Threats to Inland Water Ecosystems in the Lake Victoria Basin – A Review in Relation To Water Resources Management Planning

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Abstract

The Lake Victoria Basin (LVB) spreads over the 5 countries of the East African Community: Burundi, Kenya, Rwanda, Tanzania and Uganda. Inland water systems in the LVB include habitats such as lakes and rivers, marshes, swamps and floodplains, small streams, ponds, and cave waters, and have a temporal dimension – varying from perennial to ephemeral – and a dynamic dimension, including flowing systems, standing waters, and systems with at times large seasonal fluctuations in water depth. The ecosystem represents approximately 11% of the LVB, excluding Lake Victoria itself. The study aimed to assess the major threats to the inland water ecosystems of the basin, focused on the threats to the ecosystem vis-à-vis their future contribution to the quantity and quality of water in the basin as it was part of a preliminary study leading to the formulation of a water resource management plan for the LVB. It involved mainly document review and limited field observations. The major current threats were found to be Forest clearing, Agricultural expansion, and Urban and industrial pollution, all driven by a rapidly expanding, poor population. The study concluded that poverty was the defining driver, and that reducing environmental degradation requires a global integrated approach targeting poverty: it is clear that any effort in reducing ecosystems degradation may be nullified in the medium-term if it is not accompanied by a reduction in the growth of the population using agricultural land. This could be achieved by a global reduction in population growth rate and/or by providing alternative sources of livelihoods (mainly off-farms activities) to the population. Without this the quality of the basin‘s waters and livelihoods will be in jeopardy.

Key Words: Lake Victoria Basin, Inland Water Ecosystems, Ecosystem Threats, Wetlands

INTRODUCTION

Inland water systems in the Lake Victoria Basin (LVB) include habitats such as lakes and rivers, marshes, swamps and floodplains, small streams, ponds, and cave waters. In this paper, for simplification, inland waters are regrouped into rivers and lakes on the one hand and ―wetlands[1]‖ on the other, which as used here includes marshes, swamps and floodplains (LVBC-b, 2014).

[1] The term ―wetland‖ is sometimes used to define all inland aquatic systems, such as lakes, rivers, or lagoons. In this study, it is used to describe a narrower group of habitats that represent a variety of shallow, vegetated systems, such as bogs, marshes, swamps, and floodplains.

Inland water systems have a temporal dimension – varying from perennial to ephemeral – and a dynamic dimension, including flowing systems (rivers), standing waters (lakes and ponds), and systems with at times large seasonal fluctuations in water depth – with some being waterlogged and others flooded permanently, seasonally, intermittently, or even episodically (LVBC-b, 2014).

The inland water ecosystem represents approximately 11% of the Lake Victoria Basin (≈22,300km^2) excluding Lake Victoria itself (LVBC-c, 2014). These ecosystems are, of course, very important in relation to water resources management as emphasized by UNEP (2005):

- ***In hydrological regulation***. Some inland waters serve as important storage sites, accumulating water during wet periods and thereby providing a reserve of water during dry periods that maintain base flow in adjacent rivers; and attenuating floods and thus reducing the need for engineered flood control infrastructure.
- ***Sediment retention and water purification***. In addition to retaining sediments, the vegetation in some inland water systems remove high levels of nutrients, especially phosphorus and nitrogen, commonly associated with agricultural runoff, which could otherwise result in eutrophication of receiving ground, surface, and coastal waters. For example, Arcadis Euroconsult (2001) found that vegetation along the edge of Lake Victoria have a phosphorus retention of 60–92%. The capacity of many wetland plants to remove pollutants derived from chemical or industrial discharges and mining activities is well established and increasingly used as a passive treatment process in the so-called constructed wetlands.
- ***Recharge/discharge of groundwater***. Most wetlands in the LVB are fed by surface water and recharge of the aquifer during flooding periods. As the LVB ground is relatively watertight (clay) (LVBC-c, 2014) the groundwater recharge largely concern alluvial groundwaters, which are subsequently also key for hydrological regulation, water purification and water uses (potable water abstractions).
- ***Climate change mitigation***. Inland water systems play two critical roles in mitigating the effects of climate change: the regulation of greenhouse gases (especially carbon dioxide) and the physical buffering of climate change impacts. They have been identified as significant sinks of carbon as well as sources of carbon dioxide, as net sequesters of organic carbon in sediments, and as transporters of carbon to the sea.
- ***Water uses***. Including irrigation, fisheries, water supply, sanitation, navigation, recreation and tourism, cultural value, use of wetland products, etc.

This study focused on identifying threats to this ecosystem with regard to its long-term contribution to the quantity and quality of water in the Lake Victoria Basin. It was part of a larger study on threats to the LVB ecosystems *vis-à-vis* their future contribution to the quantity and quality of water in the LVB to inform development of a water resources management plan.

MATERIALS AND METHODS

The area of study (Fig. 1) is all of the Lake Victoria Basin, spread over the 5 countries of the East African Community: Burundi, Kenya, Rwanda, Tanzania and Uganda. The basin is bordered to the east by the western rim of the Great Rift Valley in Kenya and Tanzania, and to the west by the eastern rim of the Western Rift Valley, which defines the Nile River/Congo River water divide. The southern and northern boundaries of the basin are not as well defined by prominent geomorphological features. The basin is very narrow in the low-relief south-central Uganda area (Entebbe-Kampala-Jinja area) which also provides the only surface outlet for Lake Victoria at Jinja-River Nile. The terrestrial area of the basin, excluding Lake Victoria itself, measures approximately 197,700 square kilometers, and the lake occupies an area of approximately 66,800 square kilometers, with a shoreline of approximately 3,450 km. The Lake Victoria Basin lies astride the equator, stretching from latitudes 01º15‘N to 04º05‘S, and longitudes 29º20‘E to 35º55‘E. The Lake Victoria Basin consists of 19 major river sub-basins identified here with their major rivers (LVBC-c, 2014) (Fig 1; Table 1).

The basin encompasses a variety of climates, including cool, humid temperate tropical highland climate, moist sub-humid highlands, and the warmer tropical dry sub-humid climates in the lower altitudes of the basin to the south and southeast. The average shoreline altitude of Lake Victoria is located at 1,133masl. Average annual rainfall in the basin varies from less than 500mm in the south-eastern end of the basin to more than 2000 mm on the mountains on the eastern and western rims (LVBC-c, 2014). The predominant land use in the basin is agriculture (food-crop cultivation and livestock keeping), mainly of subsistence variety.

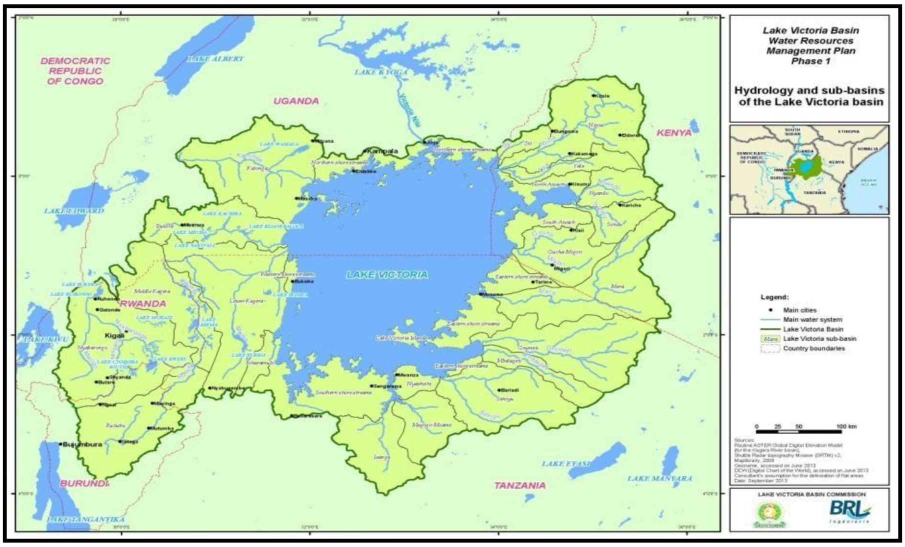

Fig 1. River sub-basins of the Lake Victoria Basin Source: Task C report (LVBC-c)

In methodology, the study involved mainly document review, internet research and limited field observations, assessing the major threats to the inland water ecosystems of the basin. As mentioned earlier, it was focused on the threats to the ecosystem *vis-à-vis*their future contribution to the quantity and quality of water in the basin as it was part of a preliminary study leading to the formulation of a water resource management plan for the LVB. The data collected was tabulated and collated according to identified ecosystems and river basins. Prior experience of the authors with some of the river basins in previous studies also contributed greatly to this study.

RESULTS AND FINDINGS

LVB Rivers and Lakes Ecosystems

The rivers ecosystems. The LVB river ecosystems include the numerous rivers in the basin that ultimately reach Lake Victoria (Fig 1; Table 1). Most of them are part of the 19 LVB main sub-basins, namely: Biharamulo, Isanga, Magogo-Moame, Nyashishi, Simiyu, Mbalageti, Grumeti, Mara, Gucha-Migori (also called Kuja), South Awach, Sondu, Nyando, North Awach, Yala, Nzoia, Sio, Katonga, Bukora and Kagera (divided into 4 sub-basins for this study – Lower Kagera, Middle Kagera, Nyabarongo and Ruvubu) (Table 1). The catchments of the rivers range in area from 640km^2 of the western shore streams in the Tanzania/Uganda border area to more than 18,000km^2 of the Nyabarongo catchment which spreads over four countries (Table 1). Some of the sub-basins are transboundary.

The common threats to river systems include the following:
Forest clearing: This increases the susceptibility of river catchments to high rates of soil erosion, especially if the catchment, or part of it, consists of steep, mountainous topography. With decreased gradient downriver, high levels of sediment deposition is also experienced. In the LVB, this threat is strongly manifested in the catchment of Mara River, especially in the upper catchment, and throughout the Nyabarongo catchment. It is also evident in the Sondu, Nyando, Yala and Nzoia river catchments; the Sondu River has built a depositional delta at its mouth as a result of high sediment loads.

Fig. 2. Land fragmentation and cultivation on steep slopes in the Nyabarongo sub-basin, Rwanda. Source: Gunya (2009)

Agricultural expansion: This is often achieved by converting natural inland systems to cultivated landscapes. It reduces both terrestrial and aquatic biodiversity and natural flood control functions of rivers. When accompanied by intensive use of agrochemicals, pollution effects can be extensive. In the LVB, an estimated 13.9 million hectares, or more than 70% of the terrestrial area of the basin, is under cultivation (crops and pasture) (LVBC-b, 2014), which means that a very large proportion of the LVB is exposed to accelerated erosion especially as the majority of the cultivation is subsistence agriculture, with no soil conservation measures. Mathayo *et al.* (2006) estimated the suspended sediment load to the Lake Victoria from the Tanzanian catchment (excluding Kagera River) to be 4,905.2kT/year, with Simiyu River carrying the largest suspended sediment load, estimated at about 42.3% of the total load to the Lake. Myanza *et al.* (2006) estimated the suspended sediment load of the Kagera River to be 1,400kT/year (Fig.1). In the Kenyan catchment, Okungu and Opango (2006) reported that ten rivers contributed 4,390.6kT/yr of total suspended solids, with river Nzoia contributing the highest at 2,504.4kT/year to the lake. Other Kenyan rivers (Gucha/Migori, Sondu, and Yala) were also found to carry substantial suspended sediments into the lake. River Nzoia hasalso been shown to carry substantial amounts of pesticides (*Organochlorines* and *Pyrethroids*) into the lake (Tarus *et al.*, 2011).

Urban and industrial pollution: When solid and liquid wastes and industrial effluents are released into aquatic environments the water quality is often greatly reduced, in turn affecting the diversity and abundance of aquatic organisms as well as human health. In the Kenyan LVB, Okungu and Opango (2006) found that the ten rivers carried 12,193 T/yr of Nitrogen and 2,113 T/yr of Phosphorus into the lake, again with river Nzoia carrying the bulk at4,820 T/yr N- and 1,365 T/year P-. They also reported substantial amounts of Silicon at 140,849 T/yr, with Nzoia accounting for 58,386 T/yr and Gucha/Migori 35,440 T/yr. Myanza *et al.* (2006) estimated that the Kagera discharged 16,357N T/yr and 2238.5P T/yr into Lake Victoria, while the Simiyu River discharged 1695.6N T/yr and 1904.4P T/yr. They also reported a high discharge of 1645.9N T/yr for Mara River.

Major LVB rivers currently affected most by industrial pollution include Nzoia river, through Pan Paper Mills in Webuye, Mumias Sugar Company and others (Akali *et al.*, 2011; Achoka, 1998; Davies, 1996); Nyando river, through several sugar factories, (Awiti *et al.*, 2004, Raburu and Okeyo-Owuor, 2002); Nyabarongo river, especially various types of industrial pollution from Kigali and other urban areas (Gasana *et al.*, 1997; Marie-Brigitte, 2012; Nhapi *et al.*, 2012; Etale & Drake, 2013). In Tanzania the Mara river is carrying the burden of wastes (sometimes toxic) of the Mara North Gold Mine such as mine tailing spills (Esri, 2014; Kisamo, 2003); and the Simiyu river carries a variety of industrial effluent from the numerous agribusiness investment in the catchment (Anonymous, 2012; GURT, 2012). COWI (2002) reported a total number of 68 major industries in the LVB causing industrial pollution in the catchment (16 in Kenya, 34 in Tanzania and 18 in Uganda) discharging an estimated annual load of 5,606 T/yr BOD, 414 T/yr N and 342 T/yr P into Lake Victoria. A more recent estimate (LVBC-c 2014) has reported 4,300 T/yr TN and 1,690 T/yr TP from point source, indicating significant increase.

Large-scale irrigation and river diversions: These alter natural flow regimes and reduce downstream water availability for agriculture and other uses. Currently there are few formal irrigation schemes of more than 500ha (Yala, Nyando, and Nzoia sub-basins) in the LVB however, there are at least 34 planned formal irrigation schemes of more than 1,000ha in the basin (LVBC-f, 2014) and therefore this will be a relevant source of threat to river ecosystems in the future.

Roads and flood control infrastructure: These interrupt river and wetland connectivity, disrupt aquatic habitat, and reduce the function of wetlands to remove pollutants and absorb floodwaters, potentially increasing the losses when flooding occurs. There are very ambitious plans for infrastructure (roads) improvement and expansion in all the countries of the LVB and this is therefore bound to be a significant threat to riverine ecosystems in the future.

Dams: These also interrupt the connectivity of river systems, disrupting fish migration and spawning and sometimes cause degradation of riverbed downstream of dam. Dams with large reservoirs also alter seasonal flood regimes and retain sediments needed to maintain the productivity of floodplain agriculture. Currently, there are 9 hydropower dams in the Lake Victoria basin of less than 5MW with another 3 planned; and fiveexisting hydropower plants of up to 80MW with another 10 planned (LVBC-f, 2014). The extent of disruption of river ecosystems in the basin by reservoirs of various capacities therefore will increase with time.

Table 1. Major river sub-basins of Lake Victoria Basin, their status and major threats. Source: modified from LVBC-c

River	Country(ies)	Catchment Area (km^2)	Major threats /status
Biharamulo	Tanzania	1,990	Increased cultivation in unprotected areas
Isanga	Tanzania	7,080	Low rainfall, high evapotranspiration, extended aridity, erosion
Magogo/Moame	Tanzania	5,400	Intense subsistence cultivation and erosion
Nyashishi	Tanzania	1,690	Urbanization, intense subsistence cultivation and erosion
Simiyu	Tanzania	11,100	Severe reduction in wetland coverage and increased subsistence and commercial cultivation (and human settlement) in unprotected areas
Mbalageti	Tanzania	3,540	Increasing population and subsistence cultivation in unprotected areas
Grumeti	Tanzania/Kenya	12,810	Increasing population and subsistence cultivation in unprotected areas
Mara	Tanzania	13,420	Upper Mara - severe threat of deforestation in the Mau forests, increased human settlement and conversion to agriculture will exacerbate the situation. Lower Mara - mine tailings spills and toxic effluent, increased population and subsistence cultivation in unprotected areas

Gucha/Migori	Kenya/Tanzania	6,730	Increased subsistence cultivation, which will b exacerbated with the planned large scale irrigation in lower Gucha
South Awach	Kenya	2,180	Increased population density and subsistence cultivation
Sondu	Kenya	3,530	Increased population density, subsistence cultivation and erosion
Nyando	Kenya	3,790	Industrial pollution and agricultural chemicals, expanding subsistence and irrigated cultivation
North Awach	Kenya	2,180	Increased population density, subsistence cultivation and erosion
Yala	Kenya	3,150	Agricultural chemicals, increased cultivation, and conversion of wetlands. Proposed large Nandi forest dam in upper catchment will alter natural flow.
Nzoia	Kenya	12,785	Industrial pollution and agricultural chemicals are important issues. Cultivation will continue to increase and planned dams will also interfer with natural flow.
Sio	Kenya/Uganda	1,440	Increased population and subsistence cultivation
Katonga	Uganda	15,060	Increased population and cultivation outside protected area
Bukora	Uganda	8,330	Intense cultivation in unprotected areas, increasing population density
Lower Kagera	Tanzania/ Uganda	16,930	Increasing population density, increased subsistence cultivation, erosion
Middle Kagera	Rwanda/ Tanzania/ Uganda	10,330	Dense population, subsistence cultivation on steep slopes, wetland conversion, erosion, riverbed sedimentation
Nyabarongo	Burundi/ Rwanda/ Tanzania/ Uganda	18,340	Dense population, subsistence cultivation on steep slopes, wetland conversion, erosion, riverbed sedimentation
Ruvubu	Burundi/ Tanzania	12,210	Increased population, subsistence cultivation on steep slopes, wetland conversion, erosion and riverbed sedimentation
Western shore streams	Tanzania/ Uganda	640	Agricultural chemicals
Southern shore streams	Tanzania	8,980	Increased population, intense subsistence cultivation, increased erosion
Eastern shore streams	Kenya/Tanzania	6,680	Increased population, intense subsistence cultivation, increased erosion
Northern shore streams	Uganda	4,260	Increased population, intense subsistence cultivation, increased erosion
Lake Victoria Islands	Kenya/Tanzania/U ganda	2,460	Increasing population density, deforestation, cultivation

The lakes ecosystems. The lakes ecosystems include of course the Lake Victoria itself, as well as about 50 satellite lakes: 15 in Uganda, 13 in the upper Kagera region (Rwanda and Burundi), 18 in the lower Kagera region (Rwanda and Tanzania), and about 4 in Kenya. There are also numerous small man-made reservoirs, as mentioned above (LVBC-f, 2014) built in the basin over the years. The larger lakes in the LVB include:

- Lake Wamala, in the Katonga sub-basin in Uganda, is around 150 km² large[2] and is completely surrounded by wetlands (Fig 3), and only seasonally drains towards Lake Victoria - the lake and its wetlands are closely associated with local cultural norms and beliefs and is therefore of traditional and cultural significance to the people of Buganda. It is a designated Ramsar site. There is increased cultivation and deforestation in its catchment (GOU, 2011).
- LakeNabugabo (40 km²), about 20 km east of Masaka and 4 km west of Lake Victoria, is surrounded by wetlands (approx. 220 km²) and is a designated Ramsar site because of its unique bird and aquatic resources (NEMA-Uganda, 2009).
- Lakes Mburo (12 km²), Nakivali (31 km²), Kachira (40 km²), Kijanebalola (42 km²), part of the Kijanebalola swamp complex in the Bukora sub-basin in Uganda.

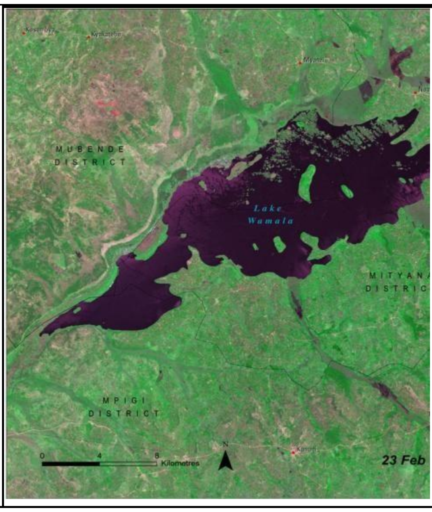

Figure 3. Lake Wamala, Uganda
Source:*http://www.na.unep.net/atlas/webatlas.php?id=391*

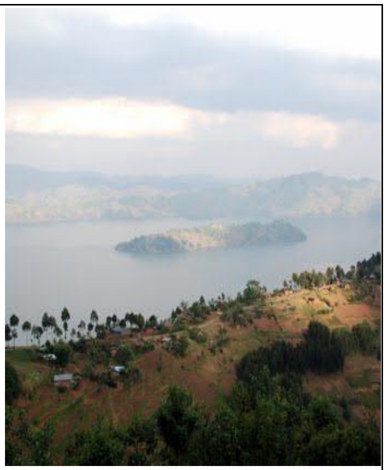

Fig 4. Lake Burera, Rwanda
Source: Newfarm 2010-Panoramio

- In the Middle Kagera sub-basin in Rwanda: Lakes Burera (35 km²) and Ruhondo (25 km²) which are connected and drain through Mukungwa into

[2] http://www.globalnature.org/29791/Living-Lakes/Regi%20onal-Networks/Network-East-%20Africa/Wamala/02_vorlage.asp

Nyabarongo River, and Lakes Muhazi (30 km^2) and Mugeseara (35k m^2), to the east and south-east respectively of Kigali.

- ❖ Lakes Rweru (102 km^2) and Cyohoha South (78 km^2) at the Rwanda/Burundi border in the Nyabarongo sub-basin.
- ❖ Lake Ihema (9.1 km^2), at the Rwanda/Tanzania border in the Middle Kagera sub-basin, which is in fact part of the numerous Kagera riverine wetlands system.
- ❖ Lake Kanyaboli (10.5 km^2) in Kenya, fed by the Yala/Nzoia sub-basins floods, as well as with Yala River waters by a man-made canal.

There are many other smaller satellite lakes in the LVB, particularly in the Kagera basin as a whole, including some essentially seasonal ones in the zone where River Kagera forms the Tanzania/Rwanda boundary. The list included here is not meant to be exhaustive.

Table 2. Major satellite lakes of Lake Victoria

Lake	Country(ies)	Approx Area (Km^2)	Threats/Status
Wamala	Uganda	250	Completely surrounded by wetlands, drains only seasonally towards Lake Victoria. The lake and its wetlands are closely associated with local cultural norms and beliefs, is therefore of traditional and cultural significance to the people of Buganda. Protected Ramsar site and thus ecologicallyBuganda sound, however increased cultivation and deforestation in the catchment is destabilising its status
Nabugabo	Uganda	40	Is a designated Ramsar site because of its unique flora and fauna and thus ecologically sound
Mburo-Nakivali	Uganda	33	Within Lake Mburo National Park and therefore ecologically sound because of its protected status
Kachira(40km^2), Nakivali(31km^2), Kijanebalola(42km)Mburo(12km^2)	Uganda	125	Kijanebalola swamp complex in the Bukora sub-basin. Mburo and Nakivali lakes are designated Ramsar sites for flora and fauna, which have reduced human pressure in the complex
Burera (35km^2) Ruhondo(25km^2)	Rwanda	60	Intensive cultivation in steep hills in catchment threatens future sustainability and health of lakes
Muhazi (30 km^2), Mugeseara (35k m^2),	‗‘	65	Intensive cultivation in steep hills in catchment threatens future sustainability and health of lakes
Rweru(102km^2), Cyohoha South (78km^2)	Rwanda/Burundi	180	Intensive cultivation in catchment in both countries, water hyacinth invasion
Ihema	Rwanda/Tanzania	9	Located in protected Akagera National Park and thus no human invasion
Kanyaboli	Kenya	11	Fish harvesting pressure, facing isolation from recharge with extended cultivation of the Yala swamp and future damming of River Nzoia

In summary, the major threats to riverine ecosystems and the Lake Victoria satellite lakes are associated with intense (mostly subsistence) cultivation, in some places on steep slopes and therefore increased sedimentation and, where they are not in protected areas, conversion of adjoining wetlands to agriculture. With increasing population density fish resource in the lakes will be more and more under increased pressure.

All the threats to riverine ecosystems, satellite lakes, and riverine wetlands translate in various measures to threats to Lake Victoria itself.

The wetlands ecosystems. Two major types of wetlands exist in the LVB: wetlands associated with satellite lakes and Lake Victoria itself, and riverine wetlands. Riverine wetlands are threatened mostly by conversion to agriculture, which has been particularly intensive in Rwanda and Burundi (middle Kagera and Ruvubu sub-basins), but has also become increasingly evident in Tanzania (Grumeti and Simiyu sub-basins). Infact, between 1973 and 1991 it was reported that the Simiyu wetland reduced by over47% and by 2010 more than 43% of the catchment was under cultivation (GURT, 2012). Riverine wetlands in Kenya are also being increasingly invaded (Nzoia, Yala and Nyando sub-basins) and turned into cultivated lands, (mostly subsistence, except for Yala swamp), and brick-making yards. Brick-making in riverine swamps is also a widespread activity in Uganda (Fig 4). Riverine wetlands in certain rivers, e.g. Nyabarongo in middle Kagera are under pressure from industrial and municipal wastes; while agricultural chemicals and their residues are significant in Nzoia (Tarus *et al*, 2011, Okungu and Opango, 2006) and Nyando (Raburu and Okeyo-Owuor, 2002). Some of the LakeVictoria wetlands are choking with liquid and solid wastes, in particular those ones near major urban areas (Kampala, Jinja, Mwanza, Kisumu and Musoma (Davies, 1996; Raburu, 2005; Muwanga & Barifaijo, 2006; ICRAF, 2006; Mkuula, 2006; Musamba *et al.*, 2011). Wetlands in protected areas generally retain ecological integrity. Unprotected wetlands in and around Lake Victoria are, however, under severe pressure as has been shown in a comprehensive list showing degree of human disturbance by LVBC (2011).

Source: New Vision, 2013 at
ttp://www.newvision.co.ug/news/641281-human-activity
chocking-uganda-s-wetlands.html.

Figure 5. Clay for making bricks is dug in a wetland at Kawanda in Uganda (LVB border)

Ranking threats. The threats to aquatic ecosystems in the LVBC were ranked in an effort to highlight the main hotspots which may require prioritization in future ameliorative actions in the basin. This is presented in Table 3.

Table 3. Matrix rankings of level of threat to aquatic ecosystems: **4** (highest, hotspot), **3** (high), **2** (moderate), **1** (low), and **/** (undetermined) of the various threats to each of the sub-basins

Threats / Sub-basin	Deforestation / devegetation	Wetland conversion	Agricultural chemicals	Nutrient loads	Soil erosion	Sedimentation	Municipal / Industrial waste loads	Eutrophication	Mining wastes	Population pressure	Dams
Biharamulo	1	1	/	1	1	/	/	/	/	1	1
Southern shore streams	3	3	/	2	2	2	/	/	/	1	1
Isanga	2	/	/	/	/	/	/	/	/	1	1
Magogo-Moame	2	2	/	/	/	2	1	/	/	3	1
Nyashishi	4	3	/	/	2	3	4	4	/	4	1
Simiyu	2	3	/	/	1	1	1	/	/	2	1
Eastern shore streams	2	4	/	/	/	/	2	2	/	2	1
Mbalageti	2	3	/	/	2	2	/	/	/	2	1
Grumeti	2	4	/	/	2	/	/	/	/	2	1
Mara	4	1	2	2	2	2	2	/	4	2	2
Gucha-Migori	2	4	2	2	2	3	2	/	2	4	2
South Awach	2	2	1	/	2	3	1	1	/	2	1
Sondu	2	2	1	/	2	2	/	3	/	3	1
Nyando	2	2	3	3	3	3	2	2	/	3	2
North Awach	2	/	/	/	/	/	4	4	1	3	1
Yala	2	2	2	2	3	3	2	/	/	3	2
Nzoia	2	2	2	3	3	3	2	2	/	3	2
Sio	/	/	/	/	/	2	/	/	/	3	2
Northern shore streams	3	/	/	4	/	/	4	4	/	4	1
Katonga	2	3	1	2	/	2	3	2	/	3	1
Bukora	2	2	1	/	/	2	3	/	/	2	1
Western shore streams	/	/	/	/	/	2	3	2	/	3	1
Lower Kagera	2	2	/	/	2	3	/	2	/	1	2
Middle Kagera	4	4	2	2	4	4	2	3	2	4	2
Nyabarongo	4	4	2	2	4	4	2	3	2	4	2
Ruvubu	4	4	2	2	4	4	2	3	2	4	2
Lake Victoria islands	2	/	/	/	/	/	/	2	/	2	1

How Can We Reconcile Development and Water Resources Conservation?

Given the climate, elevation and population distributions in the Lake Victoria Basin, the upstream ecosystems will have a major role to play in climate and flow regulation whereas the downstream ecosystems will have major role to play in water purification. All these ecosystems services will finally lead to a provision of a certain quantity and quality of water. Therefore the degradation of aquatic ecosystems (and, indeed all other ecosystems) of the LVB threatens the LVB water resources, occasioning negative impacts on climate regulation, river flow regulation, water purification, and ultimately water provision.

It is also important to note that the erosion issue is central to these ecosystems water services as less vegetation cover will lead to direct erosion as well as indirect erosion through more flooding events. Erosion will then have direct impacts on water quality, as well as indirect impacts on new ecosystems degradations through the vicious circle of poverty and ecosystems degradation as described below.

Ending the Complex Vicious Circle of Poverty and Ecosystems Degradation that Threatens the LVB Water Resources

The present environmental degradation in the LVB has its roots in poverty. The LVB countries are among the poorest in the world (LVBC-d, 2014). Their populations are heavily dependent upon the environmental resources for their daily subsistence and livelihoods. In situations of poverty and social insecurity, short-term survival prevails over medium- and long- term conservation goals. The unregulated use of these resources creates an unsustainable situation, leading to deforestation, soil erosion and land degradation, which in turn lead to decreases in land productivity, wildlife population decimations, and loss of biodiversity. The destruction of the natural resource base leads to greater impoverishment of the population, and perpetuates a vicious circle of poverty and ecosystems degradation as illustrated in Figures 6 and 7.

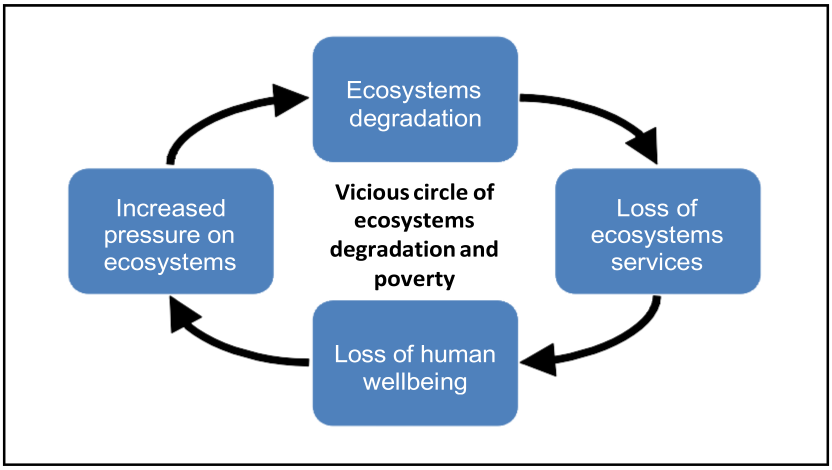

Figure 6. The vicious cycle of ecosystems degradation and poverty
Source: This study, inspired by Munang *et al.*, 2013

While not exhaustive, Figure 6 shows that it is possible to detail a lot in the LVB the various links between poverty and ecosystem degradation. It shows that many social, economic, institutional and environmental aspects contribute to the vicious circle of poverty and ecosystem degradations. This stresses notably that reversing the ecosystems degradations call for a global approach targeting poverty.

Thus, it is clear that reducing environmental degradation requires a global integrated approach targeting poverty. As the high population density is a key issue in the LVB, it is clear that any effort in reducing ecosystems degradation may be nullified in the medium-term if it is not accompanied by a reduction in the growth of the population using agricultural land. This could be achieved by a global reduction in population growth rate and/or by providing alternative sources of livelihoods (mainly off-farms activities) to the population.

Currently, a lack of control over resources, population growth, a lack of alternative avenues of livelihood, and inequity are all contributing to the degradation of the region's resources. In turn, environmental degradation perpetuates poverty, as the poorest attempt to survive on a diminishing resource base (LVBC-d, 2014). The following three steps will be inevitable: (i) reducing the rate of population growth - no reduction in population growth rate will definitely lead to a land crisis; (ii) reducing the share of population working in the agricultural sector through the reinforcement of the secondary and tertiary sectors at national and regional levels, and (iii) reducing the land pressure within the agricultural sector through the diversification of rural employment: bee keeping, agroforestry, fish farming silk production, the gathering and processing of medicinal plants, weaving, carving and pottery. In addition, there are possibilities for developing small-scale agro-industries to process, or partly process, whatever is produced locally. These would take a portion of the rural population away from land cultivation.

Finding a Balance between Utilization and Conservation of Wetlands

Wetlands can be considered as sinks into which surface water or groundwater flows from a surrounding catchment. Within landscapes they are ―natural harvesters‖ of rainwater and, by definition, sites where water occurs at or close to the ground surface (McCartney *et al.*, 2010). They can be found in various locations in the landscape, but it is their natural tendency to be most prominent in river floodplains and lakeshores in the LVB that associates them with agriculture and makes them a threatened ecosystem. In fact, they constitute the ideal landscapes for irrigated agriculture because this type of agriculture needs flat, fertile land with a ready supply of water. In many arid and semi-arid regions, the capacity of wetlands to retain moisture for long periods, and sometimes throughout the year, has meant that their use for cultivation is widespread and a long-established land-use practice. A minimum of drainage even allows double cropping. In the LVB, wetlands are also threatened by over-grazing, construction or collection of construction material.

Whereas wetland utilization can be sustainable if implemented correctly, different issues still have to be solved in the LVB to achieve a balance:

1. There is no wetland evaluation at LVB level that could permit an adequate wetland management (present state identification, choice of priority areas for full conservation and enforcement, sustainable development activities in other areas);
2. Once again, the wetland encroachment in the LVB is part of the vicious circle of poverty and ecosystems degradation described in the section 4.1 above – high poverty/population pressure combined with the lack of clear management plan, have already resulted in an uncontrolled and unsustainable encroachment of wetlands for conversion to agriculture.

This situation has been experienced elsewhere and is what has brought about the notion of ―wise use‖[3] of wetlands, in particular because, as the human population increases and further influences the management of water and other natural resources, the value of wetlands to society increases, but so also do the pressures on them.

The wise use of wetlands is defined as their sustainable utilization for the benefit of humankind in a way that is compatible with the maintenance of the natural properties of the ecosystem (Ramsar Convention Secretariat 2004). The key principle of the approach is that all the benefits provided by wetlands must be incorporated in resource planning and decision making. In particular, concerted efforts are required to achieve a mutually beneficial balance between agriculture and the conservation and sustainable use of wetlands, and to prevent or minimize the adverse effects from agricultural practices on the health of wetland ecosystems. The concept of wise use therefore acknowledges that human development necessitates adjustment of wetland ecosystems, but differs from conventional natural resources management because much higher priority is given to those processes that sustain the ecosystem and the people that depend on them (Davis 1993, quoted by McCartney *et al.*,2005

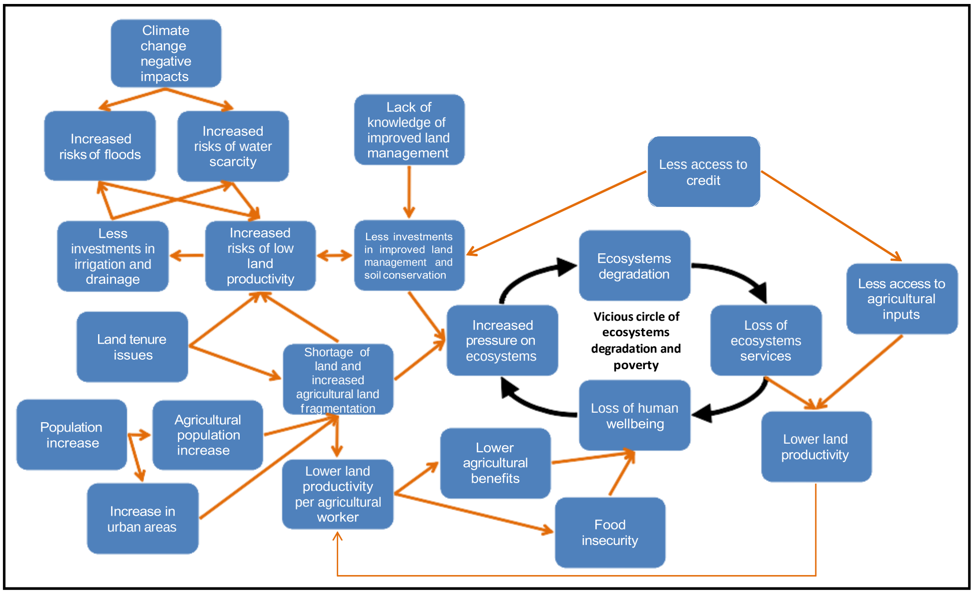

Figure 7. Possible details of the various cycles of ecosystems degradation and poverty
Source: This study

[3] Under Article 3.1 of the Ramsar Convention, Contracting Parties agree to ―formulate and implement their planning so as to promote the conservation of the wetlands included in the list, and as far as possible the wise use of wetlands in their territory‖

As at the time of this study (2013), the LVB appears to be at the cross-road between wetlands protection, wetlands wise use, and wetlands unsustainable utilization because, on the one hand, wetlands unsustainable utilization in the LVB is clearly a serious threat as discussed above, but on the other hand, the LVB countries are also moving towards a ―wiser‖ use of wetlands.

CONCLUSIONS

The Lake Victoria Basin, which currently supports a population of about 40 million (LVBC-d, 2014) contains significant inland water ecosystems resources that are vital for the livelihoods of this population, but is currently under enormous pressure due to the rapidly increasing, poor population dependent on agriculture. Poverty appears to be the defining driver of ecosystem degradation. Therefore reducing environmental degradation requires a global integrated approach targeting poverty, as it is clear that any effort in reducing ecosystems degradation may be nullified in the medium-term if it is not accompanied by a reduction in the growth of the population using agricultural land. This could be achieved by a global reduction in population growth rate and/or by providing alternative sources of livelihoods (mainly off-farms activities) to the population. Without this the quality of the basin‘s ecosystems and livelihoods will be in jeopardy.

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