Status, Threats and Management of Wetlands in the Lake Tana Sub-basin: A Review

Ibrahim Mohammed [*] ***and Minwyelet Mengist***

College of Agriculture and Environmental Sciences, Bahir Dar University, Bahir Dar, Ethiopia
Corresponding author: ibro_muhe@yahoo.com

Received: September 11, 2018 Accepted: October 10, 2018

Abstract: *Wetlands are one of the most productive ecosystems that play significant role in providing multiple ecosystem services. They are the heart of the landscape, which serve as natural filters for the world's wastewater with no cost and biological supermarkets that contain miscellaneous biodiversity. In the Lake Tana Sub-basin, majority of the wetlands distributed along the tributaries and around the lake shores and estimated to cover 2.14% of its total surface area. The wetlands in the Lake Tana Sub-basin support many endemic and globally threatened fish species as well as wintering site for world`s migratory birds. Regardless of their importance, the Lake Tana Sub-basin wetlands are under great pressure. The major anthropogenic threats are recession agriculture, unplanned urbanization, rapid population growth, indiscriminate industrial and development activities, disposal of domestic and industrial toxic wastes and free grazing. Many people in the lake sub-basin still now considered wetlands as unhealthy that are breeding places for disease vectors. Development activities in Lake Sub-basin very rarely consider the ecological and socio-economic values of wetlands and wetland destruction and conversion for the purpose of recession agriculture is still seen as advanced mode of development. Therefore, to halt these problems and to use the wetland resources sustainably, integrated problem solving approaches such as collaboration among the relevant stakeholders, public awareness creation, formulation and implementation of wetland policy, implementation of biosphere reserve and ratifying the Ramsar Convention are vital. Furthermore, in-depth research regarding the status and challenges of wetlands in the Lake Tana Sub-basin should be conducted.*

Keywords: Ecological status, Ecosystem services, Wetland distribution

1. Introduction

About 9% of the world`s population is undernourished which can be associated with the degradation and losses agricultural land along with the utilization of 70% of fresh surface and ground water for agriculture (WBCSD and IUCN, 2008). According to FAO (2015), sufficient food is therefore needed for additional 2 billion people by 2050. In this regard, minimizing challenges as well as promoting wetlands in the world may play significant role in the production of food crops. Because the ability of wetlands to store water during the wet season and release it in the dry season, its nutrient rich soil and year round soil moisture availability provide farmers with the opportunity to produce crops all year round thereby improving food security and income (Sakane *et al.,* 2011). Besides, wetlands support peoples livelihood by providing dry season livestock grazing and watering, domestic water supply, fishing and natural products (Mmopelwa, 2006).

The extent of world's wetlands is generally thought to range from 7 to 9 million Km^2, which is approximately 6% of the Earth's surface area (Mitsch and Gosselink, 2002). However, the U.S Department of Agriculture cited in Desta (2006) states that the world's wetlands cover about 18.8 million Km^2 (approximately 13.7% of the Earth's surface area).In Africa, it is estimated that 4% of the land surface is covered by wetlands (Lehner and Döll, 2004). In sub-Saharan Africa, wetlands constitute approximately 4.7% of the land surface (Rebelo *et al*., 2009). While, in Ethiopia, the total wetlands coverage is estimated to be about 2% of total country's surface area (EWNRA, 2008).

Although wetlands cover only small part of the Earth, they contribute 40% of the annual global ecosystem services (Zedler and Kercher, 2005). All over the world, wetlands are hot spots of biodiversity and provide various services such as water quality maintenance, carbon sequestration, shoreline protection, and recreational values (Dise, 2009). Wetlands, for example, remove up to 80% of

suspended solids, 60- 80% of organic matter, 20 - 60% of nitrogen, and 20 - 80% of phosphorus in treating wastewater (Ejigu, 2010). Additionally, wetlands have indispensable socio-economic importance. Ethiopian wetlands, for example, contribute billions of birr every year in the form of clean water, soil formation, provision of food and medicine, etc (Abunie, 2003). The importance of wetlands can be better understood by knowing the fact that two thirds of the world population live along the banks of wetlands, including rivers, lakes, and beaches (Nazaridoust, 2010).

Despite the fact that wetlands are among the most productive ecosystems, they are also the most threatened (Delelegn, 2003). More than 50% of the global wetlands were lost over the last centuries (Davidoson, 2014). For instance, in North America, Europe, and Australia more than 50% of the wetlands were lost over the last 20 years (MEA, 2005). Likewise, in Ethiopia, wetlands are ranked among the most threatened ecosystems (G/Silasie *et al.*, 2014). Decision makers, who are involved in wetlands conservation, are unaware of the biological, ecological and socio-economic importance of wetlands. Wetlands are considered as wastelands, which are obstacles to agricultural development (Taffa, 2007). Furthermore, many people in Ethiopian still consider wetlands solely as the breeding places for disease vectors like mosquito (Taffa, 2007). Due to this perception, wetlands in the Lake Tana Sub-basin are drastically degraded leading to habitats and biodiversity degradation (Gebremedhin *et al*., 2018). Among others damming, agriculture, grazing, and irrigation are the main anthropogenic impacts (Gebremedhin *et al.,* 2018). Additionally, untreated effluents and encroachment for different purposes are negatively affecting the wetlands water quality and biodiversity (Atnafu *et al*., 2011). Due to these threats, between 1986 and 2013, over 52% of the wetlands in the lake sub-basin were converted into other land use forms (BNWI, 2014 unpublished). Thus, for sustainable exploitation of the wetland resources, considerable attention should be given to their threats. Therefore, this review aimed at providing a comprehensive report on the existing situation, distribution, and threats of wetlands in the Lake Tana Sub-basin and suggests optimal management options.

2. Distribution of Wetlands in the Lake Tana Sub-basin

Wetlands in the lake sub-basin are distributed in 29 districts and three administrative zones (BoEPLAU, 2015) (Table 1). Most of the wetlands are found in the low lying plains adjacent to the lake and major rivers (Shimelis *et al*., 2008). They distributed from the headwaters of Guna and Gishe-Abay to the Fogera and Dembia floodplains mainly around the lake shores and along the tributaries of Gilgel Abay, Ribb, Gumara, and Megech River (Shimelis *et al*., 2008).

Table 1. Wetland types and distribution in the Lake Tana Sub-basin

Name of wetlands	Estimated area (ha)	Location		Type of wetland	Main source of water
		District	Zone		
Tana Dar	150	Bahir Dar Zuria	W/Gojjam	Palustrine	Gilgel Abay
Ambo Bahir	45	Bahir Dar Zuria	W/Gojjam	Palustrine	Lake Tana
Mesenta	300	Bahir Dar Zuria	W/Gojjam	Palustrine	Gilgel Abay
Lata Amba *	80	Bahir Dar Zuria	W/Gojjam	Palustrine	Gilgel Abay
Yiganda **	468	Bahir Dar Zuria	W/Gojjam	Lacustrine	Lake Tana and Mina stream
Infranz Springs	200	Bahir Dar Zuria	W/Gojjam	Palustrine	Springs
Infranz River Outlet**	1225	Bahir Dar Zuria	W/Gojjam	Riverine	Infranz River
Tekuma	88	Bahir Dar Zuria	W/Gojjam	Palustrine	Spring
Ambo Mesk *	275	Bahir Dar Zuria	W/Gojjam	--	--

Amluk	--	Bahir Dar Zuria		Lacustrine	Lake Tana
EngidoDengel	161	Bahir Dar Zuria	W/Gojjam	--	--
AmlkoMesk*	836	Bahir Dar Zuria	W/Gojjam	--	--
Abuach *	719	Bahir Dar Zuria	W/Gojjam	--	--
Chimba **	3230	North Achefer	W/Gojjam	Riverine	Gilgel Abay
Abay Dar	2048	North Achefer	W/Gojjam	Riverine	Gilgel Abay
Legidia	1445	North Achefer	W/Gojjam	Palustrine	Gilgel Abay
Shobela	1625	North Achefer	W/Gojjam	--	--
Dawnti	1419	North Achefer	W/Gojjam	--	--
Chomet	300	South Achefer	W/Gojjam	--	--
Kurt Bahir	45	Mecha	W/Gojjam	Palustrine	Koga River
Dengira Mender	70	Mecha	W/Gojjam	--	--
BeyMeda	200	Mecha	W/Gojjam	--	--
Cheqecheq*	150	Mecha	W/Gojjam	--	--
AbeyMesk	156	Mecha	W/Gojjam	--	--
Shesher	650	Fogera	S/Gondar	Palustrine	Rib river
Daga	100	Fogera	S/Gondar	Lacustrine	Lake Tana
Wolala	100	Fogera	S/Gondar	Palustrine	Rib river
Taqua	75	Fogera	S/Gondar	--	--
Dingzi	200	Fogera	S/Gondar	--	--
Daba	125	Fogera	S/Gondar	--	--
GirmoEwaka*	40	Libokemkem	S/Gondar	--	--
Aminda	40	Dera	S/Gondar	--	--
Atirko	38	Dera	S/Gondar	--	--
FetoMidir	44	Dera	S/Gondar	--	--
YetanaRegreg*	280	Dembia	N/Gondar	Palustrine	Lake Tana
Dirma**	--	Dembia	N/Gondar	Lacustrine	Lake Tana
Gibara	131	Dembia	N/Gondar	--	--

Likilik	127	Dembia	N/Gondar	--	--
Ketera	148	Dembia	N/Gondar	--	--
Abelay	181	Dembia	N/Gondar	--	--
AshiwaBahir	245	Dembia	N/Gondar	--	--
Teter	229	Dembia	N/Gondar	--	--
Bichign	246	Dembia	N/Gondar	--	--
Mehalge*	152	Dembia	N/Gondar	--	--
AmbaMesk*	221	Dembia	N/Gondar	--	--
Sheha Gomen*	200	Gondar Zuria	N/Gondar	--	--
Firiqua Dengure*	450	Gondar Zuria	N/Gondar	--	--
Mitriha *	321	Gondar Zuria	N/Gondar	--	--
Agid Kirigna	7	Gondar Zuria	N/Gondar	Palustrine	Lake Tana
Asratie Toka	30	Takusa	N/Gondar	--	--
Gohil Toka	30	Takusa	N/Gondar	--	--
Mate	80	Alefa	N/Gondar	--	--
Kudadie	41	Alefa	N/Gondar	--	--

Note: * Source: Hunegnaw *et al.* (2013)
** Source: Aynalem *et al*. (2017)
Without asterisk sourced: BoEPLAU (2015)

The plains around Lake Tana are often flooded during the rainy season and form extensive wetlands. Some of the main flood plains in the lake sub-basin are the Fogera plain in the east, the Dembia plain in the north, and the Kunzila plain in the southwest (Shimelis *et al*., 2008). Additionally, there are a number of small sized wetlands dispersed in the upper catchments (ANRSBA, 2013) (Figure 1).

In the Fogera district, wetlands are mainly located in Kidest Hana, Shaga, Nabega and Sheha villages (BoEPLAU, 2015). The two main wetlands are Shesher and Welala, characterized by seasonal inundation from Gumara and Rib rivers (IFAD, 2007). There are also delta types of wetland formed by Gumara River, which is located in low lying area around eastern shores of Lake Tana. Of the various wetlands in the Bahir Dar Zuria area, Tekuma (Wonjeta village), Mesenta (Deber Mesenta village), Infranz Minch Wuha (Wogelisa village), Ambo Bahirand Tana Dar (Debiranta village), Yiganda (Yiganda village), and Amilko Mesk (Lijimi village)are the major ones. The Dembia floodplain is also endowed with various types of wetlands. Of which, Gibara (JerJer Amba village), Tikur Bahir (Gurandi Wonbha village), AshiwaBahir (Achera village), and Ketera (Tana Weyna village) are the main wetlands in the area. Moreover Infranz spring (Wegelisa village) and Infranz river-outlet (behind Bahir Dar Airport) are some of the major wetlands in Infranz floodplains.

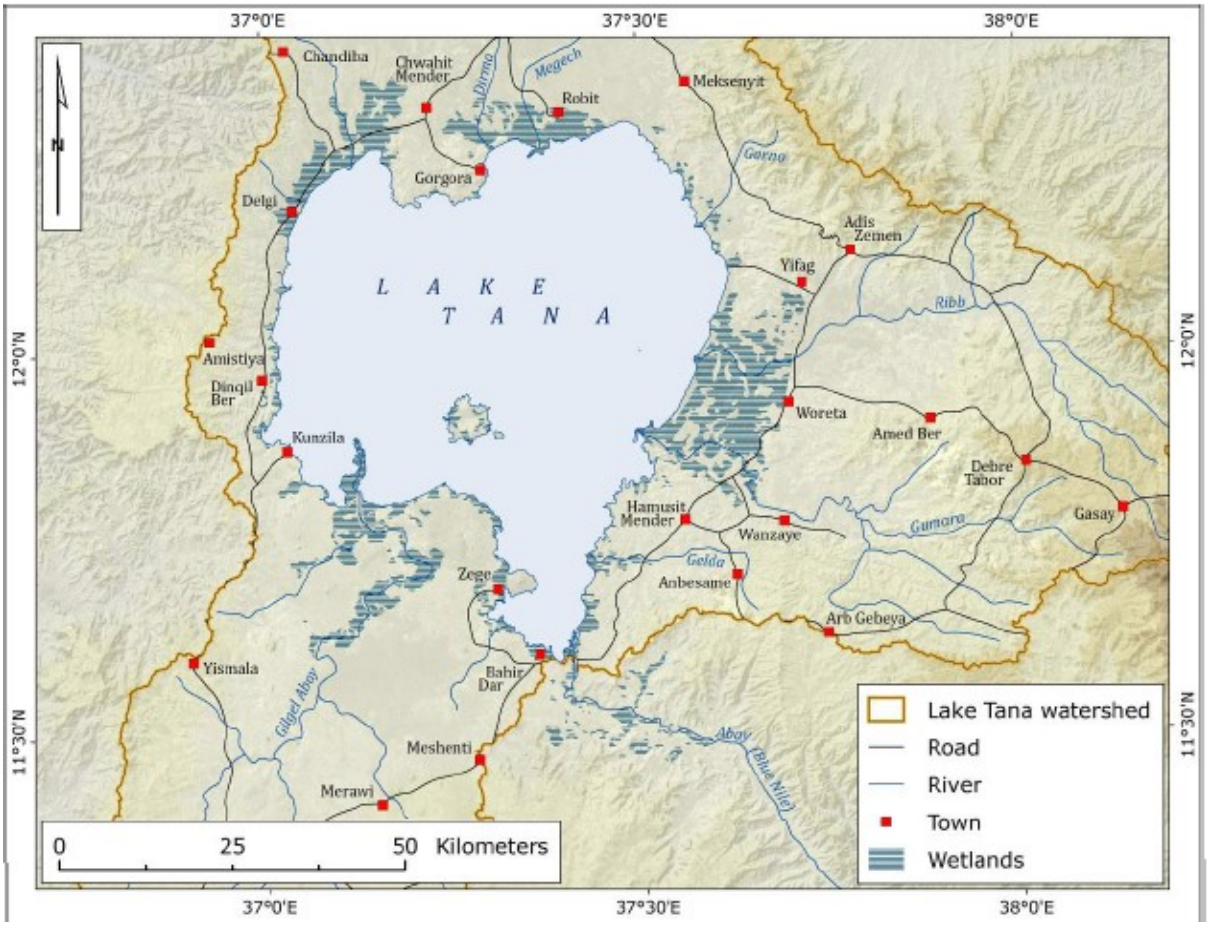

Figure 1. A map showing the Lake Tana Sub-basin and distribution of wetlands (ANRSBA, 2013)

3. Wetlands Ecosystem Services

Historically wetlands were designated as breeding places for disease vectors and as impediments to civilization (Day *et al.,* 2006). However, wetlands are now well recognized for their ecological functions and services they provide to human (Dixon and Wood, 2007). They are the heart of the landscape which serve as natural filters for the world's wastewater with no cost and biological supermarkets that contain miscellaneous biodiversity. The benefit people obtain from ecosystems is called ecosystem services (MEA, 2005). The Millennium Ecosystem Assessment (2005) categorized ecosystem services in to four main groups (Table 2). These are provisioning services: tangible products people obtain from wetlands; regulating services: the benefits obtained through the role of wetlands in the regulation of ecosystem processes; cultural services: non-material benefits people derive from wetlands through spiritual enrichment, cognitive development, and recreational, educational and aesthetic values; and supporting services: those services that are necessary for the production of all other ecosystem services such as soil formation, nutrient cycling, and biodiversity.

Ethiopia, with its varied geologic formations and climatic conditions, has considerable wetland ecosystems. Ethiopian wetlands provide various provisional, supporting, regulating and cultural services to the local people (G/Silasie *et al*., 2014). The Lake Tana Sub-basin embraces abundant wetlands (i.e. 24000 ha, 1.6% of its watershed) all-round its shores and tributary rivers (ZurHeide, 2012). Together these form the largest wetland complex in Ethiopia and are ecologically most important in the country (Wondie, 2010). The wetlands in the Lake Tana Sub-basin support many endemic globally threatened fish species and are also world recognized migratory birds wintering sites (Gebremedhin *et al.,* 2018). The wetlands, in the

Lake Tana Sub-basin, provided various goods and services to more than 500,000 people (Gordon *et al.,* 2007).

Since wetlands produce much plant biomass and invertebrate life, they serve as important nursery areas for fish and nesting sites of birds (Aynalem *et al.*, 2017). The Yganda and Dirma wetlands were known for feeding and breeding grounds of *Labeobarbus*, *Claris*, and *Oreochromis* fish species. Furthermore, most fish species in Lake Tana reproduce in the shallow shore areas and some migrate to adjacent wetlands (e.g. *C. gariepinus*) (Anteneh *et al*., 2012).

Wetlands also provide habitats for globally threatened wetland birds. For instance, wetland in Shesher provided a huge roosting site for 21,000 Common Cranes (Nowald *et al*., 2010). Yganda, Chimba, Debre Maryam, Dembia (near Gorgora) and wetlands close to Bahir Dar provided breeding sites for Black Crowned Cranes (Aynalem, 2011). Moreover, Aba Gerima (near Bahir Dar city), Infranz (behind Bahir Dar Airport), Abay Inflow Delta, Kunzila area, Delgi, and Dirma wetlands were known sites for both breeding and feeding of birds (Aynalem, 2017). In addition, wetlands provide habitat for wild life (Jacobs *et al.,* 2009). Amphibians, especially Anurans, reptiles, and mammals such as Hippos (*Hippopotamus amphibious*), reptiles like the Nile Monitor (*Varanusniloticus*) and African rock python (*Pythonsebae*), species were mainly present in the marshy shore-areas.

Table 2. Ecosystem services provided by wetlands (modified from Finlayson, 2005)

Services	Description of services	Examples
Provisioning services	Food	Production of fish, wild game, fruits and crops
	Water	For drinking, irrigation, cleaning
	Raw materials	Fiber, timber, firewood, fodder, fertilizer
	Genetic resources	For crop-improvement and medicinal purposes
	Medicinal resources	Biochemical products and test-organisms
	Ornamental resources	Artisan work, decorative plants, pet animals
Regulating services	Air quality regulation	Capturing (fine) dust, chemicals, particles
	Climate regulation	C-sequestration, vegetation influence on rainfall
	Moderation of extreme events	Storm protection and flood prevention
	Regulation of water flows	Natural drainage, irrigation & drought prevention
	Waste treatment	Water purification
	Erosion prevention	Retention of soil and or sediment
Supporting service	Maintain life cycles of migratory sp.	Nursery services
	Maintenance of genetic diversity and biodiversity	Provision of habitat for wild plant and animal
	Nutrient cycling	Store, recycle, process & acquisition of nutrients
Cultural services	Aesthetic information	Provision of attractive landscape features
	Opportunities for recreation	Provision of access for tourism
	Opportunities for tourism	Provision of access for recreation
	Spiritual experience	Religious heritage (sacred forests)
	Information to cognitive development	Provision of scientific & educational information

4. Major Threats to Wetland Ecosystems in the Lake Tana Sub-basin

Several reviews have identified a number of pressures facing tropical wetlands (Mitsch, 2010). Identifying the underlying causes is, therefore, necessary to prevent further loss and degradation. The main driving forces for wetland degradation in the lake sub-basin are rapid population growth and increasing economic transformation (Gebremedhin *et al*., 2018).

A recently observed threat is the expansion of the water hyacinths (*Eichhornia crassipes*) along several parts of the lake´s shorelines. According to Anteneh *et al*. (2015), infestation rate was increased alarmingly hence more than 50,000 ha of the lake shore was infested. It has threatened wetlands ecology by blocking sunlight from reaching native aquatic plants and hampers oxygen supply to the water body. And also by forming impenetrable thickets and destroying and replacing natural biodiversity. Furthermore, by increasing siltation and evapo-transpiration, it reduces water quality, fish stocks, and affects the biodiversity (Ayalew, 2003).

In the Lake Tana Sub-basin growing human population goes with livestock, whereas grazing area is limited and even shrinking due to extended agriculture (EPLAUA, 2007). Hence, there was continuous conversion of wetlands into crop and grazing land (IFAD, 2007). When grazing continuous livestock trample and compact the soil destroys natural vegetation, affect the infiltration capacity of the soil and erode drainage channels leading to gullies and water outflow (McKee, 2007).

Wetlands also threatened from sedimentation as a result of upstream agriculture and de-forestation (Wondie, 2010). Deforestation and recession agriculture coupled with erosion from the catchments resulted in high sediment deposition (Gebriye *et al*., 2009). Also riparian transport might add sediment to wetlands, which contributes to the deterioration (Heimann and Roell, 2000). Sediment accumulation finally might lead to the loss of wetlands. When wetlands are used for agriculture the soil may lose its fertility after drainage because of oxidation, acidification, and other processes that take place once the anaerobic conditions are removed (Wood, 2001). Thus, its ability to support biodiversity might be reduced.

Settlement, a growing problem of wetlands around Lake Tana (Ayenew, 2009), was another cause of wetland loss (Sisay, 2003). Due to the abundance of natural resources in wetlands, many urban centers are located near or in their vicinity. However, through time it becomes source of pollution (Mckee, 2007). If nutrient concentrations in the receiving waters becoming high, it might cause increase organic matter accumulation, decrease amount of oxygen and cause changes to water temperatures (Jackson, 2011). The pollutions might contribute to the degradation of wetlands particularly fishes, macrophytes, riparian vegetation, and other biodiversities found in the ecosystems. Besides, most of the wetland areas were lost by the settlement and associated demand of land for food, grazing, construction and agriculture.

Wetlands are also threatened by hydrologic alterations; any change in hydrology alters soil chemistry and plant and animal communities (EPA, 2001). Water extraction which is a common hydrologic alteration in wetlands affects the hydrologic and ecological functions by diminishing water availability and changing water levels, thus affecting the biodiversity composition. Water extraction could sometimes exacerbate the effects of other stressors on the ecosystem, resulting in effects that exceed those that would be expected from dewatering alone. For instance, dewatering in a wetland that receives water polluted by organic materials will result in increasing eutrophication due to a higher concentration of pollutants.

Apart from drainage, wetland hydrology has been modified by the construction of channels, dams, and ditches to achieve irrigation, transportation, and industrial activity. In the Lake Tana Sub-basins a number of irrigation and hydro-dams were under construction on the tributaries of the lake. In the watershed, the Koga, Rib, Gumara, Megech, Gilgel Abay and Jema Irrigation project have been initiated (Mulugeta, 2013). Also there was an effort to promote small scale irrigation in the sub-basin. Hence, if all the planned development occurs, the mean water level of the Lake Tana will drop by 0.44

m and the average surface area will decrease by 30 km^2 and up to 81 km^2 during some dry seasons. Such changes have affected estuarine and coastal ecology, and reduced the amount of water reaching flood plain wetlands (Kingsford, 2000). For instance, the hydrological modification due to the Rib Dam construction along Rib River was threatening the Shesher and Walala wetlands that depend on Rib River (Mekuriaw and Sewnet, 2014).

Additionally, different studies indicated that the abstraction of water from wetland for irrigation was a major factor for the loss of wetland (Ajibola *et al.,* 2012). Channelization increases the speed of water moving into and through wetlands. As a result, patterns of sedimentation and values that depend on the normal slow flow of water through a wetland could be affected.

In the Lake Tana Sub-basin, according to Ligdi *et al.* (2010), the Fogera floodplain wetlands have been among the most disturbed wetlands. More than 75% of the Fogera catchment was intensively cultivated (Asres and Seleshi, 2010). Due to conversion for agriculture and dam construction purposes and direct water extraction for irrigation or chat production, the wetlands in the Fogera floodplain are facing increasing pressures (Dejen *et al*., 2008). Besides, these wetlands are threatened by ecological degradation stemmed from invasion by alien species (ZurHeide, 2012). The intensive cultivation and free grazing activities in Shesher and Welala wetlands, for example, resulted in drastic shrinkage of their coverage (Atnafu *et al*., 2011; BoEPLAU, 2015). Similarly, Sisay (2013) reported the severe degradation of Shesher and Welala wetlands due to drainage and expansion of seasonal cultivation. In1987, the total area coverage of Shesher and Welala wetlands was 1,551 and 298 ha, respectively (Burnside and Taylor, 2009), while this was reduced to 134 and 159 ha in 2008, respectively. Thus, in the Fogera floodplain, only from the two major wetlands, a total of 1,560 ha were lost in a two decades time. Generally, in the Fogera floodplain, wetlands coverage was decreased from 0.66% in 1957 to 0.26% since 1985 and to 0.19 since 2005 (Anteneh *et al*., 2016). Similarly Ligdi *et al.* (2010) reported that, Gumara has producing high sediment load presumably due to degradation of riverine wetlands, buffer strips, and intensive farming.

The wetlands in the Bahir Dar Zuria area have been suffered by several threats such as free grazing, chat production, water abstraction, urbanization, encroachment, settlement, drainage for agriculture, and wetland distribution to landless youths (Table 2). Due to the lack of certified farming land, farmers mainly convert wetlands into farming land (Sewnet, 2015) and settlement led to intensification of the use of wetlands (personal communication). Above all, apart from the illegal expansion of farming land by farmers, the local government had officially distributed wetlands to youths for agricultural purpose (BoEPLAU, 2010). For examples, due to unwise utilization, wetlands in the Infranz watershed sharply declined, while settlement and farming land were rapidly increased (Figure 3).

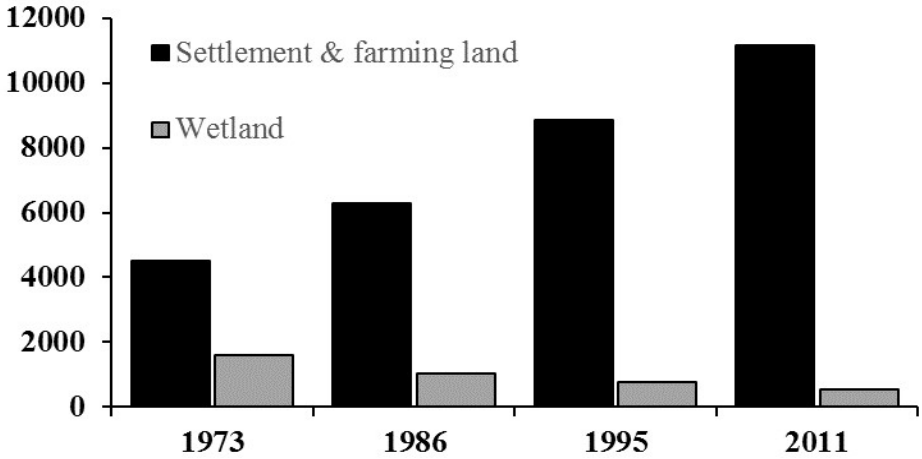

Figure 2. A bar graph that shows the change in wetland size, settlement area and farming land in the Infranz watershed from 1973-2011 (Sewnet, 2015)

Similar to the other areas, wetlands in the Dembia floodplain are also suffered by several threats including settlement, free grazing, farming, damming and water hyacinth invasion (Table 2). For examples, due to the Megech irrigation, the meadows which are important birds feeding site have been severely degraded (Ligdi *et al.*, 2010). Tewabe (2015) also reported that the occurrence of the highest water hyacinth infestation (80-100 ha) in the North and North-east parts have negatively affected the wetland resources in the area.

Regardless of their importance, wetlands in the Kunzila floodplain have been seriously threatened by increasing pressures such as free grazing, agriculture and overexploitation of the reeds. Free grazing is a common practice and the delta type wetlands are drastically degraded (Francis and Aynalem, 2007). Similarly, Sewnet and Kameswara (2011) reported that most of the wetlands in the catchment have been continuously declined, while the farming lands and settlement area have been increased.

Overall, the major threats to wetlands in the Lake Tana Sub-basin attributed to anthropogenic activities such as recession agriculture, unplanned urbanization, rapid population growth, indiscriminate industrial and development activities, disposal of domestic and industrial toxic wastes and free grazing (Gebremedhin, 2017; Gebremedhin *et al*., 2018)(Table 3). Many people in the lake sub-basin still now considered wetlands as unhealthy that are breeding places for disease vectors. Decision makers that are involved in natural resource conservation are unaware of the wetlands ecosystem services. Development activities in Lake Sub-basin very rarely consider the ecological and socio-economic values of wetlands. Wetland destruction and conversion for the purpose of recession agriculture is still seen as advanced mode of development. Above all a campaign is organized by development agents and undertaken every year to dry up clay soils, which are actually wetlands, for the purpose of agricultural activities. Additionally, *Cyprus papyrus*, one of the characteristic features of Lake Tana, has dramatically declined in its distribution with some local extinction due to overexploitation (ZurHeide, 2012). Therefore, the wetlands in Lake Tana watershed are not wisely utilized in the sense of the Ramsar Convention's definition, which emphasizes high yields and continuous benefits, while maintaining the wetlands' potential to meet the needs and aspirations of future generations (Ramsar Convention Manual, 2006).

Table 3. The major cause for the existing threats of wetlands in the Lake Tana Sub-basin

Major wetland threats	Wetlands in the Lake Tana Sub-basin			
	Fogera floodplain wetlands	Wetlands in Bahir Dar Zuria area	Dembia floodplain wetlands	Kunzla floodplain wetlands
Overgrazing	√	√	√	√
Recession agriculture	√	√	√	√
Settlement	√	√	√	√
Water abstraction	√	√	√	√
Irrigation	√	√	√	
Lack of awareness	√	√	√	√
Overexploitation		√		√
Dam construction	√		√	√
Water hyacinth	√		√	

5. Management Options

Due to the complexity and multifaceted nature of the factors that threatened wetlands, there is no quick and one-off solution to remedy the threats. However, there are options recommended to manage wetlands. In this regard, we have comprehensively reviewed different wetland management options and a detail explanation about each of the optimal management options for sustainable use of the wetlands in the

Lake Tana Sub-basin is given in the following sections.

5.1. Awareness creation about wetlands

Lack of awareness about the functions and values of wetlands have often led to their drastic degradation. Public awareness creation is one of the most important ways to conserve wetlands and enable the public to be more environmentally conscientious. Through public awareness campaigns, the importance of conserving wetland ecosystem would reach the public. However, awareness creation about the importance of wetlands in the Lake Tana Sub-basin is virtually lacking (Woube, 2008).Consequently, many people in the Lake Tana Sub-basin still consider wetlands solely as the breeding places for disease vectors like mosquitoes. This perception makes the wetlands susceptible to degradation. Therefore, this knowledge gap needs to be bridged through dissemination of information to the public. This can be achieved through: a) distribution of awareness raising materials (posters, fact sheets, booklets), b) use of mass media to put out features on wetlands, c) awareness raising workshops on identified knowledge gaps, d) promotion of environmental education and f) establishment of wetland clubs/support groups (Dejen, 2008).

5.2. Independent wetland policy development

Sustainable use of wetland resources is hardly possible if effective rules are not in place. Lack of independent wetland policy is the primer challenge to successful wetland management in Ethiopia. Even though various policies such as environmental, land, and water resources management have been issued to address the different aspects of environmental problems including wetlands, there is no specific national policy that deals with wetland issue (Bezabih, 2008). The implementation of wetland management in the context of the above policies is compounded by a more pressing wetland task force, extension package and food security policies that seek to convert wetlands for agricultural purposes (Aragaw, 2001). Thus, preparation and proper implementation of independent wetland policy is fundamental. Besides, ratifying the Ramsar Convention on wetlands could be helpful for sustainable conservation of the Ethiopian wetland resources.

Development of a unique or standalone wetland policy statement and/or strategy could be an important step in recognition of wetland problems and targeted action to deal with them. A unique wetland policy provides a clear opportunity to recognize wetlands as ecosystems requiring different approaches to their management and conservation, and not being masked under other sectorial management objectives (Ramsar Convention Secretariat, 2007).

In many cases, however, wetland policies or strategies are made a component of national sustainable development, water or other sectorial environmental policies. The wetland messages can therefore become diffused and remain dominated by the broader objectives of other Government policy objectives. The implication is that in many countries, institutions having a stake in natural resources management will not be motivated to assign adequate staff and even the available staff will be overloaded and pressurized to deal with the broader issues and tend to overlook wetland conservation and management (Ntambirweki, 1998). This seems an all pervading challenge observed in many areas of Ethiopia where wetlands are located. In view of these challenges, initiating a standalone wetland policy has the potential to draw the attention of legislators and the public to consider better and strong management interventions on wetlands.

5.3. Biosphere reserve

Biosphere reservation has great importance for ecosystem conservation and sustainable development. In the Lake Tana watershed three biosphere reserve zones (potential core zones, buffer areas and transition zones) were already identified (BoEPLAU, 2015). These zones are very important and can be the solution to minimize the risk of wetlands and the lake ecosystem as a whole (ZurHeide, 2012). Therefore, implementation of biosphere reservation could be one of the solutions.

5.4. Impact assessments and continuous monitoring of wetlands

Implementing detailed environmental impact assessments before any form of development (e.g. draining, damming, and diversion) is needed to ensure that the new modification will not bring

hazardous consequences on the ecology of a wetland area (Woube, 2008). It also involves implementing integrated management plans covering every aspect of wetlands and their relationships with catchments.

Besides the impact assessment, the other problem is proper implementation of the assessment study. This might be due to poor understanding of the economic value of the ecosystem services in terms of monetary unit (Lambert, 2003). So, in order to properly implement the impact assessment studies the government should first understand its countless value and change his attitude from 'waste land' to 'wealth land'. Since when the value of wetlands is known because of their incalculable value they are regarded as 'wealth lands' (Lee, 1999). Then formulate enacted legal frameworks, directives, and regulations that serve as an enforcement mechanism for the proper implementation. In addition, defining pertinent stakeholders having vested interest in wetlands and involving and consulting them in the whole process of wetland management issues are essential to achieve effective results. Additionally, ratifying the Ramsar Convention indirectly support and enforce the implementation process as well as the wetland management.

Besides to assessing the impacts of development, wetland monitoring is vital. It addresses both the issue of wetland integrity, *i.e.* change in wetland area, and change in wetland quality. This includes assessment of changes in biodiversity, physical and chemical properties of wetlands, water quality, and social activities around wetlands and considers if there are any new development plans that will potentially affect the wetlands. It is only through monitoring programs that the extent and causes of loss and degradation of wetlands can be determined, and the success of conservation actions be measured. It can be carried out at different levels of intensity, depending on available funding and/or technology (Woube, 2008). Monitoring methods include simple field observations, remote sensing, and quantitative sampling techniques. This activity is envisaged to take place at least at selected priority wetlands. In the sub-basin besides to field observation and quantitative sampling techniques using the remote sensing is beneficial. Since knowledge of the spatial distribution of wetlands and land cover maps assist in targeting and prioritizing risk mitigation activities.

5.5. Institutional nexus

In the Lake Tana Sub-basin, resources such as wetlands shared with public goods and there is no institution clearly responsible for management of the resources. This makes it difficult to sustainably exploit these natural resources. The problem of shared or lack of ownership is clearly reflected when it comes to the management wetland resources. Despite the fact that solving wetland problems in the Lake Tana Sub-basin appears to be very much dependent on institutional collaboration, the current cooperation among the institutions with a similar scope is weak. These institutions do not communicate very well about conservation of the wetland resources. Being a common ground they are suffering from the 'tragedy of the commons'. For example, although Ministry of Agriculture, Ministry of Water Resources, Environmental Protection Authority and Biodiversity Institute are the responsible organizations to wetland management, there is no organized system, in which these institutions co-operate and share their knowledge. Therefore, the organizations having similar scope should strengthen their co-operation and this is vital to have robust and holistic wetland management (EWNRA, 2008).

6. Conclusion and Recommendation

The Lake Tana Sub-basin is endowed with large number of wetlands, which are ecologically and socio-economically most important. The wetlands are distributed all over the sub-basin but most of them found around the lake shores and the tributaries. Despite the fact that wetlands in the Lake Tana Sub-basin provide wide range of social, economic, and environmental benefits, most of them are either severely degraded or are at the verge of extinction. Therefore, urgent action is required to combat the existing problems and successfully manage the wetlands. Among others, public awareness creation, independent wetlands policy development, strengthening the cooperation among organizations, buffer zone development and continuous monitoring are the optimal management options. Furthermore, ratifying the Ramsar convention is of crucial to sustainable conserve wetlands.

References

Abunie, L. (2003). The distribution and status of Ethiopian wetlands: An overview. In: Abebe, Y., and Geheb, K. (eds.).Proceedings of a seminar on the resources and status of Ethiopia's wetlands. pp. 116.

Ajibola, M.O., Adewale, B.A., and Ijasan, K.C. (2012).Effects of urbanization on Lagos wetlands. International Journal of Business and Social Science.3: 17.

ANRSBA (Amhara National Regional State Bureau of Agriculture). (2013). Biodiversity and wetlands. Community-based integrated natural resources management project in Lake Tana Sub-Basin draft baseline report. Bahir Dar, Ethiopia.

Anteneh, W., Getahun, A., Dejen, E., Sibbing, F.A., Nagelkerke, L.A.J., De Graaf, M., Wudneh, T., Vijverberg, J., and Palstra, A.P. (2012). Spawning migrations of the endemic Labeobarbus (Cyprinidae, Teleostei) species of Lake Tana, Ethiopia: Status and threats. Journal of Fish Biology.81:750-765.

Anteneh,W., Tewabe, D., Assefa, A., Zeleke, Z., Tenaw, B., and Wassie, Y. (2015).Water hyacinth coverage survey report on Lake Tana Biosphere Reserve, Technical Report Series 2.

Anteneh, M., Assen, M., and Melanie, D.N. (2016).Patterns, causes and consequences of land use/cover dynamics in the Gumara watershed of Lake Tana Basin, Northwestern Ethiopia. Environmental Systematic Resources.5: 8.

Aragaw, H. (2001). Researching on wetlands in Southwestern Ethiopia: The experience of Ethiopian wetlands research program. In: Alan, D.B., Hailu, A., and Adrian, W.P. (eds.). Proceedings of wetland awareness creation and identification workshop in Amhara Regional State, Bahir Dar.

Asres, T., and Seleshi, A. (2010). SWAT based runoff and sediment yield modeling: A case study of the Gumara watershed in the Blue Nile Basin. Ecohydrology and Hydrobiology. 10: 191-199.

Atnafu, N., Dejen, E., and Vijverberg, J. (2011).The ecological status and threats of Welala and Shesher wetlands, Lake Tana Sub-basin. Journal of Water Resource Protection. 3: 540-547.

Ayalew, D. (2003). Fisheries management: Ecosystem approach. EPA. In Tefetro: A biannual amharic-english magazine, (Year 2, No.1). Addis Ababa, Ethiopia.

Ayenew, T. (2009). Natural lakes of Ethiopia. Addis Ababa: Addis Ababa University Press.

Aynalem, S. (2011).Conservation, environmental education and eco-tourism project at Lake Tana. Biology and ecology of Cranes at Lake Tana; project report 2010/2011.Bahir Dar, Ethiopia.

Aynalem, S., Goshu, G. and Wondie, A. (2017).Wetlands of the Lake Tana Watershed. In K. Stave, G. Goshu, S. Aynalem (Eds.), Social and ecological system dynamics: Wetlands characteristics and boundaries. Washington DC: National Academy Press.

Bezabih, E. (2008). Socio-economic and environmental valuation of wetlands, biodiversity and water resources in the Lake Tana Sub-basin. Transboundary environment action project draft report. Ethiopia.

BoEPLAU (Bureau of Environmental Protection and Land Administration and Use). (2010). Socio-ecological impact assessment and proposed sustainable management options of the wetlands in Amhara region. Bahir Dar, Ethiopia. pp. 14-22.

BoEPLAU (Bureau of Environmental Protection and Land Administration and Use). (2015). Fisheries and wetlands assessment. Tana Sub-basin integrated land use planning and environmental impact study project technical report. The Federal Democratic Republic of Ethiopia, Amhara National Regional State, Bahir Dar.

Burnside, T., and Taylor, I. (2009).Supplemental work to ministry of water resources, ESIA for the Ribb Dam, Ethiopia, final report. Report for ENIDP, MoWR.

Davidoson, N. (2014). How much wetland has the world lost? Long-term and recent trends in global wetland area. Marine and Freshwater Resources. 65: 934-942.

Day, J.W., Westphal, A., Pratt, R., Hyfield, E., Rubczyk, J., Kemp, G.P., Day, J.N., and Marx, B. (2006). Effects of long-term municipal effluent discharge on the nutrient dynamics, production and benthic community structure of a tidal freshwater forested wetland in Louisiana. Ecological Engineering. 27: 242-257.

Dejen, E. (2008). Wetland and fishery resources: The impact of wetland degradation on fishery resources. In: proceedings of the national stakeholders' workshop on creating national commitment for wetland policy and strategy development in Ethiopia, EWNRA.

Delelegn, D. (2003). Wetlands of Ethiopia. In Yilma, A. and Geheb, K. (eds.). Proceedings of a seminar on the resources and status of Ethiopia's wetlands, IUCN.pp.116.

Desta, H. (2006). Environmental, biological and socio-economic study on Boye and extended wetlands in Jimma zone, Southwest Ethiopia (M.Sc. thesis). Addis Ababa University, Ethiopia.

Dise, N.B. (2009). Peat land response to global change. Science. 326: 810-811.

Dixon, A.B., and Wood, A.P. (2007). Local institutions for wetland management in Ethiopia: Sustainability and state intervention. In B. van Koppen, M. Giordano, and J. Butterworth, (Eds.), Community-based water law and water resources management reform in developing countries. Comprehensive assessment of water management in agriculture series 5. Wallingford, UK: CABI International.

Ejigu, S. (2010).Ecological and socio-economic role of wetlands in Bahir Dar city and Abay Millennium Park (AMP) (M.Sc. thesis).Bahir Dar University, Ethiopia.

EPA (Environmental Protection Authority). (2001).Threats to wetlands. The wetland fact sheet series. http://www.epa.gov/owow/wetlands.

EPLAUA (Environmental Protection and Land Administration and Use). (2007).Baseline information on livestock production/range management (final).Bahir Dar, Ethiopia.

EWNRA (Ethiopian Wetlands and Natural Resources Association). (2008). Proceedings of the national stakeholders workshop on creating national commitment for wetland policy and strategy development in Ethiopia, EWNRA, Addis Ababa. Biological Review. 8: 163-182.

Finlayson, C.M., D'Cruz, R., and Davidson, N.C. (2005). Ecosystems and human wellbeing: Wetlands and water synthesis, Millennium Ecosystem Assessment. World Resources Institute, Washington DC.

FAO (Food and Agricultural Organization of the United Nations). (2015). The state of food insecurity in the world meeting the 2015 interaction hunger targets: Taking stock of uneven progress. FAO, Rome.

Francis, I.S., and Aynalem, S. (2007). Bird surveys around Bahir Dar-Lake Tana IBA, Ethiopia. Report of RSPB Scotland, Aberdeen, UK, and Addis Ababa University, Ethiopia.

Gebremedhin, S. (2017). Land use change and its drivers in Kurt Bahir wetland, north-western Ethiopia. African Journal of Aquatic Science. 42: 45-54.

Gebremedhin, S., Getahun, A., Anteneh, W., Bruneel, S., and Goethals, P. (2018).A drivers-pressure-state-impact-responses framework to support the sustainability of fish and fisheries in Lake Tana, Ethiopia. Sustainability. 10: 2957.

G/Silasie, H., Gashaw, T., and Mehari, A. (2014). Wetland degradation in Ethiopia: Causes, consequences and remedies. Journal of Environmental and Earth Science. 4: 40-48.

Gebriye, S., Srinivasan, R., Dargahi, B., and Melesse, A. (2009). Spatial delineation of soil erosion vulnerability in the Lake Tana Basin, Ethiopia. Hydrological Processes.23:3738-3750.

Gordon, A., Sewmehon, D., and Melaku, T. (2007).Marketing for improved marketing and livelihoods. Improving productivity and market success of Ethiopian farmers, project working paper 2.International Livestock Research Institute, Nairobi, Kenya.

Heimann, D.C., and Roell, M.J. (2000). Sediment loads and accumulation in a small riparian wetland system in northern Missouri. Wetlands. 20: 219-231.

Hunegnaw, G., Mengesha, H., Aimero, A., and Ferede, B. (2013).Wetland ecosystem coverage, status and threats in the Abay River Basin. The Federal Democratic Republic of Ethiopia, Abay Basin Authority. pp.50-58.

IFAD (International Fund for Agricultural Development). (2007). Baseline information on agronomy/crop production. Amhara National regional State, Bahir Dar, Ethiopia.

Jackson, L. (2011). Conservation of shallow lakes given an uncertain, changing climate: Challenges and opportunities, aquatic conservation. Marine and Freshwater Ecosystem.21: 219-223.

Jacobs, A., Rogerson, A., Fillis, D., and Bason, C. (2009).Wetland condition of the Inland Bays watershed. Delaware, USA: Delaware department of Natural Resources and Environmental Control, Dover.

Kingsford, R.T. (2000). Ecological impacts of dams, water diversions and river management on floodplain wetlands in Australia: A review. Austral Ecology. 25: 109-127.

Lambert, A. (2003).Economic valuation of wetlands: An important component of wetland management strategies at the River Basin Scale. pp. 1-10.

Lee, Y. (1999). Sustainable wetland management strategies under uncertainty. The Environmentalist. 19: 67-79.

Lehner, B., and Döll, P. (2004).Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology.296: 1-22.

Ligdi, E.E., El Kahloum, M., and Meire, P. (2010). Ecohydrological status of Lake Tana a shallow highland lake in the Blue Nile: A review. Ecohydrology and Hydrobiology.10: 109-122.

McKee, J. (2007). Ethiopia country environmental profile. Report prepared for the European Commission, Addis Ababa, Ethiopia.

Mekuriaw, N., and Sewnet, A. (2014). Land use/cover dynamics in Ribb Watershed, North Western, Ethiopia. Journal of Natural Science.4: 16.

MEA (Millennium Ecosystem Assessment). (2005). Ecosystems and human well-being: current state and trends. Washington DC: Island press.

Mitsch, W.J., and Gosselink, J.G. (2002).Wetlands. USA: John Wiley and Sons, Inc.

Mitsch, W.J. (2010). Conservation, restoration and creation of wetlands: A global perspective. In F. Comin (Ed.), Ecological Restoration: A global challenge, (pp.175-188). Cambridge University Press.

Mmopelwa, G. (2006). The value of the Okavango delta: A natural resource accounting approach (PhD thesis). Pretoria University, South Africa.

Mulugeta, A. (2013). Modeling and analysis of Lake Tana sub basin water resource systems, Ethiopia (PhD thesis). Rostock University, German.

Nazaridoust, A. (2010). Conservation of wetlands: Adaptability to climate change' conservation of Iranian wetlands project, World wetlands day bulletin, No. 7, p.1.

Nowald, G., Schröder, W., Günther, V., and Aynalem, S. (2010). Common Cranes (Grusgrus) in Ethiopia. Vogelwelt.131: 169-174.

Ntambirweki, J. (1998). The Evolution of policy and legislation on wetlands in Uganda. Case study prepared for the technical consultation on designing methodologies to review laws and institutions relevant to wetlands. Switzerland.

Ramsar Convention Secretariat. (2006). The Ramsar Convention Manual 6th edition: A guide to the convention on wetlands (Ramsar, Iran, 1971). Ramsar Convention Secretariat, Gland, Switzerland. Http://www.ramsar.org/pdf/lib/lib_manual2006e.pdf. Retrieved: April 21, 2011.

Ramsar Convention Secretariat. (2007). A conceptual framework for the wise use of wetlands. Ramsar handbooks for the wise use of wetlands, third edition. Ramsar Convention Secretariat, Gland, Switzer land. http://www.ramsar.org/lib/lib_handbooks2006_e.htm.

Rebelo, L.M., Finlayson, C.M., and Nagabhatla, N. (2009). Remote sensing and GIS for wetland inventory, mapping and change analysis. Journal of Environmental Management. 90: 2144-2153.

Sakane, N., Alvarez, M., Becker, M., Böhme, B., Handa, C., Kamiri, H., Langensiepen, M., Menz, G., Misana, S., Mogha, N., Möseler, B., Mwita, E., Oyieke, H., and van Wijk, M.T. (2011). Classification, characterization and use of small wetlands in East Africa.Wetlands.31: 1103-1116.

Sewnet, A., and Kameswara, K.R. (2011).Hydrological dynamics and human impact on ecosystems of Lake Tana, Northwestern, Ethiopia. Journal of Natural Sciences Research. 4(16): 9-16.

Sewnet, A. (2015). Retrospective analyses of land covers and use dynamics in Gilgel Abay watershed using GIS and remote sensing techniques. International Journal of Geosciences.7: 1003-1008.

Shimelis, S., Srinivasan, R., and Dargahi, B. (2008). Hydrological modeling in the Lake Tana Basin, Ethiopia using SWAT Model. Journal of Open Hydrology 2: 49-62.

Sisay, L. (2003). Biodiversity potentials and threats to the southern Rift Valley lakes of Ethiopia. In: Proceedings of a seminar on the resources and status of Ethiopia's wetlands, Nairobi, Kenya. pp.116.

Sisay, G. (2013). Onion value chain development in Fogera Woreda agro-business induced growth program in Amhara National Regional State, Environmental Assessment Report.

Taffa, L. (2007). The dynamics of wetland ecosystems: A case study on hydrologic dynamics of the wetlands of Ilu Abba Bora Highlands, South-West Ethiopia (M.Sc. thesis). Brussels, Belgium.

Tewabe, D. (2015). Survey of water hyacinth in Lake Tana Ethiopia. Global Journal of Alergy. 1: 13-18.

Wondie, A. (2010). Improving management of shoreline and riparian wetland ecosystems: The case of Lake Tana catchment. Ecohydrology and Hydrobiology.10: 123-131.

Wood, A.P. (2001). The Role and importance of wetlands in Ethiopia. Policy briefing note. University of Huddersfield, UK: Ethiopian Wetlands Research Program; Ethiopia: Ethio-Wetlands and Natural Resources Association.

WBCSD (World Business Council for Sustainable Development) and IUCN (International Union for Conservation of Nature). (2008). Agricultural ecosystems: Facts and trends. Understanding agriculture's dilemma between food security and conservation. World business council for sustainable development, Geneva, Switzerland. Http//www.agriecosyst_wbcsd-iucn2008.pdf. Retrieved: November 25, 2014.

Woube, M. (2008). The role of wetlands in biodiversity conservation and management in Ethiopia: A case study of Berga Floodplain. EWNHS, Ethiopia.

Zedler, J.B., and Kercher, S. (2005). Wetland resources: Status, trends, ecosystem services and restorability. Annual Review of Environmental Resources. 30: 39-74.

ZurHeide, F. (2012).Feasibility study for a Lake Tana biosphere reserve, Ethiopia. BfN-Skripten 317. http//www.bfn.de/fileadmin/MDB/documents/service/script_317.pdf. Retrieved: July 13, 2015.