the fisheries sector a viable sector.
d) It is essential as a source of drinking water and for many forms of urban use.
e) It is an asset for tourism and ecotourism in particular, as it contributes considerably to the region´s attractiveness (e.g. the Nile falls, wetlands as bird watching areas).

5. THREATS TO THE LAKE

In 2002 Bahir Dar City was awarded the UNESCO Cities for Peace Prize for addressing the challenges of rapid urbanization. In June 2015, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has registered lake Tana as world heritage site. The lake is registered as UNESCO's world heritage site for its being rich in biodiversity. Thus, Lake Tana can be considered as the largest icon of the region. However, this multi-purpose lake is facing multi-problems. Recently, water hyacinth, one of the most ecologicall y dangerous weed infestations has been reported on the shore areas of this sensitive lake. Habitat characterization: Three habitats which have distinct characteristics were identified. Sand beach dominated by sand mining, fish landing sites and pasture land. Rocky Bank: shore area forest dominated by coffee, fishing, fuel wood, and monastery. Urban shore area was also included. Muddy Bank (farm land): including sediment loaded river mouths dominated by pastureland, Teff and Maize cultivation. Vegetation type is more of annual and exotic weeds. One of the characteristic features of Lake Tana, the papyrus populations, has dramatically declined in its distribution due to overexploitation and habitat fragmentation and loss. Nowadays papyrus populations are mainly found in pocket habitats along the shorelines.

Fig. 3: Constructions around Lake Tana.

The LT is exposed to a set of interrelated environmental problems induced by land and water use, notably deforestation, erosion, sedimentation, water level reduction, erratic rainfall, excessive flooding of the wetlands, competition for water resources, pollution, introduction of alien species affecting local species´ gene pools. One of the major underlying forces that endanger the ecosystems and biodiversity around Lake Tana is population growth exerting further resource-use pressure. This goes along with, for example, overgrazing and horizontal farmland expansion (formal and informal), cultivation of marginal lands like wetlands, encroachment of communal land and massive vegetation removal to meet demand for food, feed and fuel wood. Other underlying causes that threaten biodiversity and forests in particular are: limited governmental, institutional, and legal capacity; land degradation; weak management of protected areas; and deforestation.

As outlined in previous chapters, the various ecosystems and the services that they provide are under severe pressure from the following major processes

- Land degradation caused by deforestation, overgrazing, unsustainable agricultural practices and wetland degradation. The lakes buffering capacity to deal with stress is reduced from sediment loads and conversion, destruction and encroachment of important natural buffers like wetlands. Despite this high diversity of fauna and flora, several of the existing species are endangered due to loss and fragmentation of habitat. In particular the degradation of forests and wetlands has caused severe habitat destruction for both flora and fauna. As a result, various species are very few in numbers and are at the risk of, at least, local extinction;
- Risk of eutrophication: from an increasing use of fertilizers and pesticides in agriculture, from construction material from Bahir Dar triggering macrophyte growth and phosphorus level rise. Rooted macrophytes and alien species, such as water hyacinths, are favored by the muddy sediments and an alkalinity of 50 mg/l CaCO3 arising from construction activities in Bahir Dar;
- Environmental pollution: the lake is a sink for dumping municipal, industrial and domestic wastes of a growing urban population (Bahir Dar). Solid wastes and effluents from homes, factories and hotels reach the lake untreated, enhanced by an urban run-off from paved surface. This increases the risk of toxification;
- As a consequence of reduced water quality, irrigation with freshwater from the lake during the dry season would not be possible in the future. There are also increasing signs of stress from local algal blooms and pollution-induced fish decline. Fishermen become increasingly marginalized by the ongoing environmental changes;
- The decline rain fall amount for the Kiremt season (June-September) is estimated to be 14 %. Besides global climate stressors, the main driving forces in decline of precipitation pattern are mainly the changes in land vegetation cover. The regional climate seems to show an increasing trend in rainfall variability that causes droughts and floods around Lake Tana.
- During the 2003 drought, the lake surface level dropped by two metersreducing the surface area by 35 km^2. During the 2006 flood, 15,000 ha were inundated, 10,000 people displaced, 2,500 domestic animals killed and many houses demolished. The World Bank (2008) states that there is an urgent need to protect the wetlands and reduce the vulnerability to devastating floods.
- Resulting from the massive alteration of the hydrological regime from water development activities (irrigation schemes and hydropower stations), the lake water level is lowering considerably, while its total water depth is continuing to shrink due to massive input of sediments from the watershed.
- Climate Change: Some species are particularly at risk by climatic stress, likeCordia africana, Olea europea (olive), Juniperus procera (East African juniper) and Hagenia abyssinica (African redwood), due to patchy habitats, low population numbers, limited climatic ranges and restricted habitat requirements like Labeobarbus in Lake Tana. Montane centres are the ecosystems most vulnerable to temperature increase due to their isolation, which leaves no option for horizontal or vertical migration (forests).

The recorded temperature increase also has an effect on the length of the growing period and a shift in agro-ecological zones. It thereby reduces agrobiodiversity of barley, pea and faba bean varieties having declined in the cooler parts of the watershed, while in the medium and lower elevations traditionally grown tef, sorghum and noug varieties have already disappeared. It is also likely that livestock productivity will be further undermined by climate impacts on the quantity and quality of forage as well as by the spread in internal and external parasites. The above mentioned processes and threats illustrate that ecosystems and biodiversity are at risk by numerous human activities which are related to land-use and urbanization. This in turn undermines the resource base which the vast majority of the population heavily depends on. As a result, household income and land productivity will decline and eventually poverty will increase unless resources and ecosystems are managed more wisely. Lake Tana's water resources are of crucial importance serving multiple purposes and being the largest fresh water body in Ethiopia. It has also government. The lake receives urban surface runoffs, industrial and agricultural waste from the catchment. Proper monitoring of discharges and analysing the effects on Lake Tana's water quality seems to be essential. Unfortunately, not much work has been done on water quality monitoring as far as faecal related microbial and chemical contamination is concerned.

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