Economic and environmental Importance of wetlands of the Lake Tana Basin (LTB) and requirements for sustainable land management

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Abstracts
Economic and ecological relevance of wetlands in Ethiopia have not been well recognized. Traditionally, riparian lands in Ethiopia have been considered as problematic lands such as swap lands as a harbor to malaria; rivers as harboring of crop pests such as birds and wild beasts. However, with the ever increasing human population and the intensified demand for food grain, more riparian lands (particularly wetlands) are seen recently converted into intensive agricultural land use. As a result, the natural habitat of lakeshores, wetlands and riverine ecosystems have been seriously damaged and their land uses permanently converted. Apart from the loss of the main resources (wetland vegetation, water, biodiversity and habitats), there are interlinked and externalized consequences due to the degradation of these particular ecosystems through adverse loss of soil from the destabilized riverbanks, frequent flood occurrence, sedimentation and pollution of reservoirs downstream. In this paper, detailed definitions of wetlands, a range of benefits due to the management of wetlands were discussed thoroughly. Wetlands of the Amhara Region, dynamics and opportunities for sustainable management of the resources were discussed based on the case study carried out in the Lake Tana Basin (LTB). Thus, it was concluded that the sustainable management of wetlands in the basin was a complex combination of ecological, economic and social objectives determined by the participation of multiple stakeholders in a transdisciplinary research approach.

Key words: wetland, Sustainability, Amhara Region, Lake Tana Basin

1. Introduction

Wetlands are a very important aspect of the environmental resource base of Ethiopia. They produce a range of ecological and economic benefits in their natural state, which contribute to the well being of rural communities and the environmental security of the country. However, wetlands are often seen as wetlands that have no value and are best converted by drainage to allow agriculture or grazing. Such conversion may create some new benefits – increased food production and grazing, but will generally cause the loss of many other benefits. Indeed, in the end, the net result of converting wetlands can be serious environmental degradation and loss of benefits to the community. Economic analysis of the process of wetland conversions shows that wetlands are more vulnerable when used in a way that influences their natural functions (Wood, 2001).

The generally perceived wisdom is that wetlands should not be cultivated because they are fragile ecosystems which can easily be destroyed. Further it is understood that if wetlands are cultivated the hydrological system will be disrupted with increasingly erratic stream flows. However, the reality is that wetlands have become the “new agricultural frontier” in many African countries over the last few decades. Wetland farming has expanded as population growth and where land degradation has increased the pressure upon “upland” areas used for rain-fed cultivation. Wetlands now play an increasingly important role in food security, sometime as the new frontier for domestic production by poor people, but in other cases they have been appropriated by rural elites for market oriented production.

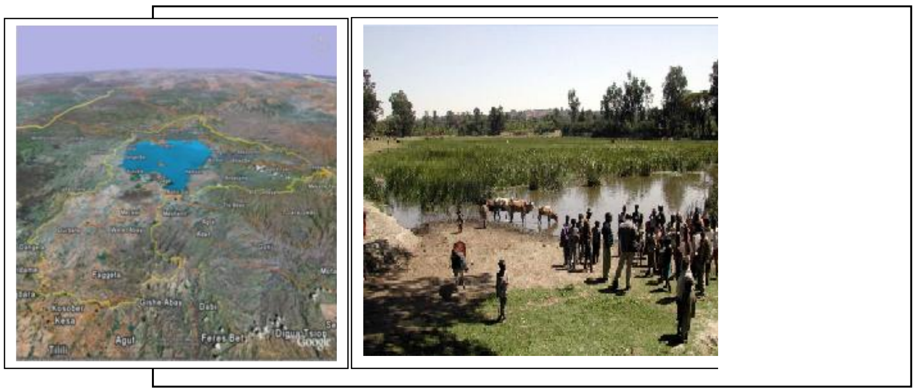


Figure 1: A 3-Dimensional view of the Lake Tana Basin (LTB) and characteristic nature of the wetlands in the basin

The livelihoods of many poor people in the developing world depend to a large extent on intact and functioning wetlands for the simple reason that many of the poor rely on wetlands for food, water, construction materials and for other necessities. Wetlands also act as wildlife corridors and provide protection against flood, drought and intrusion of pollutants – all functions crucial to environmental and food security. Hence the maintenance of healthy wetlands is important for poverty alleviation, and because wetlands are critical to water supply they are literally the source of life. Experience has shown that solutions to wetland degradation and over-exploitation must be based on a thorough understanding of how wetlands contribute to people’s livelihood strategies. This concept challenges conventional approaches to conservation and development. Whereas in the past conservation of wetlands did not necessarily recognize the need to address local poverty issues, history and practice have shown that where wetlands have been degraded, poverty generally also increases, leading to even greater wetland degradation. With so many people directly dependent on wetlands and wetland resources for their livelihoods, protecting and restoring wetlands is clearly in the interests of reducing poverty and vulnerability to poverty.

While it may not be possible in all cases to identify ways in which wetlands can be used in ecologically sound ways, there is evidence from Ethiopia that some cultivation in wetlands is feasible with a high level of sustainability and maintenance of part of the hydrological regime (Wood et al., 1998). This is only possible if the natural dynamics of wetlands and their catchments are understood and efforts made to maintain and replicate these. In other words an approach is needed with replicates the ecology of the area in the agricultural system – an eco-agriculture approach. Thus, the main objectives of the present study are to show states and dynamics of wetlands in the LTB and to create awareness among stakeholders about values/functions of the wetlands for sustainable management of the resource.

2. Overviews of the concepts and principles of wetland management

Which land areas are said to be wetlands?

Wetlands are defined as ``areas of marsh, fen, peat land or water whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters. For an area to be a wetland, water does not have to be at the surface, but it has to be close enough to the surface and for long enough to allow anaerobic conditions to develop in the soil (Wood, 2001). Some wetlands may be permanently flooded, whilst others may have water close to the surface for only a few months in a year. Wetlands are lands that are transitional between terrestrial and aquatic ecosystems wherein the water table is usually at or near the surface and the land is covered periodically by shallow water; those lands must have one or more of the following attributes (Sierra Club):

1. At least periodically, it supports predominantly hydrophytes;
2. Its substrate is predominantly undrained by hydric soil; and/or
3. Its substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year.

There are two major sources of water that determine the type of wetlands (Moorman and Breemen, 1978):

a) *Hydromorphic or phreatic wetlands*, which mainly receive water from ground water as well as precipitation.
b) *Fluvial wetlands*, which mainly receive water from surface water, runoff, streams, etc.

Functions/ values of wetlands

Even though wetlands vary in the values they bestow, depending on local variations in hydrology, soils, vegetation, and topography, healthy and functioning wetlands are vital for protection of the environment and public health. Simply put, wetlands are transitional areas that act as buffers between open waters and uplands and provide certain values/functions such as:

i. ***Environmental values/wetland functions***

- Water quality maintenance, aquatic productivity, microclimate regulation, etc.
- Fish and wildlife values (fish and shellfish, waterfowl and other birds, and furbearers and other wildlife)
- Filter pollution, purifying drinking water, and protecting rivers, lakes, and coastal waters from pollution, such as sediment, nutrients, chemical contaminants, and bacteria
- Recharge groundwater aquifers
- Provide habitat functions for plant and animal species, including threatened or endangered species, and a corridor function between the terrestrial and water bodies

ii. ***Socioeconomic values/functions***

- Flood control, erosion control, water supply, fishing and hunting, aesthetics, research, and education, etc.
- *Absorb floodwaters, protecting coasts and homes from flood damages*
- *Provide local tourism industries with opportunities to engage in activities associate with such wildlife*

What are the major causes of wetland degradation?

Degradation of wetlands is largely caused by human activities, and can result from hydrological degradation, pollutant inputs and removal of vegetation.

Hydrologic alterations

- Deposition of fill material for development.
- Drainage for development, farming, and mosquito control.
- Dredging and stream channelization for navigation, development, and flood control.
- Diking and damming to form ponds and lakes.
- Diversion of flow to/from wetlands.
- Increasing impervious surface areas, which increase pollutant runoff into wetlands.

Pollution inputs

- Runoff from urban, suburban, agricultural, silvicultural and mining activities.
- Air pollution from cars, factories, and power plants.
- Leaking landfills and dumps.
- Marinas, which cause increased turbidity and release pollutants.

Vegetation removal

- Vegetation removal associated with development activities.
- Grazing by domestic animals.

- Introduction of nonnative, invasive plan species.
- Removal of vegetation for peat mining
- Removal of vegetation for domestic use (energy, construction and others)

3. States and dynamics of the wetlands of the Lake Tana Basin (LTB)

The Lake Tana Basin (LTB) is the source of the Blue Nile that endowed with abundant water resources in the form of surface and groundwater. There are a large number of springs and rivers in the LTB draining from the mountain areas and flow to the wetlands and the lake. The central area of the basin is covered by the lake water that accounts for about 3,050 km^2 (20% of the basin). The mean annual rainfall of the basin is about 1400 mm (ranging from 900 to 2000 mm), which makes the basin water tower of the region.

3.1 Methodological consideration

The Lake Tana Basin (LTB) is part of the Nile River Basin situated at the upper course of the Blue Nile River in Ethiopia. The basin is bounded between latitude 10°58`–12°47`N and longitude 36°45`- 38°14`E. The LTB is divided into four major river sub-basins: River Gilgel Abbay in the south, River Gumara in the east, River Ribb in the northeast, and River Megetch in the north (Figure 2). However, including the perennial and other seasonal rivers and streams, the number of drainages that flow into the Lake Tana is estimated to be about 66 (Birru, 2007). Wetlands of the LTB were extracted from landsat images and by using SRTM topographic database (USGS, 2006). Flooded areas outside the lake were digitized

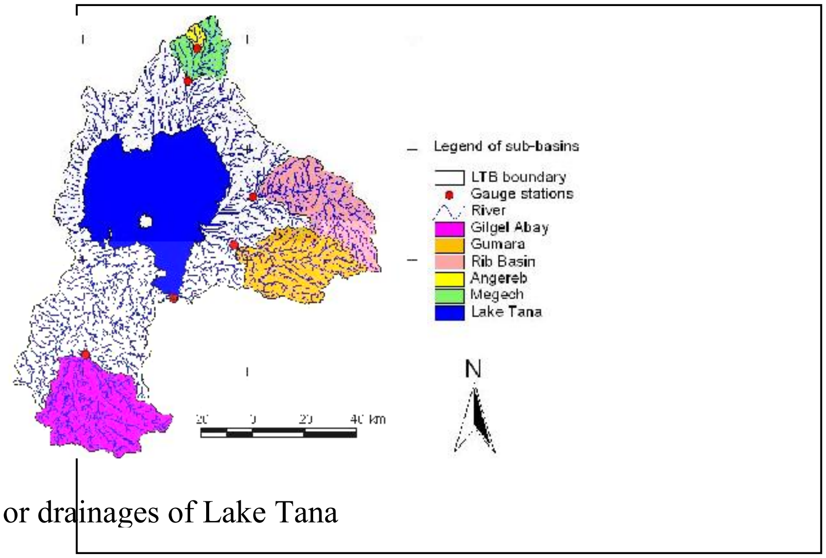


Figure 2: Rivers and drainage basins within the LTB derived from the SRTM DEM database with resolution of 90 metres (SRTM) (USGS, 2006)

3.2 Major wetlands of LTB and their changes

During the dry season, agricultural people in the LTB used wetlands for dry season grazing and growing low moisture demanding crops such as Chickpea and Grass pea (*Vicia desycarpa*) late in the season. However, with the ever-shortage to arable land, wetlands are further threatened by draining their water for early cereal cropping. Since the topographical situation of wetlands is usually plain and sediment deposition, traditional irrigation system exploits the water very easily. Traditionally, these places are known as *'Bahire-shesh',* which means that farmlands the moisture which can support second cropping late in the season.

Ecological and economic functions and/or benefits of wetlands need to be recognized and widespread. They serve a buffering purpose for the perpetuation of both the water bodies downstream by absorbing various non-point source pollutants and sediments before reaching reservoirs. Speed of runoff will get lower; because of the slope of the lower plain and thick biomass effects of the wetlands. Lake Tana being surrounded by plain and wetlands is an opportunity to the lifespan of the lake and its economic and ecological functions, which otherwise could have been silted up by the agricultural soils that annually trapped in the surrounding plain and wetlands. In this regard, despite the serious land use changes, LTB is endowed with wetlands that cover about 159,800 ha of land (Table 1).

Wetlands of LTB are more of the fluvial type, which receive their water largely from surface runoff and streams. Being *fluvial wetlands* and richness of the basin with surface runoff and precipitation, in turn, make the wetlands more resilient. However, the problem remains for so long is that people perceive wetlands as a place of breeding malaria and other tropical diseases.

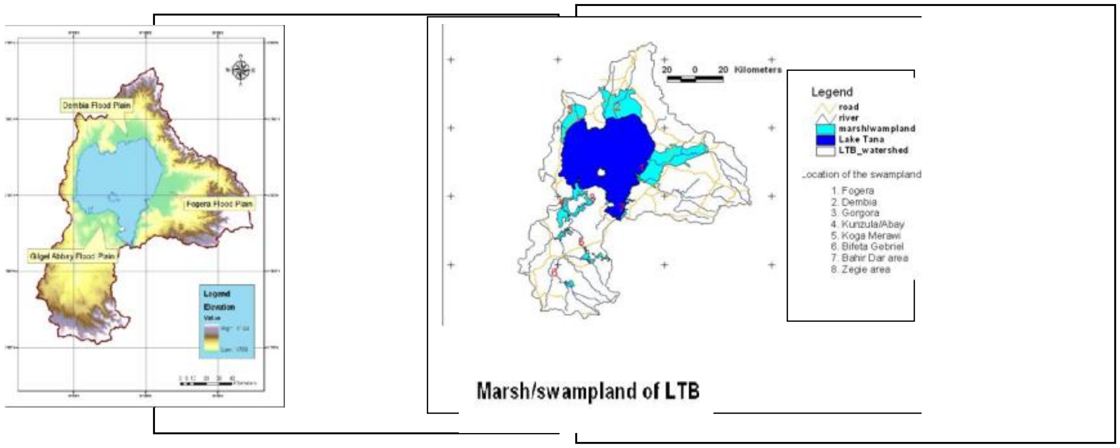


Figure 3: Wetlands and flood plains of the LTB situated across the basin that are currently seriously converted into croplands and grazing lands (Source: digitized from Landsat images (using etm+ image 169/52 for 01 Oct 1999, image 170/51 for 01 Nov 1999 and image 170/52 for 01 Feb 2001)

Fogera Floodplain: Flooding in the Fogera plain is caused by:

- bank overflow from the Ribb and Gumara rivers
- runoff from local rivers that end in depressions
- direct rainfall

Based on the main cause of inundation, the Fogera plain can be divided into three major zones: the upper, middle and lower zones. ***The upper Floodplain zone*** is mainly caused by spill from the Ribb river and a number of smaller tributaries, including the Sheni. In this area the floodwater does not stay long and it was observed to disappear at times even in 3 or 4 days. Most of the flood water quickly drains back to the river and from there to the lake. ***The middle Floodplain zone*** of the Fogera flood plain is the area where the Shesher and Welela Ponds are located in depressions. The major causes of flooding in this area are the local rainfall and the small local streams that end in these wetland areas. During large floods in the Upper and Lower Flood zones, there is additional spill from these zones into this area. Since this area does not have an outlet either to the lake or to the rivers, the flood water stays for a longer period and is mainly depleted through evaporation in the dry season. ***The lower Floodplain zone*** of the Fogera plain is mainly caused by spill from the Gumara River. Especially, the left bank of the river is prone to overflow but also spills over the right bank are observed, which sometimes join the inundated area in the Middle zone. The total maximum inundation area in three zones of the Fogera plain reached 597 km2 in 1999, whereas it was reported by the Tana-Beles study about 333.6 km2 for the 8-day average in 2003.

Dembia Flood Plain

In the Dembia floodplain, flooding occurs mostly in the lower part of the Megech, Dirma and Shenzli rivers (Figure 3). The maximum inundated area of the Dembia and Gorgora floodplain during the period in 1999 was about 459 km2 (Table 1).

Table 1: Wetlands of the Lake Tana Basin

No.	Location of swampland	Sub-basin	Area (ha)	Source: TM Landsat image
1	Fogera	Rib and Gumara	59700	169/52,01-10-99
2	Dembia	Megech	45900	170/51,01-10-99
3	Gorgora		21000	170/51,01-10-99
4	Kunzula-Abay	Gilgel Abbay	22800	170/52,01-02-01
5	Koga dam site	Koga River	5400	170/52,01-02-01
6	Bifeta Gebriel	Gilgel Abbay	1900	170/52,01-02-01
7	Bahir Dar Lakeshores	Lake Tana bay	2200	170/52,01-02-01
8	Zegie Lakeshores	Tana Shore	900	170/52,01-02-01
	Total		159,800	
9	Lake Tana	Water body	302,676	170/52,01-02-01
Grand Total			462,476	

Gilgel Abbay and Koga flood plains

In Gilgel Abbay and Koga area the flooding occurs in some flat plains along the rivers Gigel Abbay and Koga in the southern part of the Lake Tana. According to the Tana Beles report (SMEC International, 2008), some flood plains of Istumit district was considered. The flooding along the Gilgel Abbay is essentially caused by bank overflow from the Gilgel Abbay. The maximum area of inundation in the Gilgel Abbay and Koga floodplains was about 282 km2. Excluding the wetland of Bifeta-Gebriel and Koga Dam site, the Tana-Beles study report gave about 64 km2 occurred in 2006. However, starting from the wetland of Bifeta Gebriel at the foot of Gish Abbay highlands, there are a number of small wetlands along the River of Gilgel Abbay until it joins Istumit and Lake Tana.

There are also wetlands around Bahr Dar and areas away from the course of the major rivers, which accounted for about 22 km2. Thus, the LTB has a total wetland and floodplain areas of about 1,598 km2 or 11.9% of the area of LTB.

3.3 Major problems of the wetlands of LTB

The extended plain and wetlands in the north and north-east that connect the lake with the subsequent foot-slopes were intact until very recently and covered with dense grasses, sedges and shrubs that are typical of riparian vegetations. Since the largest part of the plain surrounding the lake has little altitudinal differences (about 10-15 m high) from the level of the lake, seasonal floods put these lands under water cover for some time after the rainy season, which made the area less important for main season cropping for so long. The other reason that could have kept the plain intact for so long might be the problem of malaria infestation of the place and the long existing fear of the highlanders to live in such hostile environment. According to some study reports (LURD of MoA, 1982), the eastern and northern swamplands were about 85 percent grassland before the 1980s. It is, thus, understood that the observed LUCCs in the lower plain area of the LTB, in the last 20 years, was largely attributed to the cultivation of the wetlands of the Fogera and Dembia plains. Even though it is difficult to clearly differentiate the wetlands under cultivation and areas uncultivated from the landsat images, our filed observation for the Fogera plain in 2005 confirmed that little or no land left uncultivated. In place of the wetland vegetation, invasive weeds were seen invaded the field.

The lake is one of the largest coverage of the physiographic units of the basin, which accounts for 20.32% of the basin area (Figure 4). The expansion of Bahr Dar City and the accompanied effluents, upstream land management practices, and lack of responsible institutions for the management and protection of the lake are some of the shortfalls. The sediment concentration of rivers flowing to the lake is also estimated at about 3.10 g/litre of runoff with the coefficients of the annual runoff of the rivers flowing to the lake varying from 14% to 53% (on average about 35%); thus, the total annual sediment yield reaching the wetlands and the lake system was estimated at about 9 - 15 million tons of soil per annum (Birru, 2007). Much of the sediments that have hitherto been trapped, because of the intact vegetation cover of the wetlands are now expected to pass to the lake water due to the fact that much of the wetlands are converted to crop cultivation and due to the loss of the riparian vegetation that would have been protected the lake from sedimentation and pollution. Thus, with the expansion of cultivated agriculture into the wetlands, ecological functions such as the loss of biodiversity and habitats and the loss of capacity of the wetlands to absorb the incoming sediments and pollutants are some of the problems encountered the unit.

The swamplands or wetlands in the LTB include landscapes that are seasonally flooded and lands that remain wet for a long time in the year. The land use/cover analysis revealed that the wetland or swampland is the one that is seriously threatened due to the recent expansion of crop cultivation; in the last 15 years, about 17.4% of the wetlands were converted to drained crop cultivation. On the other hand, this does not mean that the remaining wetlands are intact; rather, at present little or no swampy land is left uncultivated. Very recently, the expansion of paddy rice production in the north and north-east of the lake and irrigation-based vegetable production has attracted much attention of the farmers and the various state agents to exert unprecedented pressures on the wetlands of the basin. Thus, about 85% of the wetland and flood plains in the basin is used for intensive agriculture.

Figure 47: Major physiographic units of geomorphology, DEM, hydrol

LTB are arbitrarily divided into two zones: the first zone comprises the riverine systems that are situated in the higher topographies (>8% slopes), whereas the second comprises those found the lower topographies (<8%). Riverine systems in the mountain and foot-slope areas are the most erosion-prone places while their filter strips are removed as a result of expansion of crop cultivation and traditional irrigation cropping. The rivers, after leaving the rolling topography still serve as habitats to diverse species of flora and fauna and are sources of converged and voluminous water relevant for large scale irrigation and industrial purposes.

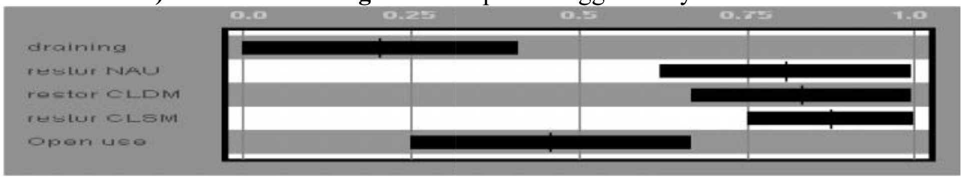
Responses of riverine ecosystems to the increasing human pressure should not be equally important in all the topographical units along the river course; deforestation of riverine vegetation and conversion of the landscape into crop cultivation were found to be serious at steeper slopes, which resulted into serious riverbank erosion and downstream flood hazards. At the present condition, no riverine system in the LTB, except for some inaccessible gorges, is covered by vegetation.

After identifying the states of land resources and the problems of degradation of the individual physiographic units, the units were further evaluated for the various degradation indicators. The indicators were: physical soil loss, in-situ nutrient depletion, pollution, loss of moisture and/or water, loss of vegetation cover or organic accumulation, loss of biodiversity, and impacts of sedimentation or siltation. As a result, the least scores were obtained for the Lake Tana and the swampy lands of the basin; however, both of them are at risk of the ever-intensifying agricultural land management upstream and the growing requirements of water for irrigation and other development interventions. The physiographic units of the LTB were grouped into four degradation contexts: (i) land units extremely prone to most of the degradation indicators (≥75%) that includes the mountain escarpments and riverine systems; (ii) land units highly prone to the degradation (50-75%), which include foot-slopes and the undulating highland plateaus; (iii) land units moderately prone to the degradation (25-50%) were those that are limited to the lower plateaus; and (iv) less prone (10-25%) are those that include the swamplands, the lake and the mountain foothills (bottom lands). However, classifying the LTB into these four degradation contexts does not imply that physiographic units that were at the extremely prone to degradation are the priority units for management interventions. On the other hand, degradation of some land resources may not have yet reached critical stages to feel the effects, but this does not mean that land resources are not in a state of degradation.

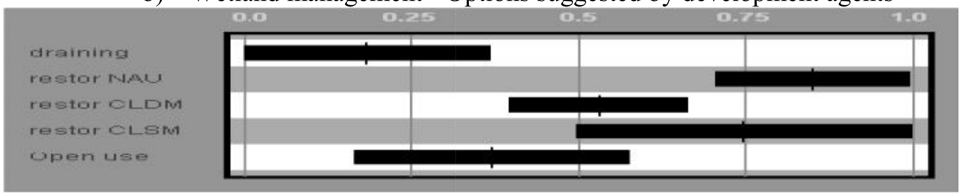
3.4 Options for the sustainable management of the wetlands of the LTB

There was a sensitization workshop held in Bahr Dar, Amhara Region (23rd January 2001) that tried to address the neglected resource – wetlands and their states and dynamics in the Region. Comparative economic advantage of utilizing wetlands in their natural and intact state was highlighted than converting them into drained crop and livestock grazing for short-term economic benefits.

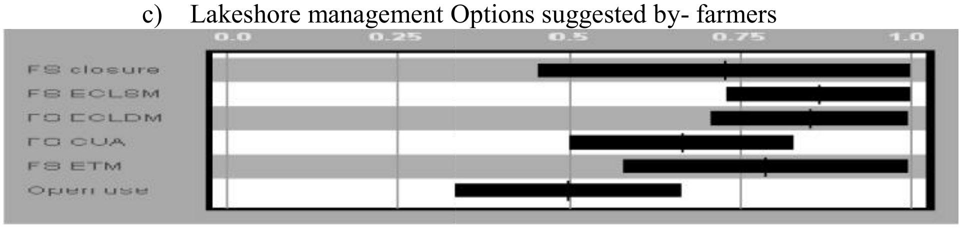
a) **Wetland management -** Options suggested by farmers



b) Wetland management - Options suggested by development agents



c) Lakeshore management Options suggested by- farmers



d) Lakeshore management - Options suggested by development agents

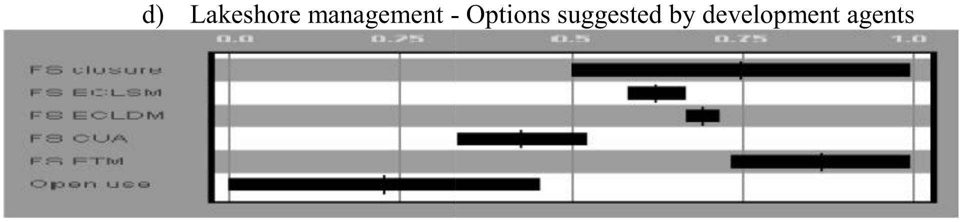


Figure 68: SLM[4] appraisals for the different physiographic units of the LTB; a and b are on the management of wetlands by farmers and development experts, and c and d are on the management of the lakeshore areas, respectively. The unit with which the individual management practice is measured in percentage

The key elements for sustainable wetland use include (Wood et al., 1998):

- only partial drainage, not draining the whole area,

[4] ***Wetland management***: NAU stands for restoring the filter strips with closure and regulated use access, CLSM for enriched closure with crop-livestock managed under the same land unit, CLDM for closure with crop-livestock managed separately. ***Lakeshore management***: FS CUS/A stands for filter strips managed under closure with regulated use access, FS ETM is for filter strips managed under eco-tourism, ECLSM for enriched closure with crop-livestock managed under the same land, ECLDM for enriched closure with crop-livestock managed separately

- maintaining areas of natural swamp vegetation within the wetland, especially at the head so it acts as a reservoir,
- maintaining areas of natural swamp at the outlet to prevent down-cutting and lowering of the water table,
- limiting drain depth and blocking of drains to retain water,
- protecting springs with areas of natural vegetation,
- use of taro or other water tolerant plants,
- maintaining well-vegetated catchments,
- fallowing with the natural vegetation to maintain soil structure and fertility,
- recreating the annual flooding – to maintain the natural hydrological cycle, and
- Control of cattle grazing, especially in the wet season.

In addition, the sustainable management of wetlands must consider economic and social benefits of the society in question. There are specific and positive economic potentials of wetlands by maintaining a tolerable ecological disturbance.

Hydrological degradation of the LTB includes increasing loss of runoffs, high runoff coefficients, and poor availability of water for the dry season irrigation, expansion of crop cultivation into swamplands, riverine systems and lakeshores. The fluctuating water volume of reservoirs and the increased sediment concentration along with discharges of the rivers are also indicators of the unsustainability of the land management systems/practices upstream, along riverine landscapes, and lakeshores.

Stopping cultivation on the steeply sloping mountains and land areas deep into riverbanks and enriching these with appropriate plant species would improve infiltration and allow safe runoff and sustainable discharges of rivers and streams in the basin. The sustainable management of the riparian systems is also possible by protecting the ecosystems of the wetlands and the lakeshores from loss of their natural flora and fauna, from conversion into other land uses, mostly into intensive crop cultivation and intensive grazing, and from the effects of sedimentation. This does not mean that the riparian areas should necessarily be kept for ecological purposes alone; rather, economic benefits need to be maintained by growing woody vegetation integrated with perennial fodder grasses. Of the potentials of the lower riparian region of the LTB (the lakeshores and the surrounding wetlands), perennial crops including coffee, fruit trees, timber production, pasture hay, eco-tourism, etc. can be mentioned.

In addition to planning the appropriate buffer strips, management requirements of riverine lands, wetlands, and lakeshores of the basin were assessed by a group of farmers and development experts using the MODSS model (Figure 6&7). As far as the management of wetlands is concerned, both farmers and development agents were least interested in the practice of draining excess water and the open access use of wetlands (Figure 6a and 6b,

Table 2: Sum of the Pair-wise Ranking (SPR) and weighted values (wt) of the evaluation criteria used in the appraisals of land management systems for the wetlands

Basic criteria	Desired impact	Farmers' group		Development agents	
		SPR	Wt	SPR	Wt
Ground water table	Maximize	3	0.96	9	2.80
Pollution effects	Minimize	7	2.24	10	3.11
Biodiversity	Maximize	4	1.28	7	2.17
Habitat preservation	Maximize	0	0.00	5	1.55
Initial cost	Minimize	4	1.28	3	0.93
Economic benefit	Maximize	10	3.21	4	1.24
Livelihood option	Maximize	9	2.88	6	1.86
Short-term shocks	Minimize	8	2.56	8	2.48
Land loss	Minimize	9	2.88	9	2.80
Aesthetic value	Maximize	1	0.32	2	0.62
Simplicity	Maximize	4	1.28	0	0.00
Risk	Minimize	5	1.60	1	0.31

Table 3: Sum of the Pair-wise Ranking (SPR) and weighted values (wt) of the evaluation criteria used in the appraisals of land management systems for the lakeshores

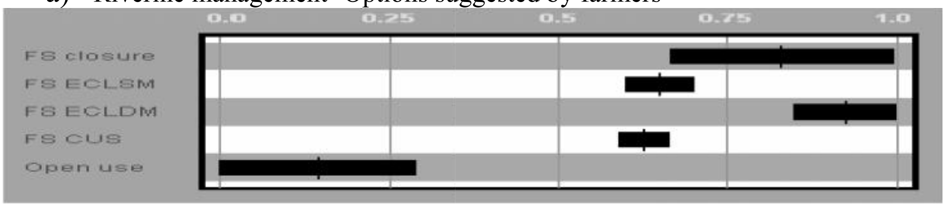
Basic criteria	Desired impact	Farmers' group		Development agents	
		SPR	Wt	SPR	Wt
Shoreline stability	Maximize	8	2.76	9	2.99
Pollution/sediment	Minimize	5	1.72	10	3.32
Biodiversity	Maximize	3	1.03	8	2.66
Habitat preservation	Maximize	6	2.07	7	2.33
Initial cost	Minimize	7	2.41	5	1.66
Economic benefit	Maximize	4	1.38	6	1.99
Livelihood option	Maximize	2	0.69	3	1.00
Short-term shocks	Minimize	9	3.10	4	1.33
Land loss	Minimize	10	3.45	6	1.99
Aesthetic value	Maximize	5	1.72	1	0.33
Simplicity	Maximize	1	0.34	1	0.33
Risk	Minimize	1	0.34	1	0.33

respectively). The group of farmers gave more emphasis to the economic objectives unlike the group of development agents, who were more interested in ecological objectives to be supported by the management options (Table 2). On the other hand, despite the wide variation between the farmers' and the researchers' groups requiring the desired impacts of the evaluation criteria (Table 3), during the assessment of the management options for the lakeshore systems, both groups believed in all the alternatives except for the open access use of the resource (Figures 6 c&d).

Furthermore, the sustainable management of hydrological and the riparian systems of the LTB require a holistic approach that may include improving the retention of rainwater in all the landscapes and land use types and the system of water balancing in the use of the water resources for various purposes. This is because, as a result of water consumption for varieties economic activities around the lake and due to much water was drained from the

Lake to satisfy the new hydropower plant (Tis Abbay hydro-electric power II), about one-third of the volume of the Lake Tana water was depleted and serious shocks were felt on the various functions of the lake. Similarly, the two major rivers of the LTB, namely, Gumara and Ribb, completely dried up in 2004 and 2005 as a result of widespread use of irrigation cropping (more than 300 pumps were installed along these rivers).

a) Riverine management- Options suggested by farmers



b) Riverine management- Options suggested by development agents

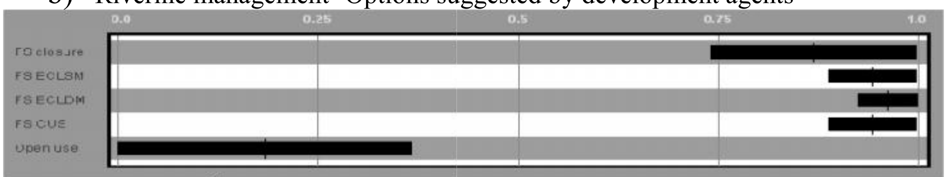


Figure 79: SLM [5] appraisals for the different physiographic units of the LTB; a and b are on the management of riverine systems by farmers and development experts. The unit with which the individual management practice is measured is a percentage

Table 4: Sum of the Pair-wise Ranking (SPR) and weighted values (wt) of the evaluation criteria used in the appraisals of land management systems for the riverine landscapes

Basic criteria	Desired impact	Farmers' group		Development agents	
		SPR	Wt	SPR	Wt
Soil conservation	Maximize	7	2.02	6	1.97
River bank stability	Maximize	9	2.59	11	3.61
Runoff effects	Minimize	8	2.31	10	3.28
Biodiversity	Maximize	1	0.29	2	0.66
Habitat preservation	Maximize	1	0.29	5	1.64
Initial cost	Minimize	6	1.73	6	1.97
Offsite impact	Minimize	5	1.44	6	1.97
Onsite impact	Minimize	11	3.17	6	1.97
Short-term shocks	Maximize	10	2.88	8	2.62
Land loss	Minimize	9	2.59	8	2.62
Aesthetic value	Maximize	1	0.29	0	0.00
Simplicity	Maximize	3	0.86	2	0.66
Risk	Minimize	3	0.86	4	1.31

[5] ***Riverine land management***: FS stands for filter strip, ECLSM for enriched closure with crop-livestock managed under the same land, ECLDM for enriched closure with crop-livestock managed separately and FS CUS for closed filter strips managed under private use access.

Of the list of management options, the farmers' group were more interested in the use of filter strips enriched with perennial-based crop-livestock production with the crop and the livestock managed in different land units (FS ECLD) (Figure 7a). In the process of evaluation, priority objectives of the farmers were found to be minimizing on-site negative impacts and economic shocks in the short-term (Table 4). On the reverse, the development agents were more interested in ecological objectives such as managing runoff effects and maintaining stability of riverbanks (Figure 7b).

Conclusions

Traditionally, the wetlands in Ethiopia are considered as problematic lands such as swap lands as a harbor to malaria; rivers as harboring of crop pests such as birds and wild beasts. However, with the ever increasing human population and the intensified demand for food grain, more riparian lands are recently converted into intensive cropping. As a result, the natural habitat of lakeshores, wetlands and riverine ecosystems have been seriously damaged and their land uses permanently converted. Apart from the loss of the main resources (riparian vegetation, water, biodiversity and habitats), there are interlinked and externalized consequences due to the degradation of these environments through loss of soils from the destabilized riverbanks, frequent flood occurrence, drying of streams, sedimentation and pollution of reservoirs downstream. Since the sustainable management of wetlands in the Lake Tana Basin (LTB) is the attribute of complex combination of ecological, economic and social objectives, a participation of multiple stakeholders in a transdisciplinary research approach is found to be a priori. A use regime is also required to be developed that ensures the fullest range of benefits for the local community in a framework that also maintains the sustainable functions of the wetlands.

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