DISCUSSION PAPER

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Development of Environmental Management Strategy Towards Sustaining Ecological Integrity of Lake Victoria

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Objective of the report

Lake Victoria is a world-renowned ecologically unique waterbody supportive of socioeconomic activities and aquatic species. The natural ecosystem of the lake and its flora and fauna are the basis for an expanding population and burgeoning economic activity in the region. However, this fragile ecosystem has suffered immensely from anthropogenic activities and could be damaged irreversibly in the absence of appropriate interventions. This calls for devising intervention measures that recognize existing efforts aimed to improve the situation. Therefore, CSE and NEMC in collaboration with other stakeholders felt the need to develop a management strategy.

The proposed environmental strategy is in recognition of the importance accorded by the government to the environmental sustainability of ecologically sensitive areas such as Lake Victoria. Sustainability of the services offered by Lake Victoria depends highly on the ecological integrity of the lake itself. Therefore, the developed strategy will assist entities such as NEMC, Lake Victoria Water Basin Commission, TAFIRI, LGAs and other conservationists in developing a broad-based understanding of the status and trends of the water quality in Lake Victoria. This will be the basis for making decisions and working with other agencies and the public for the long-term protection of the lake.

In order to develop an appropriate environmental strategy, however, there is a need to examine the current state of Lake Victoria and to establish major rivers and tributaries entering the lake. It is also important to identify various sources, namely industrial, domestic or solid waste contributing to the pollution of the lake. The first phase of the strategy involves identification of pollution hotspots and providing source specific treatment in order to reduce the pollutants entering the lake. This includes adopting different approaches simultaneously for treating industrial discharge and scientifically disposing sewage and solid waste to holistically manage the lake's water quality. The strategy, in the next phase, will ensure that all streams and tributaries entering Lake Victoria are monitored on a regular basis by establishing key parameters and procedures needed in the process of monitoring. This will also involve examining levels of pollutants in such systems based on the available data. Other activities to be monitored include aspects such as existing wetlands, industries operating in close proximity to the lake, waste management practices and pollution control systems.

The first phase of the strategy is being developed through robust data collection methods that involve the following practices:

i. Consultative meetings with stakeholder
ii. Extensive literature review
iii. Physical tour of Lake Victoria and its surroundings, water supply systems, wastewater treatment facilities, and sites for collecting and disposing solid waste
iv. Identification of the site location using GPS
v. Photo capturing of different areas
vi. An examination of environmental, administrative, technical and operating records of different institutions
vii. Interviews and discussions with key facility management and technical staff

The second phase of the strategy aims to fulfill the following objectives:

i. To collect environmental information on rivers entering Lake Victoria
ii. To determine compliance and non-compliance status of facilities and other development projects adjacent to the Lake
iii. To develop and regularly update the state of environment for Lake Victoria
iv. To determine emerging environmental issues that need immediate attention
v. To promote compliance of the facilities to EMA Cap.191 of 2004 and its regulations through awareness raising
vi. To have a governing tool that can support taking legal enforcement actions against non-complaint facilities

The current report discusses the major water quality and environmental issues of the lake and identifies aspects that have to be considered and worked upon. This will be followed by developing a monitoring network for the lake. The report is dynamic and will be updated from time to time to accommodate emerging challenges arising from changes in policy and legislation, new developments, and technology transformations.

1. Introduction

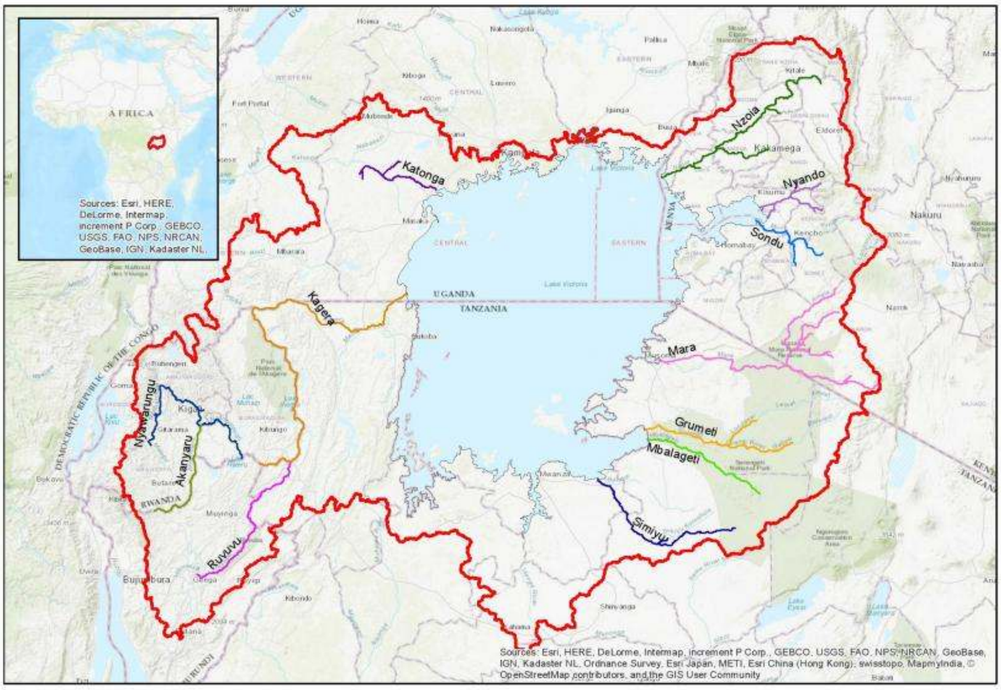
Lake Victoria is considered as the world's second largest freshwater lake with an estimated surface area of 68,800 km^2 and a volume of 2,424 km^3. The lake, situated at an altitude of 1,134 m above sea level, has a maximum and average depth of 80 metres and 40 metres respectively. The lake is shared by three countries—Tanzania (51%), Uganda (44%) and Kenya (5%)—making use of its resources for fisheries, freshwater and transportation (see *Map 1: Map of Lake Victoria*). Apart from the three host countries, its catchment area extends to Rwanda and Burundi, covering a total area of 1,69,858 km^2.[1]

Map 1: Map of Lake Victoria

Source: http://media.photobucket.com/image/lake%20victoria/peacefromtrees/lake_victoria.jpg

Lake Victoria receives its water primarily from two main sources—rainfall and rivers. A total of 17 rivers flow into the lake from the three countries with seven each from Tanzania and Kenya and three from Uganda (see *Map 2: Major Rivers and streams flowing into Lake Victoria*). While Kagera is the largest river flowing into the lake, Nile River is the single outlet from the lake, exiting the lake near Jinja, Uganda.

Map 2: Major Rivers and streams flowing into Lake Victoria



Source: Report on rapid assessment of impacts of flooding of Lake Victoria in Kagera and Mwanza regions, NEMC, 2020

Tanzania, additionally, has five more streams in the Lake Victoria catchment area that meet one of the seven major rivers and contribute to the total annual discharge in the lake (see *Map 3: River map for Tanzania*). Kagera and Mara are perennial and trans-boundary rivers while the rest of the rivers are seasonal.[2] These rivers have a total annual discharge of 476 m^3/s, with Kagera having the largest discharge volume with a contribution of more than 50 per cent of the total discharge (see *Table 1: Discharge from various river basins of Tanzania*). Nyashishi River, on the other hand, with a low discharge volume of 1.6 m^3/s seems to be equivalent to an open drain rather than a river. All these rivers, while passing through towns, collect untreated industrial effluent and domestic sewage which finally gets discharged into the lake.

The basin of Lake Victoria also supports extensive agriculture. Over 70 per cent of the population in the catchment area depends on agriculture and it forms the basis of their economic viability. Gold mining is another important activity undertaken in the lake basin, especially in Geita and Mara regions. A number of small-scale gold mining units make use of mercury and cyanide for recovering the precious metal, which results in the addition of pollutants to nearby water bodies.

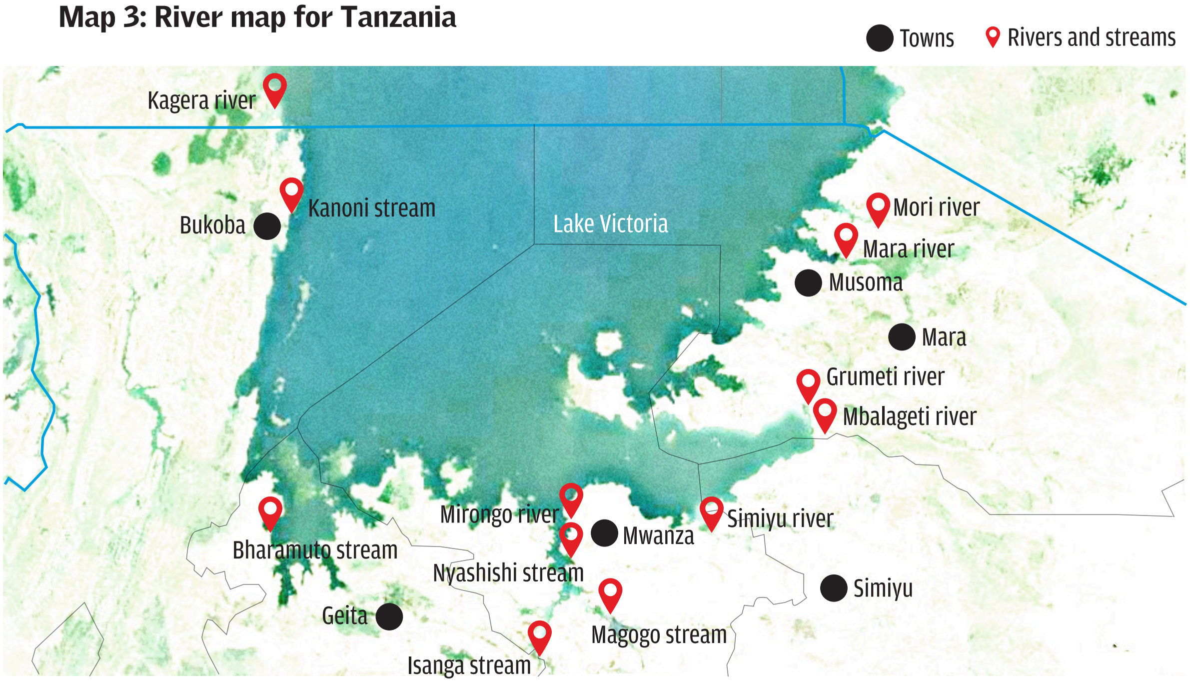
Table 1: Discharge from various river basins of Tanzania

River basin	Discharge (m^3/s)	Type
Mara	37.5	Major river
Grumeti	11.5	Major river
Mbalageti	4.3	Major river
Mori (E. shore stream)	18.6	Major river
Simiyu	39.0	Major river
Mirongo (S. shore stream)	25.6	Major river
Kagera	260.9	Major river
Magogomoame	8.3	River stream
Nyashishi	1.6	River stream
Issanga	30.6	River stream
Biharamulo	17.8	River stream
Kanoni (W. shore stream)	20.7	River stream
Total	476.40	

Source: Lake Victoria: Experience and Lessons Learned Brief, 2005

Lake Victoria, despite being a source of livelihood for 45 million people, is on the verge of degradation. The lake, which supports the most productive freshwater fishery in the world worth US$ 600 million annually and provides resources for agriculture, mining, water transport and other economic activities, has come

Map 3: River map for Tanzania



Source: Centre for Science and Environment under increasing and considerable pressure from a variety of unsustainable human activities over the past five decades.

Activities including deforestation, poor waste management and treatment, destructive fishing practices, introduction of invasive fish, wetland encroachment, unsustainable farming practices, and uncontrolled mining have rendered the lake into a sink for excessive nutrients and untreated effluent. This has led to fish die-offs, algal blooms and the spread of a ferocious waterweed—the water hyacinth.

Parts of the lake, especially the deeper areas, are already considered dead zones which are unable to sustain life due to oxygen deficiency in the water. Deteriorating water quality has reduced the lake's biodiversity, most notably affecting the phytoplankton and fish, and is causing hardship for the populations dependent on it for their livelihoods. These pressing issues have constantly kept Lake Victoria in the limelight both locally and globally (see *Box 1: Media reports on the degradation of Lake Victoria*).

Much effort has been expended by different entities to conserve, restore and manage the ecological functions of the lake. The Lake Victoria Environmental

BOX 1: MEDIA REPORTS ON THE DEGRADATION OF LAKE VICTORIA

Lake Victoria is at risk of dying from pollution and climate change

Wetlands usually filter water that makes its way into Africa's largest lake, but now untreated waste dumped into the lake risks killing off local wildlife

EARTH 1 July 2020

Villagers along Lake Victoria lament over plastic waste

THURSDAY APRIL 22 2021

Lake Victoria – Why Africa's largest lake looks ugly

The loads of herbicides, insecticides and acaricides, which should never be present in drinking water, are still found in Lake Victoria including the pesticides that were banned in 2001.

Subhro Prakash Ghosh | Updated: 07-03-2020 19:48 IST | Created: 07-03-2020 16:47 IST

It's time to charge polluters with genocide against Lake Victoria

SUNDAY OCTOBER 31 2021

Lake Victoria. The Ugandan, Kenyan and Tanzanian governments continue to let industries, and the lakeside communities without formal sewage infrastructure, dump human waste, fertilisers, garbage and plastic waste in Lake Victoria. PHOTO | MORGAN MBABAZI

Kenya: Lake Victoria Fish Died Due to Lack of Oxygen - Experts

DAILY NATION

16 FEBRUARY 2021

By Winnie Atieno

The mass deaths of fish in Lake Victoria is due to massive pollution and lack of oxygen, an expert has explained.

Panicked fishermen were recently baffled to find thousands of dead fish beached on the shoreline.

BOX 2: INITIATIVES TAKEN FOR IMPROVING THE LAKE VICTORIA BASIN (LVB)

- The Lake Victoria Environmental Management Program (LVEMP) was designed to be a long-term comprehensive effort to rehabilitate the lake ecosystem. The long-term approach to slow down the environmental degradation of the lake was recognized from the outset of the first phase of LVEMP, which included the three riparian countries and was implemented from 1996 to 2005.

- LVEMP-I greatly improved the understanding of environmental challenges faced by the lake. It helped upgrade technical and research skills in fisheries at the national level, piloted community-based catchment rehabilitation and established Beach Management Units (BMUs) to control illegal fishing at the community level. The project implemented biological controls to reduce water hyacinth infestation and helped to establish the Lake Victoria Fisheries Organization (LVFO), which in turn contributed to establishing the Lake Victoria Basin Commission (LVBC) in 2005.

- LVEMP-II aimed to (a) enhance collaborative management of trans-boundary natural resources through harmonizing policies and regulations, (b) achieve stress reduction outcomes in priority hotspots, and (c) lay a foundation for the long-term programme for sustainable improvement in the environmental status and water quality.

- A Protocol for Sustainable Development of the Lake Victoria Basin was signed by the East African Community Partner States (Kenya, Tanzania and Uganda) in 2003 and ratified in 2004. The protocol addressed the environmental concerns in and around the lake and laid down the principle that 'partner states shall utilize water resources of the basin in their respective territories in an equitable and reasonable manner.' Under the same protocol, the LVBC was established in 2005 as a permanent apex institution to the EAC to provide a regional coordination framework for sustainable development of the LVB.

- In 2003, Kenya, Tanzania, and Uganda adopted 'The Vision and Strategy Framework for Management and Development of the Lake Victoria Basin', which designated the LVB as an economic growth zone. The LVB Vision and Strategy was aimed at achieving 'a prosperous population living in a healthy and sustainably managed environment providing equitable opportunities and benefits.' The LVBC had also developed its Operational Strategy for 2007–2010 to implement its mandates stipulated in the EAC Development Strategy and the protocol on LVB.

- The 'EAC Lake Victoria Basin Water Resources Management Bill' was prepared in 2014 to enhance legal provisions but it has since been stuck under discussion and legal review. However, the road map to be followed for the approval and adoption of the bill has been agreed upon and budget has been set aside to ensure the process is completed by June 2019.

- The fisheries policy was approved by the EAC Sectoral Council in early March 2018. The new fisheries policy frameworks are already being mainstreamed at the national level in the three countries. Notably, in Kenya, they are being incorporated into guidelines to operationalize the Fisheries Management and Development Act No. 35 (2016).

- The harmonized 'EAC Regional Standards for Industrial and Municipal Effluent Discharges into Sewerage and River Systems' was adopted and gazetted in 2016. The standards are currently in use by the LVBC as benchmarks for monitoring under both regional and national RECP activities.

- Monitoring of water quality has however been weakest in terms of implementation. The Water Resources Information System (WRIS) was developed under LVEMP-II to monitor surface water, groundwater and water quality. The system is available online and publicly accessible at http://lvbc.wris.info. Building blocks were put in place (increased lab and sampling capacity, WRIS, standardized protocols), and data has been collected that confirms gross spatial patterns of worsening quality near the shore and particularly in sheltered bays with polluted inlets. But, the intensity and coordination of water quality monitoring across the lake are not sufficient to show clear temporal trends, and the collation of data under the WRIS has started to reveal the size of the challenge in ensuring quality control.[3]

Management Programme (LVEMP) Phase 1 and 2 have developed various bodies to handle different issues and also developed various strategies to improve the lake's health. However, despite such efforts, problems still persist. One of the major challenges is the lack of data needed to make informed management decisions. Likewise, monitoring programmes were also found to be inadequate.

In 2021, the World Bank reported that without concrete climate and development action, the Lake Victoria basin countries could see migration of millions of people within the country in response to water scarcity, decline in crop and ecosystem productivity and rise in sea levels.[4] Out of the five lake basin countries, Tanzania and Uganda are projected to have the highest number of migrants by 2050, reaching 16.6 million and 12 million respectively.

The available information does not show the exact extent to which Lake Victoria has deteriorated in the last two decades but it does broadly show that the situation has definitely worsened. Therefore, we can safely say that there is a need to devise a holistic and integrated strategy to preserve the lake from further degradation. From the available data and studies, it is apparent that pollution from dumping of industrial and domestic untreated waste plays a significant role in the deterioration of Lake Victoria. Thus, an attempt has been made in this report to assess the pollution load from these sources in Tanzania, to identify the potential hotspots and to develop strategies to mitigate the pollution from these sources. A reduction in pollution from industrial and domestic sources will help in controlling the degradation of the water quality substantially. This, accompanied with an adequate monitoring plan, will render favourable results for the ailing Lake Victoria.

2. Pollution assessment of Lake Victoria

The lake basin supports one of the densest rural populations in the world with population density being well over 100 people per square km. It is the most heavily populated basin within the East African Rift Valley Lakes sub-region.[5] These densely populated regions lack proper drainage and sewerage systems and thus the wastewater from these areas ends up draining in the lake via river basins. Additionally, a number of industries like breweries, sugar, soap, vegetable oil and fish processing factories operating in the lake basin do not have efficient wastewater treatment facilities. In such a scenario, untreated industrial effluent from these industries finds its way into the lake. Apart from domestic and industrial discharges, surface runoffs from agricultural lands and storm water carry nutrients and add to the pollution load of the lake. The contribution of each of these pollution sources to the pollutant loading of the lake is described in the following sections.

2.1. Industrial pollution

Most of the industries, in all three countries, are located in the larger towns bordering the lake; like Kampala and Jinja in Uganda, Mwanza and Musoma in Tanzania, and Kisumu in Kenya. While a majority of the Kenyan industries are reportedly equipped with effluent treatment plants, industries in Tanzania and Uganda either completely lack them or have inefficient wastewater treatment facilities.[6] According to a report 'Integrated water quality/Limnology study for Lake Victoria', 79 major industries operate in the catchment area of the lake with 25 in Kenya, 36 in Tanzania and 18 in Uganda.[7] Tanzania has the highest share of both organic and nutrient loading into the lake due to the large number of fish processing and vegetable oil industries in the country (see *Table 2: Pollution loading in Lake Victoria due to industries*).

Table 2: Pollution loading in Lake Victoria due to industries

Country	Number of industries	Loading into Lake Victoria (tonnes/year)		
		BOD	Total N	Total P
Tanzania	36	3,259 (58%)	324 (78%)	208 (61%)
Kenya	25	1,487 (27%)	33 (8%)	88 (26%)
Uganda	18	860 (15%)	57 (14%)	46 (13%)
Total	79	5,606	414	342

Source: Integrated Water Quality / Limnology Study for Lake Victoria, COWI, 2002

The same study also illustrated pollution loading of different streams passing through major towns for each of three countries. These streams join the major rivers which discharge into the lake. With regards to Tanzania, the findings show that Mwanza district in the catchment area of Nyashishi stream is the highest contributor of industrial pollution loading, discharging 2,838 tonnes/year (56 mg/l) of BOD in the lake (see *Table 3: Total industrial pollution loading in different catchment areas of Tanzania*). The Nyashishi stream alone adds to 98 per cent of the total BOD from Tanzania into the lake. This is because Mwanza district has the highest number of industries in Tanzania, 20 out of 36, with fish processing and vegetable oil manufacturing industries dominating in the area. These sectors generate effluent with high BOD concentration which is being discharged into the stream in the absence of any treatment facilities.

Table 3: Total industrial pollution loading in different catchment areas of Tanzania

Catchment area	Discharge of stream (m^3/s)	District/Town	Number of industries	Pollution load (tonnes/year)		
				BOD	Total N	Total P
Eastern Shore Streams	18.6	Musoma / Mara	08	170	23	15
Grumeti	11.5	Bunda / Mara	02	142	6	3
Kagera	260.9	Kyaka / Kagera	01	9	4	2
Nyashishi	1.6	Mwanza	20	2,838	289	185
Simiyu	39	Magu / Mwanza	01	0.73	0.03	0.02
Western Shore Streams	20.7	Bukoba / Kagera	04	99	3	4
Total			36	3,259	325	209

Source: Integrated Water Quality / Limnology Study for Lake Victoria, COWI, 2002

A separate study was conducted in 2017 for three major towns of Tanzania, namely Musoma, Bukoba and Mwanza.[8] The towns, situated in the catchment area of Lake Victoria, were selected as the streams passing through them are considered to be highly polluted. The study collected and analysed effluent samples from twelve industries—six from fish processing, two from breweries and one each from coffee, sugar, textile and beverage industry. While the breweries have the highest COD load in their effluent, two fish processing units show high concentration for both BOD and COD (see *Table 4: Pollution concentration from industrial effluents*).

Table 4: Pollution load from industrial effluents

Industry	Sector	Town	BOD (kg/day)	COD (kg/day)
Musoma Fish Ltd	Fish processing	Musoma	255.7	598.8
Kagera Fish Ltd	Fish processing	Bukoba	57.9	100.1
VIC Fish Ltd	Fish processing	Bukoba	158.7	255.4
Tanzania Brewries limited (TBL)	Brewery	Mwanza	95	220.4
Serengeti Brewries Company (SBC) lLtd	Brewery	Mwanza	80	115.6
Mwatex Ltd	Textile	Mwanza	55	89.9
Nile Perch fisheries	Fish processing	Mwanza	16.2	41.9
NBCL	Beverage	Mwanza	2.0	4.4
Victoria Perch Ltd	Fish processing	Mwanza	16.2	-
Omega Fish Ltd	Fish processing	Mwanza	3.2	9.0
Tanica Coffee Ltd	Coffee	Bukoba	BDL	BDL
Kagera Sugar Ltd	Sugar	Bukoba	BDL	BDL

Source: Environmental pollution and contamination of water resources within Lake Victoria: Musoma, Bukoba and Mwanza towns, Mwanza zonal water quality laboratory, Ministry of Water and Irrigation, 2017

The same study also surveyed nine streams in these three towns—four in Musoma, three in Mwanza and two in Bukoba. The results once again highlight Mwanza as the hotspot, contributing high concentration of BOD and COD in the Mirongo River (see *Table 5: Industrial pollutant loading study for Mwanza, Musoma and Bukoba*).

Table 5: Industrial pollutant loading study for Mwanza, Musoma and Bukoba

Sample location	Town	BOD (kg/day)	COD (kg/day)
Mirongo River	Mwanza	4,336.7	8,000
Sweya	Mwanza	not calculated due to lack of flow data	
Mkolani	Mwanza	not calculated due to lack of flow data	
Kanoni	Bukoba	not calculated due to lack of flow data	
Kateikya stream	Bukoba	1.8	-
Nyasho corner	Musoma	33.6	100
Mwisenge stream	Musoma	118.5	400
Bweri stand	Musoma	112.7	300
AICT dispensary	Musoma	366.9	1100

Source: Environmental pollution and contamination of water resources within Lake Victoria: Musoma, Bukoba and Mwanza towns, Mwanza zonal water quality laboratory, Ministry of Water and Irrigation, 2017

It is important to mention that the Mirongo River is one of the seven major rivers of Tanzania that flows into Lake Victoria. It is an urban stream that flows through the central part of Mwanza city and empties its water into Lake Victoria. The river has a total stretch of approximately 8 km passing through some industrial and among the most densely populated residential parts of the city. The city is partly serviced by a sewerage system which discharges about 5,000 cubic metres of raw sewage directly into the river on a daily basis. The report prepared under Lake Victoria Environmental Management project has also highlighted that the Mirongo River has turned into an open sewer transporting tonnes of industrial and municipal waste into Lake Victoria every year.[9]

Both studies, done in 2002 and 2017, have identified different river streams as major contributors of pollutants. However, Mwanza district has featured in both as a pollution hotspot.

2.2. Domestic pollution

The Lake Victoria basin consists of 87 large towns in three countries with 51 in Kenya, 30 in Tanzania and 6 in Uganda. Mwanza, Kisumu and Kampala are the major towns of Tanzania, Kenya and Uganda respectively with maximum populations. Out of these three countries, Kenya has the largest population in the basin and is thus considered the highest contributor of pollution load to the lake; higher even than the combined loading from Tanzania and Uganda (see *Table 6: Country-wise domestic pollution load added to Lake Victoria*).

Table 6: Country-wise domestic pollution load added to Lake Victoria

Country	Total population	Loading to Lake Victoria (tonnes/year)		
		BOD	Total N	Total P
Tanzania	1,020,613	5,069	729	292
Kenya	3,366,907	10,724	2,019	848
Uganda	926,879	2,145	767	484
Total		17,938	3,515	1,624

Source: Integrated Water Quality / Limnology Study for Lake Victoria, COWI, 2002

Available studies indicate that Tanzania generates approximately 119 million m^3 of domestic wastewater annually with major sources being households, institutions, commercial areas, markets, industries and stormwater runoff.[10] However, the country's sewerage system is under developed; only 10 out of more than 100 urban centres have sewerage systems which serve less than 20 per cent of the total urban population. About 90 per cent of the urban population depends on on-site sanitation systems (pit latrines and septic tanks). Emptying of septic tanks is carried out by cesspit emptiers mostly owned by private operators who are supposed to discharge their septage at municipal waste stabilization ponds and other wastewater treatment systems. The existing centralized sewerage system

Image 1: Mirongo river discharging in Lake Victoria

Source: NEMC

mostly utilizes Waste Stabilization Ponds (WSP) to treat wastewater. The treated and untreated wastewater is discharged into water bodies.

For stormwater, most of the urban areas are served by open drains along the roads. The collected stormwater from these urban centres does not undergo any type of treatment before being discharged into water bodies.

The situation of rural Tanzania is even more alarming; data from rural areas indicates that 72 per cent of the rural population uses unimproved sanitation while 17 per cent still defecates in the open.[11] Aside from polluting water bodies, this waste has also led to a sharp increase in cases of diarrhoea and cholera, especially in children.

Another 2017 study conducted in the three towns of Misungwi, Magu and Lamadi, situated along the shores of Lake Victoria, also showed that domestic wastewater in these regions is not being properly managed.[12] Misungwi is a town in Mwanza whereas Lamadi and Magu are part of the Simiyu Region. For the study, a questionnaire was used to conduct a survey in the selected towns. None of the towns surveyed had a sewerage system for disposal of domestic sewage. In the absence of such a system, the people of the town use various methods for disposal of their domestic waste; however, discharging in open spaces near their houses is the most prominent practice (see *Table 7: Methods of domestic wastewater disposal*). About 80 per cent of the respondents in all three towns confirm usage of this disposal method. Septic tanks are being used only by about 16 per cent of the people in all three towns.

Table 7: Methods of domestic wastewater disposal

Method of disposal	Misungwi (Mwanza) (%)	Magu (Simiyu) (%)	Lamadi (Simiyu) (%)
Open spaces	76.3	81	80.3
Toilet	6.5	4.1	0.8
Yard	21.3	5.8	9.4
Septic Tank	7.7	7.4	8.7
Pit	19.5	6.6	15.7

Source: Solid and liquid waste management at household level: Evidence from three small towns along the shores of Lake Victoria, Tanzania, 2017

The study also assessed the management of faecal sludge in the three towns. The findings show that a large majority of people in Lamadi (84 per cent) and Magu (61 percent) manage faecal sludge by digging holes and burying it (see *Table 8: Management of faecal sludge at household level*). This practice is unhygienic and environmentally unsound as faecal sludge can spillover and cross contaminate water sources. In addition, pits were shallow and close to the houses where they can get uncovered due to rain water. Most people in Misungwi (62.5 per cent), on the other hand, use pit emptier tanks for disposing off their faecal sludge. Pit emptier tanks are vacuum trucks that collect faecal sludge from households using onsite sanitation systems such as septic tanks, cesspits and pit latrines. The explanation for low usage of this disposal method lies in the fact that none of the studied towns had their own pit emptier trucks. Instead, they used trucks from private service providers in Mwanza, and because of the long distance from Mwanza to Magu and Lamadi, most households in these towns could not afford this service.

Table 8: Management of faecal sludge at household level

Method	Misungwi (Mwanza) (%)	Magu (Simiyu) (%)	Lamadi (Simiyu) (%)
Dig hole and bury	37.5	60.8	83.5
Discharged in open drains	0	0.8	0
Pay pit emptier trucks	62.5	38.3	15

Source: Environmental pollution and contamination of water resources within Lake Victoria: Musoma, Bukoba and Mwanza towns, Mwanza zonal water quality laboratory, Ministry of Water and Irrigation, 2017

From the studies discussed above, it is evident that in the absence of adequate sewerage systems, both domestic and faecal waste is disposed of haphazardly, ultimately finding its way into river streams and finally into Lake Victoria. The contribution of domestic waste to the pollution loading of the lake was also presented in the study 'Integrated water quality/Limnology study for Lake Victoria' conducted by COWI in 2002. The study has considered various streams passing through major towns of Tanzania and analysed the concentration of BOD, Total P and Total N in the streams (see *Table 9: Domestic pollution loading from different catchment areas of Tanzania*).

Table 9: Domestic pollution loading from different catchment areas of Tanzania

Catchment area	Discharge of stream (m^3/s)	Town or province area	Population (Year 2001)	Pollution loading (tonnes/year)		
				BOD	Total N	Total P
Biharamulo	17.8	Biharamulo	8,048	22	4	2
		Chato	13,278	37	6	3
Eastern Shore Streams	18.6	Musoma	120,025	394	66	26
		Tarime	22,079	73	12	5
		Nansio	33,038	108	18	7
Grumeti	11.5	Bunda	15,190	50	8	3
		Mugumu	9,879	33	6	2
		Kyabakari	9,000	30	5	2
Isanga	30.6	Kharumwa	6,482	21	4	2
		Malya	6,390	21	4	2
Kagera	260.9	Ngara	5,671	16	3	1
		Rulenge	7,146	20	3	2
		Kaisho	5,867	16	3	1
		Kayanga	8,631	24	4	2
Magogo	8.3	Ngudu	11,461	38	6	3
		Missungwi	10,718	35	6	2
		Misasi	10,387	34	6	2
Mara	37.5	Butiama	10,918	36	6	3
Mbarageti	4.3	Ramadi	7,918	26	4	2
Nyashishi	1.6	Mwanza	500,000	3,431	456	183
		Nyanguge	5,726	19	3	1
Simiyu	39	Magu	17,470	57	10	4
		Kisesa	9,901	33	6	2
Southern Shore Streams	25.6	Geita	34,743	114	19	8
		Kasamwa	9,814	32	6	2
		Sengerema	36,893	121	20	8
Western Shore Streams	20.7	Bukoba	61,467	168	28	11
		Muleba	9,595	26	4	2
Total			1,020,613	5,069	729	292

Source: Integrated Water Quality / Limnology Study for Lake Victoria, COWI, 2002

A close examination of Table 9 clearly identifies Nyashishi catchment area of Mwanza town as the major contributor of pollution load, discharging approximately 3,431 tonnes per year (68 mg/l) of BOD in the lake. The same stream has also been found to be the highest contributor of industrial pollution.

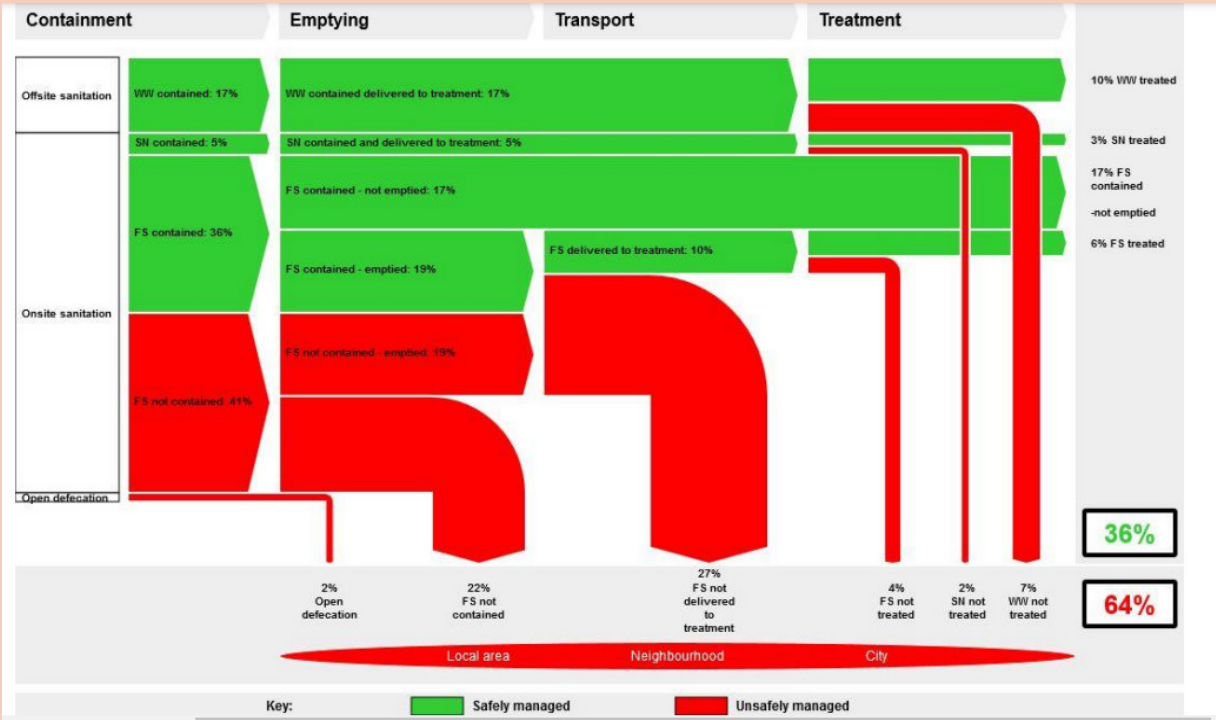
It is pertinent to mention that Mwanza has been identified as the hotspot for domestic pollution as well. The district has the largest population but lacks the facilities of adequate sewerage system, thus all its waste gets drained into rivers

BOX 3: SHIT FLOW DIAGRAM: A SOLUTION FOR MANAGING FAECAL SLUDGE

An excreta flow diagram (also often described as shit flow diagram or SFD) is a tool to readily understand and communicate how excreta physically flows through a city or town. SFD shows how excreta is or is not managed as it moves from defecation to disposal or end-use.

A first step towards providing adequate sanitation services in urban areas is to monitor the sanitation service chain, from containment, including emptying and transport, to treatment and safe disposal or resource recovery. The SFD graphic is a visual representation that enables stakeholders to identify outcomes in terms of the flow and fate of excreta produced by the population.

Excreta, which is safely managed and moves along the sanitation service chain, is represented by green arrows moving from left to right in the graphic, while excreta which is unsafely managed is represented by red arrows. Unsafely managed flows discharging to the environment are represented by red arrows turning towards the bottom of the graphic. The width of each arrow is proportional to the percentage of the population whose excreta contribute to that flow.



and streams. However, since the discharge of Nyashishi stream is quite low, approximately 1.6 m^3/s, it seems to be more of an open drain than a river stream. Thus, if the source of pollution to Nyashishi stream is controlled and treated, a major amount of pollutants can be prevented from entering the lake.

BOX 4: UNACCOUNTED MERCURY CONTAMINATION FROM GOLD MINING

Large-, medium- and small-scale gold mining sites also add a high amount of pollution to the lake. Although these sites are not situated close to Lake Victoria, they are operational near some rivers which drain into the lake. Geita and Mara regions are the major hubs of gold mining activities. Mara River, one of the seven rivers flowing into the lake from Tanzania, is a major source of pollution in terms of heavy metals coming from gold processing activities. Few studies have reported presence of heavy metal contamination in fish.[13] However, studies monitoring mercury and other heavy metals around mining sites are limited and thus the number of people at risk from mercury in water and food is unclear.

While industrial and domestic sources are major contributors of BOD load in the lake, land runoff plays a major role in deposition of nitrogen and phosphorus, accounting for approximately 90 per cent of phosphorus and 94 per cent of nitrogen input into the lake (see *Table 10: Source-wise total pollution loading in lake from Tanzania*). Unsustainable land-use practices of clearing vegetation and forest burning are the major causes of this deposition as they result in increased soil erosion and nutrient land runoff.

Table 10: Source-wise total pollution loading in lake from Tanzania

Pollution source	Loading to Lake Victoria (tonnes/year)		
	BOD load	Total Nitrogen load	Total Phosphorus load
Domestic waste	5,069	729	292
Industrial sources	3,259	324	208
Runoff into river basin	-	37,820	3,675
Total	8,328	38,873	4,175

Source: Lake Victoria: Experience and Lessons Learned Brief, 2005

2.3. Solid waste management

Tanzania is home to over 55 million people which generate approximately 15 million tonnes of solid waste annually. While households are the highest generators of waste at 75 per cent, other sources include industries and commercial areas (20%), institutions (0.5%), markets (3.5%) and street sweeping (0.5%).[14] According to a 2020 report 'Investment Guide of Waste Management in Tanzania, United Republic of Tanzania, Vice President's office,' less than 50 per cent of the waste is being collected while 3 per cent is disposed off through open burning, 30 per cent by burying and 17 per cent is haphazardly dumped into the environment. About 90 per cent of the collected waste is also disposed off in an unsatisfactory manner.

Another study[15] conducted in three towns of Mwanza and Simiyu regions shows that most of the households do not store their solid waste, but rather burn, throw away or put it in a pit (see *Table 11: Household storage facilities*).

Table 11: Household storage facilities

Facility	Misungwi (Mwanza) (%)	Magu (Simiyu) (%)	Lamadi (Simiyu) (%)
Containers	12.4	16.5	5.5
Plastic bags	1.8	5.0	6.3
Others (throw away, burn or put in a pit)	85.0	75.2	84.6

Source: Environmental pollution and contamination of water resources within Lake Victoria: Musoma, Bukoba and Mwanza towns, Mwanza zonal water quality laboratory, Ministry of Water and Irrigation, 2017

The study also reported that waste collection is done to a very small extent. Even when the waste is collected, it is disposed of at an open 'unofficial' dumpsite along the Mwanza–Musoma highway and in other open spaces due to lack of transportation and of a properly designed disposal site. This problem has been reported in other towns and cities of Tanzania as well.

There has been a rise in settlements on the shores of the lake, especially of those communities involved in fisheries and livestock. This has led to an increase in waste generation, and in the absence of any waste collection system, all this waste is ultimately getting dumped into the lake. Visible litter on the banks of the river in the form of plastic and other solid waste can be easily observed, which, besides polluting the water body, also impacts the aesthetic look of the lake.

Image 2: Waste dumped at the shore

Source: NEMC

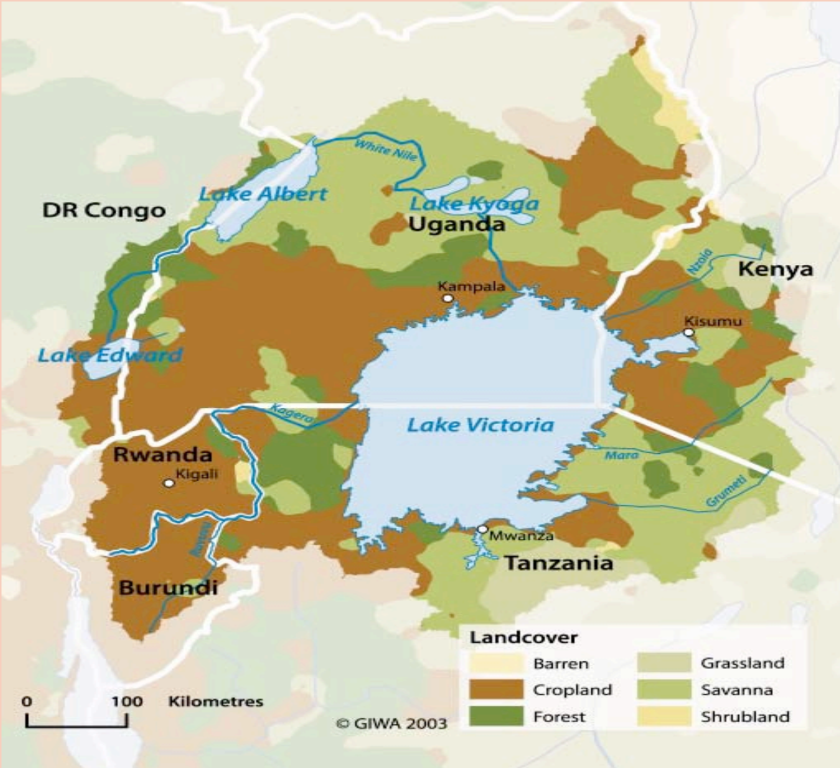
IUCN's *Tanzania National Plastic Pollution Hotspotting and Shaping Action report*[16] reveals that the country generated 315 thousand tonnes of plastic waste in 2018, out of which only 34 per cent of the waste was collected. Since there are no sanitary landfill and incineration facilities, there is no proper disposal of waste in Tanzania. The majority of plastic waste is mismanaged. According to the report, approximately 29 thousand tonnes of plastic waste got disposed off in rivers and lakes in 2018 in Tanzania.

There is a dearth of recent data available on assessment of pollution load of the rivers and Lake Victoria. Likewise, the available information does not provide the continuity status of the pollution load into the lake. Old studies have more information when compared to the recent studies that to the large extent have limited data.

BOX 5: OTHER ENVIRONMENTAL CONCERNS OF LAKE VICTORIA

1. **CATCHMENT DEGRADATION**

Communities in the Lake Victoria basin are involved mostly in crop production of maize, rice, sugar, coffee, tea, cotton, bananas, sorghum, millet, groundnuts and horticultural products. Agriculture employs about 75 per cent of the workforce and forms the basis of their economic viability. However, increasing urbanization and agriculture in the region has led to higher demand for land. More land is cleared to meet these demands, leading to change in land use in the basin. The map shows that majority of the areas around the lake basin have been converted into croplands and forest cover is minimal.



Existence of wetlands and littoral zones is closely connected to the ecological health of Lake Victoria. Wetlands are also important in terms of fish breeding, exchange of nutrients with the lake and as filters, trapping incoming sediment and pollutants. However, extensive wetlands around the lake have been destroyed through conversion to agricultural land, excavation for sand and clay, mining activities and their use as disposal sites. It was estimated that about 75 per cent of Lake Victoria's wetlands had been affected significantly by human activity, and about 13 per cent had been severely damaged.[17]

2. EUTROPHICATION

Eutrophication is one of the biggest ongoing problems of Lake Victoria. Catchment degradation and pollution are the primary causes of eutrophication. The problem of eutrophication is also aggravated by massive growth of water weeds and invasive plants in river catchment areas as a result of increased nutrient loading from surface runoffs. Likewise, clearing of riparian vegetation, which acted as filters, for agriculture practices has led to erosion and deposition of nutrient-rich sediments from agricultural runoff and deforested zones directly into the lake. In addition, discharge of untreated wastewater in rivers also ends up adding BOD and nutrients in the lake. This has resulted in widespread eutrophication in the lake leading to spurred growth of algae and aquatic weeds. The growth of algae adversely impacts the lake by depleting oxygen levels thereby decreasing aerobic flora and fauna and inhibiting navigation. Nearly the entire perimeter of the lake is experiencing hyper-eutrophication, or extremely poor water quality, whereas the rest of the lake had poor or fair water quality, and there were no zones of good water quality detected in the lake.[18]

3. INFESTATION OF WATER WEED

Water hyacinth, an invasive alien species, has a high growth rate, produces large quantities of long-lived seeds that can survive up to 30 years and weed populations can double every 5–15 days at temperatures between 25–27.5°C. The weed covers the lake surface, especially along the shoreline, with serious impacts on the livelihoods of local fishermen and farming communities. About 80 per cent of the Ugandan shoreline has been affected by this problem.[19] Some initiatives have been taken by Lake Victoria Environmental Management Project (LVEMP) to control the water hyacinth infestation and the weed infestation had been reduced by approximately 80 per cent by the year 2000. However, after 2005, the weed infestation again increased to about 30 per cent of the 1998 coverage.

4. LOSS IN BIODIVERSITY

The lake originally had a multi-species fishery, mostly dominated by perch-like fish called Cichlids. In the 1950s, two new fish species namely Nile Perch and Nile Tilapia were introduced to the lake with an aim to improve the declining stocks of indigenous species. However, an explosive population growth of Nile Perch later caused extinction of approximate 300 fish species (due to predation).[20] The change in the species composition of the lake had important economic effects as the Nile Perch found a ready international market. Processing and export industries have grown around the lake. Fast-growing population and advanced fishing methods have led to over-fishing and abusive fishing practices threatening the sustainability of the fisheries. Even though Nile Perch might have provided economic benefits, its presence has disrupted the natural balance of the lake's ecosystem. The subsequent decrease in the number of algae-eating fish, due to their predation by the Nile Perch, allows the algae to grow at an alarming rate, thereby choking the lake. This in turn results in depletion of oxygen levels, thereby inhibiting survival of aerobic life in the deeper parts of the lake.

5. OUTBREAK OF WATERBORNE DISEASES

Waste is discharged in nearby water bodies and makes people susceptible to waterborne diseases. Waterborne diseases represent more than half of all disease incidences in Tanzania and more than 80 per cent of disease incidence in rural areas. More than 1.7 million episodes of diarrhoea are reported annually in Tanzania and children are at greatest risk. Diarrheal disease was the 4th ranked cause of child mortality in Tanzania in 2006. Faecal contamination of potable water sources is most prevalent in the proximity of populated urban areas.[21]

3. CSE's recommendations to clean Lake Victoria

All the studies discussed in Chapter 2 clearly show that Mwanza is a hotspot for all kinds of waste. The Nyashishi stream passing through this town has the highest BOD contribution for industrial and domestic wastewater. Mirongo River with highest BOD contribution from industrial sources also flows through Mwanza. A large swathe of Mwanza's population disposes of domestic wastewater in the open whereas faecal sludge is managed by being transferred to pit emptier trucks. However, approximately 38 per cent of the population still buries faecal sludge in pits. The management of solid waste is also very poor; waste is thrown away, burnt or dumped in a pit.

Considering the extent of pollution from Mwanza, various pollution control measures can be implemented in the city first and then replicated in other hotspots. The measures will include steps like controlling waste disposal in streams by identifying and treating pollution at source; separate treatment for domestic and industrial wastewater; and mechanisms to treat stream water before it is discharged into the lake. Along with these, several other measures should also be undertaken in order to get the desired results. CSE proposes the following recommendations focusing not only on hotspot but on various other aspects to provide a holistic approach.

a. Track Mirongo River for point source identification and control

The identification of hotspots is a key step in developing action plans but it is not enough. The next step is to understand various specific sources responsible for this pollution. Hence, Mirongo River should be tracked to map out specific locations where waste is discharged into the stream. This exercise will help in two ways: firstly, in identifying the source of pollution (industrial or domestic); and secondly, by allowing the application of source specific treatment solutions at different locations. Treating the waste at source will minimize the waste load entering the river.

b. Shit flow diagrams to manage urban sewage

Once the mapping is done and sources are identified, various approaches can be used for source treatment of waste. For urban domestic waste, a **shit flow diagram** (**SFD**) must be developed to understand the flow and fate of waste (excreta).

As detailed out earlier, SFD will help in assessing the quantity of waste that is flowing through the well laid sanitation service chain and the quantity that is not. It will also provide information on the stage of treatment required by the waste. Additionally, a decentralized system needs to be developed to treat urban and rural domestic sewage. Since the characterization of waste differs for urban and rural sewage, this approach will provide flexibility to choose treatment technology based on geographical conditions and characteristics of sewage.

c. Mandatory effluent treatment plant for water polluting sectors

For industrial wastewater, provision of effluent treatment plants must be made a necessary condition. Existing studies show that 36 industries are operational in the river basins of Tanzania and account for a total loading of 3,259 tonnes of BOD per year, 325 tonnes of total nitrogen per year and 209 tonnes of total phosphorus per year in the river streams. While total nitrogen and total phosphorus seem to be in the acceptable range, BOD is a concern. The amount of BOD equates to approximately 250 kg/day of loading per industry. However, this value is theoretical and may not be applicable for each industry present in the basin. Hence, it is imperative to have a detailed assessment of industrial wastewater generation and its characterization. The assessment should entail the quantification of effluent generated from each industry and the pollutant concentration—namely BOD, COD, Total P and Total N—in the generated effluent. Each industry should set up an effluent treatment plant (ETP) according to the characteristics of the effluent it generates.

Subsequently, sector specific guidelines shall be prepared detailing out best practices to reduce water consumption and wastewater generation and the treatment technologies for reducing the pollutant loading in the effluent discharged from industries. The use of these guidelines by industries, whether new or existing, will certainly reduce the industrial pollutant loading into Lake Victoria.

d. Solid waste management at lake shore colonies

A well-defined solid waste management system needs to be developed to remove the litter from fisherman colonies settled near the lake shore. This strategy will include collection, segregation and appropriate disposal of waste. A waste collection system for both dry and wet waste must be installed at these colonies to initiate the segregation process at the source. Respective local government authorities of the nearby area will be important stakeholders to make this measure effective. Awareness programmes must also be conducted in these areas to educate people about the waste management systems.

e. Strategy to treat water at discharge points of rivers into lake

Treatment facilities have to be provided at the points where rivers discharge into the lake. The facilities can be effluent treatment plants or stabilization/oxidation ponds. ETPs can be provided for the streams with low discharge whereas stabilization ponds can work for high discharge streams. The existing wetlands also need to be restored so they can continue to be used as stabilization ponds. A continuous water monitoring system should be installed at the discharge point of each river to monitor the pollutant concentration entering the lake. The BOD level of the stream at the discharge point should not be more than 10 mg/l. This will in turn help in assessing the efficiency of treatment facilities provided upstream. The data from these monitoring stations will also be important in developing a robust management strategy for Lake Victoria.

f. New inventory for identification of hotspots

As stated earlier, identification of hotspots is the key step for preparing action plans and thus needs regular updating. The existing data available for LVB is old and considering the rapid urbanization, population growth and industrialization, this data might not represent the actual pollution scenario. Hence, a need for updated information regarding the pollution load of river basins is essential for identification of new hotspots and subsequent decision making. For instance, a number of gold mining sites are operational near the river basins of Tanzania, a monitoring exercise shall be conducted in those location to understand any mercury and arsenic contamination in the water bodies.

Since the LVB has seven river basins, it will be prudent to come up with a pollution load of each river basin along with sources. It might not be feasible to commence the inventory of pollution load on all rivers together. A better option would be to initiate the process in a phase-wise manner, starting with the hotspot rivers as per the existing studies for the first phase.

g. Development of water quality monitoring network

LVEMP phases I and II have achieved many of their objectives in working towards rehabilitating the lake ecosystem. However, according to the LVEMP phase II report of 2018, monitoring of water quality has been the weakest in terms of implementation. It states that the intensity and coordination of water quality monitoring across the lake are not sufficient to show clear temporal trends. CSE is of the view that no action plan will work until we have good monitoring data from various polluting sources for different parameters and sampling frequencies. High-quality monitoring data will act as a tool for effective decision making. A robust management strategy is required to assess the changing quality of Lake Victoria. CSE will prepare a water quality monitoring network after consultative meetings with stakeholders and field visits to Lake Victoria.

h. Stakeholder identification

The environmental issues pertaining to Lake Victoria are multifaceted and thus involve a wide domain of stakeholders. The involvement of relevant stakeholders is an important aspect as their respective field expertise will help in obtaining significant information and relevant solutions to the issues. A few stakeholders have already been working for the improvement of Lake Victoria, including various ministries; regulatory authorities; city, municipal and district councils; research institutes; and non-governmental organizations. However, CSE is of the view that since the lake covers many rural areas which have limited or difficult accessibility, including the civil society as a stakeholder will enhance the outreach and implementation of the work. In addition, universities and other private organizations working on issues related to Lake Victoria should also be involved. The involvement of such stakeholders will help in understanding issues associated while implementation of any activity on the ground.

i. Formation of a committee

It is understood that Lake Victoria Basin Commission already exists to regulate and monitor the activities associated with the lake. CSE feels that a separate Committee should be constituted which will work for the part of Lake Victoria which is in Tanzania. The members of the committee shall be appointed from each stakeholder group so the committee can have members with diverse opinions who work together in a balanced manner by building consent. This committee will monitor the progress achieved in different aspects of lake restoration and will provide the way ahead as and when required. CSE can also be a member of the committee and provide inputs in its areas of expertise. Additionally, CSE and NEMC can come up with an online portal which will have updated information and data on Lake Victoria.

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Lake Victoria, despite being a source of livelihood for 45 million people, is on the verge of degradation. It has come under severe pressure from a variety of unsustainable human activities over the past five decades. This discussion paper aims to contribute to the process of cleaning Lake Victoria and making its use sustainable. It discusses the major water quality and environmental problems with Lake Victoria in order to provide general guidance on various aspects which will have to be monitored to develop a long-term management strategy for the lake.

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