

Chapter 2

Problem Overview of the Lake Tana Basin

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Abstract Lake Tana Basin is the second largest sub-basin of the Blue Nile which covers an area of 15,114 km². Lake Tana is a tropical Lake with surface area of 3111 Km². It is the largest fresh water resource of Ethiopia (50%). It is the source of the Blue Nile(Abay) River. Lake Tana basin and Blue Nile river provide economic, social, political, environmental, ecological and religious benefits also for downstream eastern Nile countries. The basin problems have also influence in downstream eastern Nile countries. Food security and environmental sustainability are grand challenges in the basin. Ensuring adequate supply and quality of water for water user sectors in the basin remains a challenge. The sanitation and hygiene coverage remains not significantly improved compared to the unprecedented population growth. The basin suffers from easily perceivable land, soil and water degradation which are manifested in different forms: Sedimentation, clearing of wetland, canalization of the tributaries, increased trend of eutrophication, toxigenic cyano bacteria, occurrence of invasive species like water hyacinth (*Eichornia crassipes*), stakeholders conflict, improper damming, construction of buildings in the Lake shore areas that are natural breeding and feeding grounds for some fish and bird species, poor waste management, increased prevalence of waterborne diseases especially in the riparian community which largely depend on raw water for drinking and recreation are major problems of the Basin. Climate change is also having its impact. Though the problems and challenges are known in the area, effective measures proportion to the magnitude of the problem are not yet taken sufficiently.

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2.1 The Nile Basin

Nile River is a Trans Boundary River shared by ten riparian countries with different biophysical, socioeconomic and political settings. The downstream countries are dependent on Nile water and the demand is still increasing. Blue Nile (Abay) River, the only out flowing river from Lake Tana, and Atbara River together contributes about 85%. The Upper Blue Nile Basin is the largest one in terms of volume of water discharge - mean annual discharge of 48.5 km^3 (1912–1997; $1536 \text{ m}^3 \text{ s}^{-1}$). It is the 2nd largest in terms of area coverage in Ethiopia, which is 17% of the landmass area of Ethiopia. The climate in the basin varies greatly. As the Blue Nile River drops down into the lowlands of Sudan area, the rainfall amount decreases but evaporation increases. The daily mean temperatures fluctuate between upper 15–18 Degree Celsius ($^{\circ}\text{C}$) and lower 30 $^{\circ}\text{C}$. In Sudan the irrigated land is more than 1.3 million ha, where as in Egypt, it is more than one million ha (BCEOM 1999). Ethiopia has a potential of irrigable land estimated to be 815,581 ha. The hydropower development potential is also estimated to be 3634–7629 Mega Watt (MW) that include about 120 identified potential sites and 26 investigated ones (BCEOM 1999). The Great Ethiopian Renaissance Dam (GERD), the largest hydropower dam in Africa with production capacity of 6000 MW, is under construction across the Blue Nile (Abay) river. This project not only increases the energy provision potential of Ethiopia but also brings economic integration among the riparian countries. It also brings a number of advantages to Sudan and Egypt. Flood risk avoidance and increasing the routing capacity of High Aswan Dam, controlled and uniform flow during dry period, drought mitigation through creating additional system storage, water saving and reduced transmission losses and Sediment control could be accounted as great advantages.

2.2 The Lake Tana Basin

Tana Basin is the second largest sub-basin of the Blue Nile, and covers an area of $15,114 \text{ km}^2$. The highest elevation is 4100 m a.s.l (meter above sea level) but 2025 m a.s.l is the average one; however, at Blue Nile out flow, at Lake Tana it is 1785 m a.s.l.

The average annual rainfall in Lake Tana is 1248 mm per year (mm yr^{-1}), which is 7% lower than the surrounding watershed. Atmospheric temperature decreases by $0.7 \text{ }^{\circ}\text{C}$ per 100 m and ranged from 13 to 22 $^{\circ}\text{C}$. The main landforms in and around Lake Tana comprises plains, hills, mountains, mountain cliffs and depressions in different proportions. The flat plains and depressions mostly are wetlands. The land use in the Lake Tana basin is predominantly cultivable Land (71%), grazing (9%),

Infrastructure (6%), forest (3%) and others. The major type of land cover includes farm land, water bodies, wetlands, forest, wood land, shrubs, rangeland, grassland and settlements.

The soil type in the Lake Tana islands, peninsulas and wetlands and in the upland areas of the lake are dominated by Nitosols, Luvisols and Vertisols. Whereas flood plains of Fogera area, Libo Kemkem and Dembia places as well and the river mouth delta of Stumit, Kristos Semera, Nabega, Angara and Dirma area are dominated by alluvial deposits. This soil deposit has made shallow water depth and cultivated during the dry season following the receding or retreating lake water. Most of the transported high sediment loads are deposited and silted down in the water body of the lake. Thus, it can be said that Lake Tana is both a natural water reservoir and silt refinery for the Blue Nile River, but becomes detrimental to the long term existence of the lake to function as habitats for aquatic organisms.

Because of the significant importance of Lake Tana in supporting intensive irrigation based agriculture now and in the future, as a source of hydroelectric power (the source of water for Tana Beles and GERD Hydroelectric Power Plants supposed to produce 460 and 6000 MW respectively), fishery and tourist industry, bird habitats and biodiversity resources, it is worthwhile safeguarding its environment. However, the lake is receiving an ever increasing wastes from the point and diffuse sources.

There are 37 islands in lake and most of them have monasteries with historical, cultural, religious and touristic values. The riparian communities largely depend on the raw water for drinking, cattle watering, irrigation and recreation.

The wetlands of Lake Tana area are an integral part of the lake and play a significant role in sediment retention, flood protection, purification of water 'Kidney' of the landscape, important breeding grounds for birds and some fish species like *Oreochromis niloticus*. Lake Tana and its associated wetlands are also identified by IUCN as an important bird area (BirdLife International 2004). The Lake also provides valuable transport services to connect islands and Lake shore towns.

Lake Tana

Lake Tana is the largest Lake in Ethiopia which accounts for 50% of the fresh water resource of the country. The Lake has a surface area of ca. 3111 km², 284 km³ volume, and has maximum length of 90 km and width of 65 km. Lake Tana is a shallow lake with a maximum depth of 14 m (m), but the average depth is eight m. The only out-flowing river is the Blue Nile River. This lake is the source of the Abay (Blue Nile) River and covers 20% of the surface area of the Lake Tana sub-basin. The Lake has an elevation of 1800 m.a.s.l and is fed by many streams and rivers with catchments in excess of 1000 km². The Lake basement comprises Pre-Cambrian, Metamorphic and Granitic rocks. These basement rocks are overlain by extensive deposits of Mesozoic sedimentary rocks that do not out crop in the Tana basin but are observed in Abay Valley.

Lake Tana use to be an oligotrophic lake (Wondie et al. 2007; Teshale et al. 2002; Wudneh 1998; Nagelkerke 1997) but its trophic status has changed gradually. Especially river mouths have experienced seasonal eutrophication (Goraw

2012). Lake Tana's bottom substrate is volcanic basalt mostly covered with a muddy substratum with little organic matter content 1% in 1994 (Howell and Allan 1994) and 14% in 2011 (Goraw 2011).

Basin potential and benefits

The basin in its natural state has high potential for agriculture, livestock, water resource, forest and wildlife, tourism, and fishery development besides too high biological diversity. There are animals, plants, fish, wetland and forest resources. The basin has also fertile soil and cultivable land for intensive agriculture. The agro-ecologies are also suitable to produce more than once per year. The population in the basin is increasing rapidly and there is no shortage of productive labor force in the region (Sewnet and Kameswara 2011). The basin provides multiple benefits like economic, social, political, religious ecological benefits. However, there seems to have imbalance between production and consumption pattern and conservation measures which has led to unsustainability (Teshale et al. 2002).

There are many policies and strategies in Ethiopia that directly and indirectly address the basin's challenges and threats. The policies were developed and have been implemented since last two decades. The policies include Environmental Management proclamations, Agricultural and Rural Development Strategy, The Sustainable Development and Poverty Reduction Programs, Food Security Strategy (FSS), The National Biodiversity Conservation Policy, Science and Technology Policy, Water Resource Management Policy and Proclamations, Wildlife Policy, utilization of wildlife, Land use and land administration Proclamation, Forest Policy, Climate Resilient Green Economy (CRGE) Strategy and Fisheries Development and Utilization Proclamation. However, their implementation is weak and do not curb the problems caused by unsustainable management of resources in the basin.

Socioeconomic situation

The basin is a densely populated area due to high population growth rate and immigration (Sewnet and Kameswara 2011). This has resulted high dependency of the population on the basin resources. This high dependency in turn has already put high pressure on the basin resource.

To decrease threats and improve the management, proper identification of the stakeholders and ensuring active participation at all levels is indispensable. The stakeholders can be broadly classified into governmental organizations, local communities, nongovernmental organizations, private (investors and enterprises) and international communities (Ketema 2013).

Lake Tana basin supports different economic activities, and agriculture is the major one. The basin has huge potential for socio economic development and because of this it has been identified as a major 'economic corridor'.

Biophysical situation

Lake Tana basin is the second largest sub basin of Blue Nile River basin and lake tana is the largest fresh water resource in the country. Regarding the hydrological characteristics of the basin, the lake water serves many functions apart from the ecosystem services. The annual out flow of water for the period 1976–2006 were

estimated (Kebede et al. 2006). A total of more than 40 rivers drain water from Tana Basin into the lake. However, most of the hydrological analysis estimate was derived from gauged Lake Tana basin, which is only 42% of the basin (SMEC 2007). Due to this fact the estimated flow from the ungauged catchment highly varies across studies. There is limitation of data and diversification of the basin in terms of climate, geomorphology, and geology. This suggests that further research is needed to understand the hydrology of the ungauged catchment. Current research suggests how critical the soil erosion and sedimentation processes are in the basin. In addition, due to a number of projects planned in the basin the knowledge of soil erosion and sedimentation has become more important than ever. Hence, to understand the sediment transportation and deposition, the main factor driving the soil erosion should be investigated.

Most of the soils morphological, physical and chemical characteristics are identified and characterized but for a sustainable crop production, there is a need for guided inorganic fertilizer use and improved management practices in the area which will effectively minimize erosion and enhance and maintain soil quality and productivity (Mekonnen 2015). Further soil nutrient analysis and soil type identifications of the basin should be carried out at micro watershed level in order to recommend appropriate fertilizer application with a little impact on the environment or water quality of Lake Tana. The Vertisols at Fogera, Dembia and Alefa-Takusa plains have drainage problems due to inundation during the rainy season. Hence monitoring the water levels and developing appropriate irrigation schedules must be addressed in order to improve crop production.

The Lake Tana Basin biodiversity resource is so diverse and rich. The faunal diversity spans from the minute and cryptic puddle- and tree-frogs, to the medium sized Nile monitor lizard and African rock python, to the large-sized Nile crocodile, leopard and hippopotamus. So far 19 amphibians, 35 reptiles and 28 mammalian species have been identified. However, the total number of species listed could be underestimated. In addition, the bird fauna of the Lake Tana Basin is prominent. At varies studies a total of 437 birds are identified As well, several species of globally threatened, highland biome, winter migrant and endemic birds were recorded (Ash and Atkins 2009; Shimelis et al. 2011; Shimelis 2013). Areas that are important for breeding, roosting and feeding for globally threatened and migratory birds are identified. With regard to the flora, the major classification of forest resource types in the Amhara Region has been identified as Afroalpine and Sub-Afroalpine Forests, Dry Evergreen Montane Forest and Evergreen Scrub Combretum-Terminalia Woodland, Acacia-Commiphora Woodland, Bamboo Forests and Plantations. The size and quality of Afroalpine and Subafroalpine vegetation, the high Dry Afromontane forests, Bamboo forests and the Woodlands have decreased. These ecosystems have suffered considerable degradation in structural and species composition. This has resulted into a serious loss of indigenous biodiversity and created opportunities for invasive species.

The Lake Tana watershed wetlands are mainly occurring around the Lake Tana shore, major rivers that contribute to the lake and also in seasonal flood plains. The distribution and status of wetlands is not well studied. Some invasive and alien

species are becoming a problem in the watershed. Water hyacinth infestation in Lake Tana can be a symptom of broader watershed management and pollution problems (Goraw 2011). Even though different alien species exists in the basin, water hyacinth becomes the most noxious and widespread weed in the basin. It is speculated that the biomass can be used for crafting, waste water treatment, heavy metal and dye remediation, of any invasive plant (EEA 2012). While researchers continue to investigate the perceived potential uses of water hyacinth, the current negative impacts of the weed far outweigh its benefits. The use of water hyacinth as raw material in cottage industry should not encourage propagation of the weed, but rather help control its growth. Changing land use practices in the catchment communities through watershed management will help reduce agricultural runoff as a mechanism for controlling the proliferation of water hyacinth. This is considered by many as one of the most sustainable long-term management actions.

Agriculture is the main stay of the Lake Tana Sub-Basin economy. The crop diversity and cropping pattern is widely known in the area. More than 80% of the cultivated land during the base-year is under rain-fed system, and the remaining are cultivated using irrigation and residual moisture, respectively. The farming system is characterized by crop-livestock mixed production system. Insect pests and diseases are one of the major production constraints.

Lake Tana, the biggest lake in Ethiopia, is very important water resource for community living and depending on the lake's resources. It plays a role in balancing of the microclimate of local areas in the catchment of the lake. However, the recent development activities at the catchment areas have negatively affected the natural systems of the catchment. Natural resource degradation in the form of soil erosion, deforestation, and wetland resource depletion, is a major problem in Lake Tana Sub-Basin, Ethiopia. Lack of active participation of the local people, weak implementation of policies, lack of enforcement of some policies/laws, overlapping and conflicting responsibilities of different government institutions and conflict of interests accounted to failure to achieve the desired outcomes.

In Lake Tana basin, there are fragmented management interventions to conserve the natural resource. The major conservation effort so far has been the soil and water conservation campaign of Amhara region bureau of agriculture which mobilizes about 4–5 million farmers every day for two months every year since the last few years. These and other efforts do not stop the basin from degradation. There are also management interventions to control the spread of water hyacinth. Very recently, Lake Tana has been nominated as a new UNESCO-Biosphere reserve under the UNESCO Man and the Biosphere program. It is Ethiopia's fourth natural heritage inscribed by UNESCO, after Simien National Park, Lower Valley of the Omo and Lower Valley of the Awash.

In the basin there is significant land use land cover change in the year between 1986 and 2013; built-up areas and cultivated land cover increased but the natural forest land and grassland covers decreased (Wubneh 2013 Unpublished).

The farming system in the basin is predominately crop production, mixed with animal production. Due to awareness and economic interest of the local community, new farming systems have been introduced, e.g. rice and eucalyptus production.

Bahir Dar and Gondar are rapidly urbanizing cities in the basin. Following the urbanization and immigration in search of better jobs, waste generation rate has increased. There is no integrated waste management system implemented in the basin. There is no liquid waste management at all. The only effort to manage the solid waste in Bahir Dar city is the effort of ‘dream light’ to collect solid waste door to door.

Problems in Lake Tana basin

There are a number of problems in the Lake Tana Basin watersheds that are easily perceivable. These problems mainly arise from imbalances of development interventions and environmental protection activities (Teshale et al. 2002). Unprecedented population growth, migration to Bahir Dar for better jobs, and urbanization exacerbate the problems. The problems include soil erosion, deforestation, hydrological interventions, wetland farming, habitat destruction, improper solid and liquid waste management, over grazing, lack of awareness, stakeholders’ conflict and lack of decision support tool and inadequate organized data base system.

We began looking at the problems in the Lake Tana basin in a holistic way when the Blue Nile Water Institute (BNWI) was established in 2012 under the office of the Vice President for Research and Community Service, Bahir Dar University. The main justifications for establishing the institute include geographical proximity of the University to the largest water bodies of the nation, i.e., Blue Nile River and Lake Tana, a serious lack of basic information in the water bodies and a constantly increasing demand for information from internal and external stakeholders.

The vision of the Blue Nile Water Institute is to become one of the ten premier water research centers in Africa by 2025 recognized for its quality research, training, and service in support of sustainable management of water and water related resources in the upper Blue Nile basin. The mission is to conduct applied and basic research, provide tailor-made trainings, consultancy and advisory services, document and disseminate water and water related information and proven technologies. The institute shares the vision of Bahir Dar University and aligns its work with the different sustainable water resources development programs of the Ethiopian government. It functions under a multidisciplinary and project-based approach focused on applied research.

The BNWI consists of 13 research units across BDU from a variety of disciplines, including. Hydrology, watershed management, irrigation, hydraulics drainage, hydrogeology, socioeconomics, ecology, environment water supply, sanitation and hygiene, climate sciences. Since the establishment of BNWI, a grand National workshop has been planned as a platform for coordinating different institutions and individuals to discuss and produce useful information towards the interest of the institute. To this end, the second national Workshop on “Challenges and Opportunities of Water Resources Management on Lake Tana and its Environs, Upper Blue Nile Basin, Ethiopia” was conducted on 26–27 March 2012 at Bahir Dar, Ethiopia. The objectives of the workshop were: (1) To carry out awareness creation conference to disseminate important information on water resources of upper blue Nile Basin to relevant stakeholders (2) To identify research gaps towards sustainable utilization of water resources in the basin (3) To learn on the modalities

of future communications between stakeholders (4) To establish a network of stakeholders and formulate inter-universities research taskforce that writes grant proposals (projects) and conduct research based on priority research gaps (5) To document fragmented research works on Lake Tana and its environs into compendium and organize into useful knowledge package. A team of experts in the water research and development arena were given task to review the state of the art knowledge in research, model development, policy recommendation gaps and capacity building of the institute following a holistic approach than a piece meal approach which had been the case before. The following issues were highlighted at the 2012 workshop.

2.2.1 Deforestation

Deforestation in the Lake Tana basin and other highlands of Ethiopia is a prominent watershed problem. It contributes to soil erosion and consequently to decline of soil fertility and agricultural productivity. The forest cover of the country was 46% in 1957 and decreased to 2.7% in 1987 (USAID 2004). However, due to watershed management and afforestation campaign this time, the forest cover reached 12% (Yihenew 2014 Wetland policy brief unpublished). In Lake Tana Basin, a total of 116358.5 ha of forest was lost or converted to another land cover during the period 1986–2013 (Wubneh and Goraw 2013 the land use land cover of Lake Tana area report, Unpublished).

2.2.2 Soil Erosion and Sedimentation

According to the Ethiopian highland reclamation study (FAO 1984), in the mid 1980's 27 million hectare or almost 50% of the highland area was significantly eroded, 14 million hectare seriously eroded and over 2 million hectare beyond reclamation. Soil erosion is a major watershed problem in Lake Tana basin causing significant loss of soil fertility, loss of productivity and environmental degradation. The Lake Tana basin is heavily affected by watershed management problems, caused by overpopulation, poor cultivation and improper land use practices, deforestation and overgrazing as a result sediment depositions in the lakes and reservoirs are becoming major issues (Setegn et al. 2008). According to the study by Setegn et al. (2009), around 12–30.5% of the watershed in Lake Tana basin is high erosion susceptible areas. There is a high silt concentration with loading rate of 8.96 to 14.84 Million tons of soil per year (Yitaferu 2007). Williams (2000a, b) reported deforestation in the Ethiopian highlands which has led to accelerated soil loss from the Ethiopian highlands to downstream reservoirs resulting siltation. The rate of erosion in the Ethiopian highlands today is one to two times higher than it used to be before

30 years (Hurni 1999; Williams 2000a, b). The long term rate of erosion averaged over 30 years is 10 to 15 million tons (McDougall et al. 1975 in Williams 2009).

2.2.3 Wetland Deforestation

In Lake Tana basin there are different forms of wetlands: lacustrine, riverine, floodplains, marshes and swamps. The wetlands in the Lake Tana basin comprise one of the largest wetlands in Ethiopia. They are mainly located surrounding the Lake and are flooded during the rainy season. The papyrus beds are one of the characteristic features of Lake Tana, but have declined in their extent dramatically. It is due to catchment degradation, over exploitation, expansion of invasive weed species and habitat fragmentation and loss of wetlands. The lake level drops during the dry season, the shore area become available for agriculture. The wetland areas are severely degraded due to siltation, conversion into cultivation and overgrazing.

The land use land cover change between 1986 and 2013 has indicated a total of over 52% of wetlands is converted to other land use forms; about 1259.1 ha (19.6%) is converted to farm villages with trees and cultivation, about 1388.9 ha (23.4%) is converted to intensively/moderately cultivated land, about 233.2 ha (3.9%) is converted to natural/plantation forest (this could be trees in swamps), about 193.52 ha (3.27%) is converted to water body (this could be the Lake is regulated by Chara-Chara weir) and about 501.23 ha (8.46%) is converted to woodland. The largest conversion is for cultivation and settlement (BNWI 2014 Wetland Management Plans Lake Tana Survey Report, unpublished).

2.2.4 Eutrophication and Problem of Toxigenic Bacteria

Water resources all around the world are under pressure and especially eutrophication is a major environmental problem. It is caused by excessive loading of dissolved and particulate organic matter and inorganic nutrients (Carbon, Nitrogen and Phosphorus). These nutrients are loaded by municipal and industrial sewage discharges and/or from diffuse sources in catchments areas. In addition to external nutrient loadings and even after their reduction, eutrophication can be maintained by internal loading, which corresponds to the release of nutrients from the lake sediments into the water column.

The concentration of nitrate and phosphate in the Lake Tana basin is increasing from time to time. Lake Tana used to be oligo-trophic (Wondie et al. 2007; Dejen et al. 2004; Wudneh 1998) but there is an increasing trend of increase in concentrations of nitrate and phosphorous especially in shore areas and river mouths that would eventually lead to eutrophication (Ilona et al. 2011; Wondie et al. 2007; Goraw 2012) (Fig. 2.1). These could happen as a result of improper disposal of waste water, and poor soil and water conservation practices in the catchment areas (Teshale et al. 2002; Yitaferu 2007).

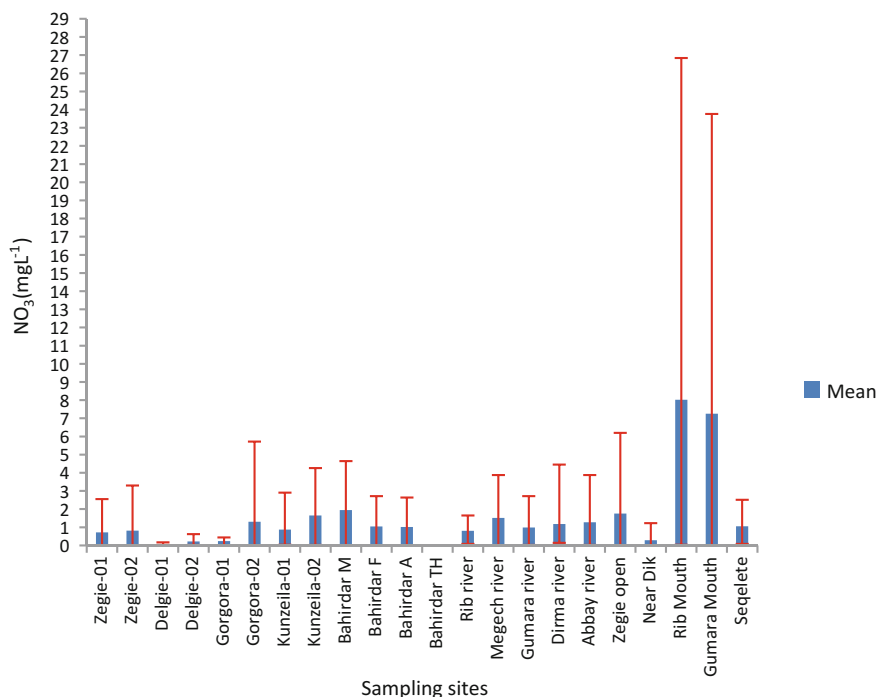


Fig. 2.1 Spatial patterns in nitrate concentration (mg L^{-1}) in Lake Tana samples collected from different littoral (Zegie 01, 02, Delgi 01, 02, Gorgora 01,02, Kunzeila 01 and 02), city adjacent (Bahir Dar M, F, A and TH) Rivers (Megech, Gumara, Dirma, Abay, Ribb and Gumara) and pelagic (Near Dik and Sqelete) sites in March 2010 (*Source* Goraw 2012)

Toxigenic (potentially toxic) cyanobacteria were detected in Tana Lake on the basis of the new primers designed for *mcyE* gene (Ilona et al. 2011). The highest biomass of cyanobacteria (188.18 mg L^{-1}), with domination of *Microcystis aeruginosa*, and the highest concentration of microcystins ($2.65 \mu\text{g L}^{-1}$) were detected in the dry season, in November 2009 from Lake Tana and tributary rivers. The concentration of microcystins in the dry season exceeded the limit value for drinking water ($1 \mu\text{g L}^{-1}$) (WHO 2006) and indicated the first alarm level of risk for recreational activities (WHO 2003). Amount of total phosphorus appears to be an important parameter for the creation of the algal blooms in Tana Lake.

2.2.5 Climate Change

Ethiopia experiences persistent land, water and environmental degradation due to localized and global climatic anomalies. Climate change can cause significant impacts on water resources by resulting changes in the hydrological cycle. Climate

change studies in the basin reported that the water balance can be significantly affected, which clearly amplifies its impact on sectors like agriculture, industry and urban development (Hailemariam 1999 cited in Sewnet and Kameswara 2011).

2.2.6 Invasive Weeds

There are many weeds that are already found in the Lake Tana Basin. The presence of water hyacinth (*Eichornia crassipes*) was reported and confirmed in Lake Tana at various times (Wondie et al. 2012). The presence of the floating weed, *E. crassipes*, was also reported in the area between Rib river mouth, Mitreha Abaworka kebele, Gondar Zuria Woreda and Dirma River mouth, Dembia Woreda (Shimelis and Getachew 2013 ecological effect of water hyacinth on waterfowls of Megech, Dirma and Rib River mouths at Lake Tana, Ethiopia unpublished paper). The areas where the weed was observed are mostly river mouths where the nutrient condition was relatively good and the water quality condition has started to deteriorate. The weed is very notorious and can cover the whole lake in a few years' time if immediate control strategies are not in place. It can destroy the fishery industry, create obstacles to navigation, clog canals of hydroelectric power plants and will generally create serious environmental imbalance.

2.2.7 Improper Solid and Liquid Waste Management

Bahir Dar and Gondar are the fastest growing urban cities in the basin with current population of 299,272 and 278,135 respectively (BOFED 2015, Amhara Region Bureau of Finance and Economic Development annual report, unpublished). It is expected that the expansion of Bahir Dar and Gondar may form a mega city. The Lake Tan Basin is identified as main economic corridor of the country. Large scale irrigation projects with a command area of more than 20,000 ha have been planned; most tributaries are dammed mainly for irrigation. In a nut shell, urbanization, population increase, agricultural intensification and industrial development will lead to generation of more solid and liquid wastes which has already created environmental problems. The solid and liquid waste management in the basin is very poor. None of the cities has waste water treatment plant and neither sanitary land fill.

2.2.8 Stakeholders' Conflict

Lake Tana is everybody's property which practically means nobody's property, "The tragedy of the common" applies to the resources utilization. There is no institution clearly responsible to manage Lake Tana. Different users would like to maximize their profit out of the Lake and its resources which lead to un attainability and conflict.

2.2.9 No Data Base System

There is no systematically organized data base system in the Lake Tana basin. The biophysical, socioeconomic and demographic characteristics of the basin are not monitored properly; no long-term and spatially representative data. The data is mainly of expeditious type and available here and there. Development intervention plans in the basin are not based on well-organized data. It is simply because of absence of adequate and well organized data. So documenting and conducting various researches to fill the gap and to build up the data system is mandatory.

2.2.10 Unsustainable Exploitation of Fisheries

The fisheries in the Lake Tana Basin is a livelihood for half million people (Gordon et al. 2007). This resource is not exploited sustainably; there is labeobarbs fish species stock decline (Degraaf 2003), off flavor of Nile tilapia (Workiyie and Goraw 2014) and decrease in distribution and abundance of other fish species over time. The immediate causes are introduction of monofilament gillnet which has a mesh size less than allowable (less than 10 Cm mesh size), habitat destruction, targeting spawning aggregation of migratory fishes at river mouths, pollution from the basin, sedimentation, hydrological regime change, invasive weeds, urbanization, and use of fish poisonous plants like *Millettia ferruginea*, which indiscriminately kills fishes of different type and age groups.

2.2.11 Lack of Enforcement of Environmental Related Policies and Strategies

Though there are policies like water and environment which in principle aims sustainable development, their enforcement is lacking resulting with many adverse impacts on the environment (Teshale et al. 2002).

2.2.12 Hydrological Alterations

There is intensification of large and small scale irrigation agriculture in Lake Tana basin with increasing trend of utilization of streams and rivers. Many farmers pump water from tributary rivers and streams to the extent of affecting the natural flow regime. Floriculture is also booming around all corners of the Lake, abstracting water from Lake Tana and ground water resources. Changing of the natural

hydrological regime influences the biota and ecological integrity which in turn make the water system unsustainable (Zalewski 2002).

2.2.13 Fecal Pollution

Water supply and sanitation coverage of Ethiopia in general and Amhara Region in particular is improving from time to time though still remains a lot to be done. Because large proportion of the rural population mainly depend on unsafe drinking and recreational water sources. The sanitation facilities are neither to the standard nor enough. The Lake Tana area is an area where frequent water borne disease outbreaks have occurred due to fecal pollution from point and diffuse sources. In 2006, the joint Government, WHO and UNICEF Rapid Assessment of Drinking Water Quality established that about 28% of all protected rural water supplies were contaminated with fecal micro-organisms (Rapid Assessment of Drinking Water Quality, Ethiopia Country Report, March 2007 unpublished). Goraw et al. (2010) also reported high level of fecal pollution of Bahir Dar gulf of Lake Tana which is higher than WHO standard for recreation. Total coliforms (TC), fecal coliforms (FC), *Escherichia coli* (EC) and *Clostridium perfringens* (CP) were detected in 100, 86, 82 and 90% of all sampling sites analyzed throughout the sampling period, respectively.

2.3 Summary

The Lake Tana basin faces multiple challenges. These challenges and problems should be solved in order to sustain the resource for now and the next generation. This chapter has given an overview of the major and foremost problems in the watershed today. Further chapters in this book expand on this overview, describing the ecological and socioeconomic context of the problems, what is known about the linkages in the system, and posing questions for further research.

Management of Tana basin resources traditionally concentrates on single issues and in a fragmented way such as one area specific activity, single season/period and on a targeted resource. The complexity of the basin and the negative influence and consequences for humans have brought this day a more integrated thinking that management of Lake Tana basin should follow. Since the basin has great concern especially of the water system due to the mere location in Ethiopia, the multipurpose role it has, and because it is the largest fresh water body in the country - and yet the basin is identified as growth corridor, its sustainable management in general calls an urgent integration of all stakeholders. The Government of Ethiopia needs to prepare and implement integrated water resources management plan in Lake Tana basin with full participation of all relevant stakeholders including the riparian community to sustain the water system in the basin. The background and baseline information provided in the following chapters is a resource for such integration.

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