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An Overview of the Main Environmental Issues Affecting Kisumu and Lake Victoria's Winam Gulf

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An Overview of the Main Environmental Issues Affecting Kisumu and Winam Gulf of Lake Victoria

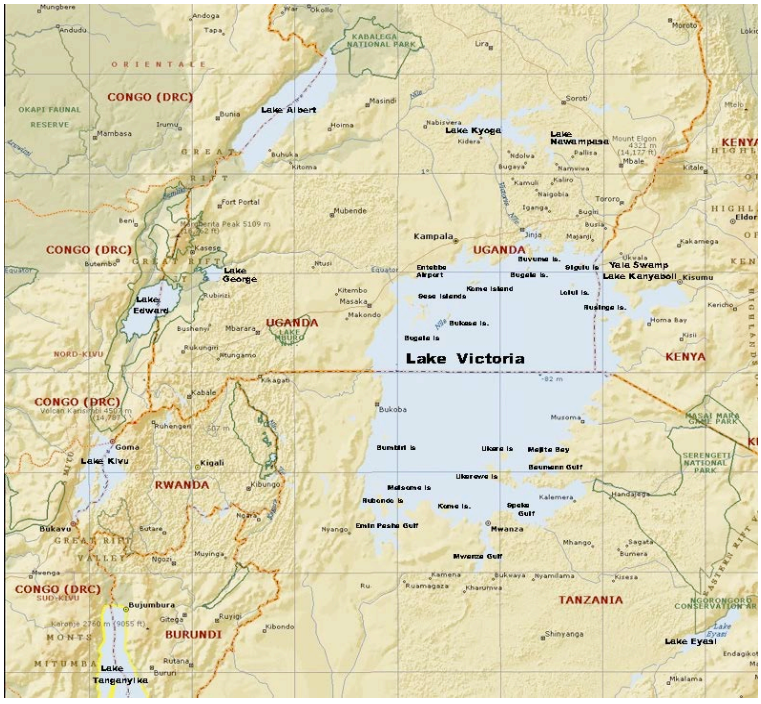
Background

This overview was produced in response to a request from the Mayor of Kisumu, who expressed the urgent need to deal with the deteriorating environment in and around the City and in the Winam Gulf of Lake Victoria. [1] Researched and written by experts at the Earth Institute, the Millennium Cities Initiative (MCI) and the environmental team of the MDG Centre in Nairobi, it describes and analyses the current environmental condition in Kisumu and its surrounding catchment; discusses some of the factors contributing to the ongoing degradation, and proposes a set of recommendations for constructive action. [2]

The study is sub-divided into the following sections:

- Lake Victoria and its Catchment Area
- Winam Gulf and its Catchment Area
- Kisumu City and its People, Water Supply, Sanitation and Waste Management
- Conclusions and Recommendations

Lake Victoria and its Catchment Area



[1] This course of action was discussed and planned in a December 2008 teleconference that included Professor Jeffrey Sachs, Dr. Susan Blaustein and Markus Walsh (in Kisumu) of EI, and Dr. Glenn Denning and Sharon Gordon of The MDG Centre, Nairobi.

[2] Sections 1 and 2 were prepared by Sharon Gordon, with input from Markus Walsh; section 3 was prepared by MCI researcher Andrea Castro and MCI Social Sector Research Manager Moumié Maoulidi; the recommendations were contributed by both teams.

Source: www.african-cichlid.com/Lake_Victoria_Map.htm

Lake Victoria is the second largest freshwater lake in the world, when measured by surface area and not by depth. It is bordered by Kenya, Tanzania and Uganda, with each country having 6 percent, 49 percent and 45 percent of the Lake respectively (again, by surface area). Burundi and Rwanda, although not riparian, lie within the catchment area of the Lake and are therefore also important, when considering any environmental management recommendations. The Lake stretches approximately 412 km from north to south and 335 km from west to east. It has a volume of 2,760 km^3, an average depth of 40 meters and a surface area of 69,485 km^2.

Lake Victoria has a catchment area of about 193,000 km^2 and currently supports approximately 30 million people (Kiwango and Wolanski, 2008). The Lake has a highly indented shoreline of about 3,460 km and many islands. The flushing time (volume/average outflow) is 123 years, and the residence time is about 23 years. This long retention time means that contaminants and pollutants entering the Lake are likely to remain there for a considerable time. Modified after Kayombo and Jorgensen (2006), the major environmental threats to Lake Victoria can be summarized as:

- High population density in Kisumu and other primary and secondary towns that contribute to pollution 'hot spots' caused by insufficiently managed human waste (both liquid and solid), urban runoff and effluent discharges from basic industries[3].
- Increasing nutrient inflow (nitrogen and phosphorous) to the Lake from both the atmosphere and rivers resulting in a five-fold increase in algae growth since the 1960s and deoxygenation of the waters. This in turn threatens the survival of deep-water fish species and ultimately all life forms.
- Proliferation of the accidentally introduced water hyacinth, *Eicchornia crassipes*, due to the nutrient-rich waters which has both negative and positive impacts.
- The conversion of wetlands in the catchment into agricultural land for crops, pasture for livestock and the utilization of the clay for bricks, thereby compromising the buffering and screening capacity of the wetlands for the Lake, again leading to nutrient enrichment of the Lake.
- The conversion of forests and flood plains into agricultural land for crops and pasture, thereby increasing sediment-laden runoff and causing nutrient enrichment of the Lake.
- The introduction of two exotic fish species into the Lake, namely the Nile perch, *Lates niloticus,* and the Nile tilapia, *Oreochromis niloticus,* which have considerably reduced the biodiversity of the Lake, but have contributed to a large and important fishery -- probably the largest freshwater fishery in the world. Annual catches are in the order of 300,000 tons worth more than $600,000 per year (Kayombo and Jorgensen, 2006).
- A limited increase in inflows of pesticide and herbicide residues from farming and heavy metals from artisanal gold mining activities mainly from the Mwanza area, since the 1960s.
- An increase in hydrocarbon pollution from a modest increase in shipping traffic since the 1960s, near-shore hydrocarbon-related activities (such as the fueling of ships, lorries and vehicles and the washing of lorries and vehicles within 500 meters of the Lake) and the continued disposal of bilge water from all ships and ferries directly into the Lake.

[3] Basic industries are breweries, tanneries, fish processors, sugar factories, coffee washing stations and abattoirs.

- A 2.5 meters decrease in the Lake level between 2000 and 2006. Approximately 80 percent of the Lake's water comes from rainfall and 20 percent from Lake Basin discharge. Recent research suggests that this decline in the Lake level is attributed to increased discharge from the expanded Owen Falls dam (Awange et al, 2007).

Winam Gulf and its Catchment Area

Photograph courtesy of Markus Walsh

Winam Gulf is a large, shallow inlet connected to Lake Victoria by Rusinga Channel, which is only 3 km wide, thus restricting water circulation. Prior to 1980, when the causeway between Rusinga Island and the mainland was built, there was better circulation of waters, due to dual flow to the north and south of Rusinga Island, but also because the channel to the south was deeper and allowed for greater water flow.

The port of Kisumu, Kenya's third largest city, stands on the northeastern shore of Winam Gulf. It is estimated that the city has a population of approximately 400,000 in 2009. In 1999, the district had a population of half a million and while the official growth rate is estimated to be 2.0 percent for the district, unofficial estimates put the growth rate at over 6 percent, particularly for the municipality. This suggests that the population of the district is likely to be approaching 900,000 in 2009. The Gulf has an average width of 25 km (but a maximum width of about 100 km), extends for about 64 km from Kisumu to Rusinga Channel and has a shoreline of about 550 km. The Gulf is shallow, with an average depth of 6 meters and a maximum recorded depth of 68 meters.

The catchment of Winam Gulf supports about 4.5 million people (Njuguna et al, 2006). The major activity in the catchment is subsistence agriculture, which has increased to match the needs of the growing population. This has caused soil erosion, sediment-laden run-off and ultimately turbid rivers. Four major rivers, Sondu-Miriu, Kibos, Nyandao and Kisat, discharge an average of $231 m^3 s^{-1}$ into the Lake, which constitutes 37.6 percent of surface water inflows into the whole of Lake Victoria (Osumo, 2001).

The main environmental issue affecting Winam Gulf is eutrophication of the shallow inlet. The key sources of the nutrients are understood to be the sediment-laden rivers, untreated sewage and run-off from Kisumu and other towns, combined with increased absorption of nitrogen and phosphorous from the atmosphere. While the first three sources of nutrients are predictable, the increase in atmospheric deposition is not obvious and is still contested by some local scientists (Kayombo and Jorgensen, 2006). It is, however, attributed to the changes in land use, particularly the frequent burning of unwanted vegetation cover, dust and vehicle and industry emissions.

Eutrophication of the Lake waters has caused the proliferation of the invasive alien species *Eicchornia crassipes,* more commonly known as the water hyacinth, which is endemic to South America. It was first reported in the Ugandan part of Lake Victoria in 1990 and is generally thought to have entered the Lake via the Kagera River from Rwanda (Osumo, 2001). It is a free-floating plant that draws its nutrients from the water and has been used effectively in wastewater treatment plants. It comprises 95 percent water and 5 percent dry matter. Of the latter, 50 percent is silica, 30 percent potassium, 15 percent nitrogen and 5 percent protein[4]. Water hyacinth is now found in most African countries and is a problem in part due to the lack of naturally occurring predators for it in Africa.

A number of papers have described its impacts, which include restricting the exchange of oxygen across the air/water interface and generating large amounts of organic matter that increase the biological oxygen demand and reduce water quality. This has caused fish kills and a loss of biodiversity. In extreme situations, it can cause anoxic conditions, which gives rise to high levels of iron, manganese, ammonia and hydrogen sulphide. It has also blocked Kisumu and other harbors, the hydroelectric plant at Owen Falls in Uganda, irrigation channels, fish, landing piers and beaches. It has resulted in an increase in water-borne diseases, such as malaria, bilharzia and lymphatic filariasis.

It can be removed by mechanical, biological and chemical methods, and all three approaches have been piloted during the Phase I Lake Victoria Environmental Management Project (1997-2004). The mechanical method involves shredding of the plant and allowing it to sink to the bottom of the Lake. Of course, removal of the hyacinth from Lake to land could be an option, but the energy requirements and costs are significantly higher.

The biological method involves the rearing and releasing of two species of water hyacinth weevil, *Neochetina eichhorniae* or *Neochetina bruchi*, which are also endemic to South America. Osumu, 2001, reported that this method during pilot trials was found to be ineffective because

[4] Makhanu (1997) as reported in Osumo (2001).

the water hyacinth doubles its biomass every 6 to 18 days, the weevils could not keep pace and could not withstand the heavy rainfall that occurs over the Lake. However, Kayombo and Jorgensen (2006) indicate that biological control has been successful, and a further positive effect has been the involvement of local communities in the rearing and distribution of the weevils.

The chemical method involves the use of herbicides. Herbicides used in the USA and other places include 2,4-d Diquat and Glyphosphate. However, it is not clear whether either of these herbicides has actually been used in Lake Victoria. There are reportedly good success rates for the removal of small infestations of hyacinth, but the effectiveness is diminished as the area of hyacinth cover increases. In addition, there are serious environmental and health concerns, especially in the case of Lake Victoria, which is the drinking water source for so many people and livestock.

While the negative impacts outweigh the positive ones, two notable positive impacts are the hyacinth's ability to accumulate heavy metals and reports of increased fish diversity in the Kenyan parts of Lake Victoria, with the reappearance of *Protopterus aethiopicus* and *Clarias gariepinus* (Ogari, 2001).

Kisumu City and its People, Water Supply, Sanitation and Waste Management

The city of Kisumu is located next to Lake Victoria, the second largest fresh water lake in the world; yet the city is characterized by chronic water shortages, poor water quality and inadequate sanitation services. In September-October 2008, a Millennium Cities Initiative (MCI) researcher travelled to Kisumu, Kenya, to conduct the UNDP's Millennium Development Goals (MDG)-based water and sanitation needs assessment, to determine the measures needed to improve access to environmentally sound water and sanitation services. Efficient delivery of water and sanitation services and a summary finding of the needs assessment as well as findings from other research are presented.

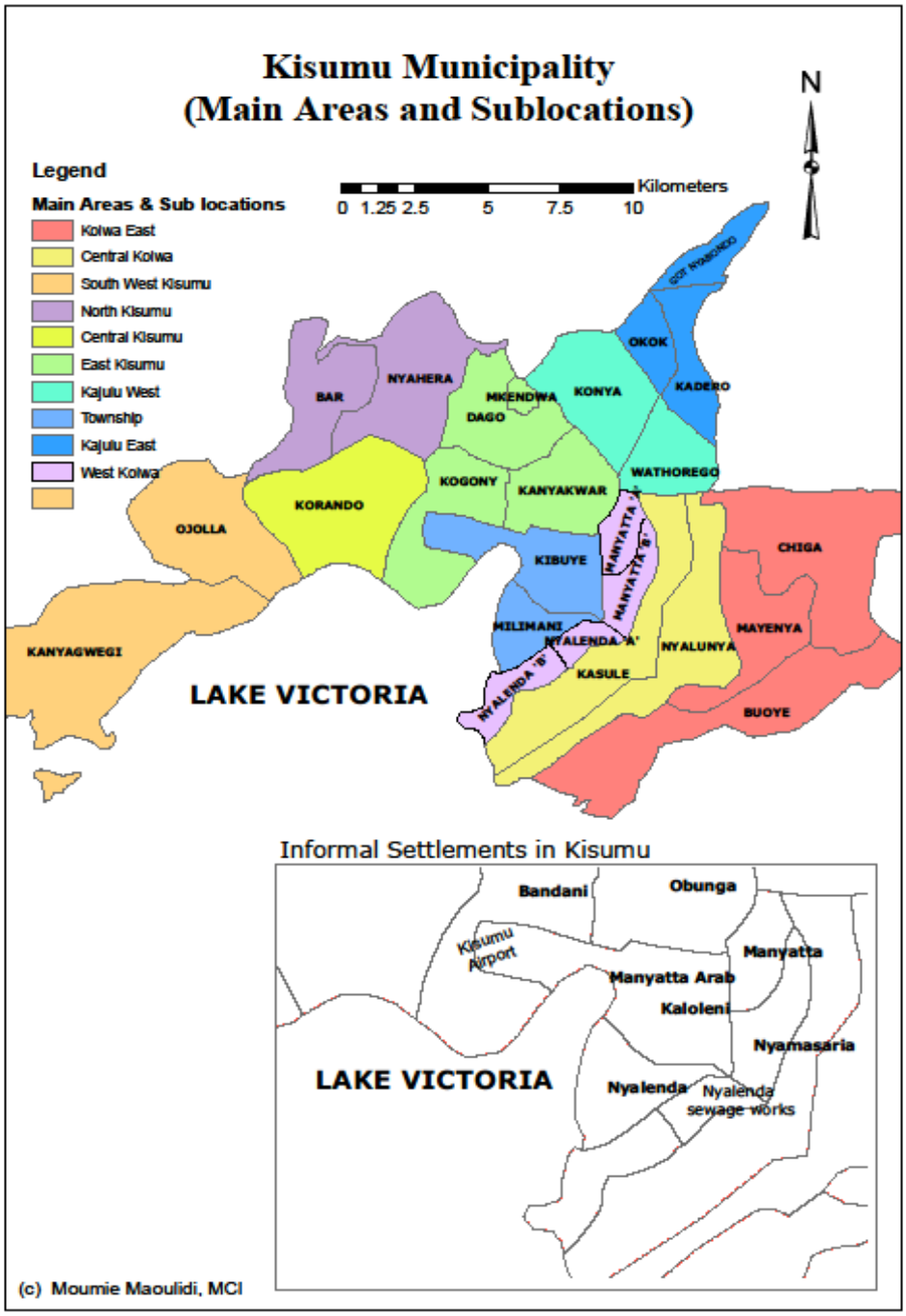
Thirteen percent of Kisumu residents use piped water that is delivered to dwellings or compounds, 63 percent rely on kiosks and public taps while 24 percent depend on other sources, including vendors, open wells, streams and ponds (CRC, 2007). Only about 24 percent of the population has access to a private flush toilet, while 37 percent have access to private pit toilets, 34 percent use shared toilets and 5 percent rely on open defecation (CRC, 2007). In order for Kisumu City to achieve Target 7C (formerly Target 10) of Millennium Development Goal #7 -- to cut in half, by 2015, the proportion of people without access to safe drinking water and basic sanitation— particular attention needs to be paid to rehabilitating and expanding the water supply and sanitation infrastructure.

Research on the water sector in Kisumu City shows that population growth outstrips water production, and existing infrastructure is operating at between 85 and 93 percent of maximum design capacity.[5] There is also evidence that the water quality is low, while the cost of vendor-provided water is unreasonably high (LVSWSB, 2008; CRC, 2007). Table 1 presents the 1999

[5] Information provided by Kisumu Water and Sewarage Company (KIWASCO)

population and projected population figures for the period after the 1999 census, which are based on Central Bureau of Statistics' (CBS) recommended growth rate of 2.8 percent. It is projected that the city's 2006 population was 392,615, and it is expected to reach 451,614 by 2011. As the population and total water demand increases, there is an urgent need to rehabilitate and improve water supply facilities.

Map of Kisumu Municipality Showing Main Areas and Informal Settlements



The Municipal Council of Kisumu (MCK) owns all water and sewerage facilities in the city. However, since the passage of the Kenya Water Act in 2002, which separated the functions of policy formulation and regulation from service provision, the task of efficient and economical provision of water and sewerage services has been devolved to Water Service Boards. In line with the requirements of the 2002 Water Act, the MCK has taken steps to privatize the water supply and sewerage service provision. Since 2003, the agency responsible for executing and implementing water projects, as well as licensing water service providers, is the Lake Victoria South Water Services Board (LVSWSB). The largest provider of piped water and sewerage services is the Kisumu Water and Sewerage Company (KIWASCO). There are also small-scale community water and sanitation service providers in town.

Most of the water in Kisumu is obtained from Lake Victoria, with a small percentage extracted from the Kibos River. There are currently two raw water intake points on Lake Victoria and one intake at Kajulu. The water from Lake Victoria is treated at the Dunga Water treatment plant, located 0.6 km from the intake, and is then pumped to a storage tank in Kibuye, while the water from the Kibos River is treated and then flows by gravity to a reservoir. A 2008 study reports that the water supply facilities had a design capacity of 22,700 m^3/day, but were operating at a capacity of 18,700 m^3/day, with Kajulu supplying 1,700 m^3/day and the Dunga treatment plant producing 17,000 m^3/day (LVSWSB, 2008). The study estimates the demand in 2007 at 47,700 m^3/day, leaving Kisumu with a supply deficit for that year of over 29,000 m^3/day.

Efforts to reduce the proportion of Kisumu residents without sustainable access to water are constrained by several factors:

1. First, the existing water supply facilities were constructed over 50 years ago and were designed to cope with a much smaller demand. Given the city's rapidly increasing population, water supply shortages are likely to worsen, unless existing facilities are expanded.
2. Second, facilities such as the Dunga and Kajulu plants have not been properly maintained and, as a result, have not been operating at full capacity.
3. Third, in low-income areas, the existing water supply does not meet the demand. Some residents in these areas have access to piped water provided by water kiosks and handcart vendors, but these providers charge fees far higher than the cost of receiving water directly through the supply meter. The poor who access water through kiosks in Kisumu spend an average Kshs. 55 ($0.73) per cubic meter of water (CRC, 2007). As a result, many low-income residents rely on alternative water sources, such as shallow wells, boreholes, springs, rivers and streams.

The reliance on shallow wells and boreholes is problematic because water from these sources is of poor quality. Kisumu City has high water tables; consequently, boreholes are easily contaminated by overflowing pit latrines, poor wastewater management and inadequate drainage systems. Many residents in peri-urban areas also use shallow well-water situated in close proximity to the pit latrines, thereby increasing the chances of cross-contamination, especially during the rainy season. The contamination of groundwater by overflowing pit latrines and inadequate drainage are a major concern because they contribute to outbreaks of diseases such as diarrhea, cholera, typhoid, dysentery and malaria.

Table 1 presents the city's population in 1999 and the projected populations in 2006, 2011 and 2015. These figures are different from those in publications such as LVSWSB (2008) because the latter only covers Central and West Kolwa, Central & East Kisumu, East and West Kajulu, parts of East Kolwa, Manyatta and Township.

In 2006, about 81 percent of the poor and 93 percent of the non-poor residents of Kisumu City treated water before drinking by either boiling, using chemicals and/or filtering (CRC, 2007). Several methods of point-of-use water treatment are available on the market in Kisumu City, including Water Guard (a form of chlorination).

With regard to sanitation, there is a need to expand coverage within the informal settlements (Manyatta, Nyalenda, Obunga, and Bandani), where 60 percent of Kisumu City residents live. Pit latrines are the main type of sanitation in these areas, but many latrines are poorly constructed and tend to collapse or over-flow during the rainy season. There is, therefore, a need to invest in technologies such as Ecosan toilets[6] and condominium sewers. In Nyalenda, one of the largest informal urban settlements in Kisumu, there is also a need to improve drainage channels. Nyalenda residents experience major drainage problems because they rely on naturally formed open gullies as drains. Standing water is common in many areas.

There is also a need to build new wastewater treatment plants. With population growth, the volume of wastewater to be treated is likely to increase from 29,000 to 60,000m^3/day, at an estimated cost of Kshs. 745 million (ca, $9.93 million).

One management issue requires urgent attention: currently, the City itself (the MCK) is responsible for environmental sanitation services, as well as pit latrine/septic tank drainage, although it has long been planned for the LVSWSB and KIWASCO to assume responsibility for all drainage services. No date has been set for this transition and the delay has impeded action and accountability. A legal impediment also needs to be addressed: existing MCK sanitation by-laws, dating from 1954, recognize only sewer, septic tank and conservancy tanks -- not pit latrines -- as legal structures. Part of the difficulty here is the presence in Kisumu of black cotton soils, which are not conducive to pit latrine construction, as they are loose, and latrines built on them are prone to collapse. Nonetheless, the by-laws need to be amended, because the current laws hinder the proper construction, operation and maintenance of much-needed pit latrines.

[6] Eco-san, or ecological sanitation, is a new paradigm in sanitation that recognizes human excreta and water from households not as waste, but as resources that can be recovered, treated where necessary, and safely used again.

Ideally, eco-san systems enable a complete recovery of nutrients in household wastewater and their reuse in agriculture, thereby helping to preserve soil fertility and safeguard long-term food security while minimizing the consumption and pollution of water resources. (Source: WatSan Resource Centre (Uganda, http://www.watsanuganda.watsan.net/page/121)

Table 1: Kisumu City Population (1999, 2006, 2011, 2015), by Area

Area	1999	2006	2011	2015	Area (Sq Km)
Central Kisumu	**14,950**	**18,187**	**20,920**	**23,399**	**17.2**
Korando "A"	9,538	11,603	13,347	14,929	9.5
Korando "B"	5,412	6,584	7,573	8,471	7.7
Central Kolwa	**19,387**	**23,585**	**27,129**	**30,344**	**36**
Kasule	10,701	13,018	14,974	16,749	20.4
Nyalunya	8,686	10,567	12,155	13,595	15.3
East Kajulu	**12,064**	**14,676**	**16,882**	**18,882**	**15.3**
Got Nyabondo	3,483	4,237	4,874	5,452	5.1
Kadero	5,304	6,452	7,422	8,302	6.6
Okok	3,277	3,987	4,586	5,129	3.6
East Kisumu	**27,626**	**33,608**	**38,658**	**43,240**	**32.6**
Dago	4,422	5,379	6,188	6,921	10.2
Kanyakwar (Obunga)	8,576	10,433	12,001	13,423	8.5
Kogony (Bandani)	13,961	16,984	19,536	21,851	13.1
Mkendwa	667	812	933	1,044	0.8
East Kolwa	**15,843**	**19,273**	**22,170**	**24,797**	**56**
Buoye	4,586	5,579	6,417	7,178	22.2
Chiga	7,109	8,648	9,948	11,127	22.2
Mayenya	4,148	5,046	5,804	6,492	11.6
Kondele	**69,521**	**84,574**	**97,283**	**108,813**	**4.8**
Manyatta "A"	41,910	50,985	58,646	65,597	2.0
Migosi	14,771	17,969	20,670	23,119	1.7
Nyawita	12,840	15,620	17,968	20,097	1.1
North Kisumu	**16,337**	**19,874**	**22,861**	**25,570**	**30**
Bar "A"	3,709	4,512	5,190	5,805	6.5
Bar "B"	3,605	4,386	5,045	5,642	7.9
Nyahera	9,023	10,977	12,626	14,123	15.9
S.West Kisumu	**18,831**	**22,908**	**26,351**	**29,474**	**50**
Kanyawegi	5,846	7,112	8,181	9,150	17.1
Ojolla	6,841	8,322	9,573	10,707	17.0
Osiri	6,144	7,474	8,598	9,616	16.0
Township	**40,295**	**49,020**	**56,386**	**63,069**	**14.2**
Bandari	7,039	8,563	9,850	11,017	5.7
Kaloleni	13,515	16,441	18,912	21,153	2.1
Northern	10,117	12,308	14,157	15,835	1.3
Southern	9,624	11,708	13,467	15,063	5.1
West Kajulu	**17,478**	**21,262**	**24,458**	**27,356**	**22**
Konya	10,308	12,540	14,424	16,134	11.9
Wathorego	7,170	8,722	10,033	11,222	9.8
West Kolwa	**70,402**	**85,646**	**98,516**	**110,192**	**12.2**
Manyatta "B"	21,027	25,580	29,424	32,911	3.3
Nyalenda "A"	23,731	28,869	33,208	37,143	2.8
Nyalenda "B"	25,644	31,197	35,885	40,137	6.1
TOTAL	**322,734**	**392,615**	**451,614**	**505,136**	**290**

Source: 1999 figures are from Government of Kenya 1999 Census. 2006, 2011 and 2015 figures are projected using a 2.8 percent growth rate and an exponential growth formula.

What is being done?

KIWASCO currently meets about 40 percent of the water demand (LVSWSB, 2008). Water is delivered to the population via individual connections, yard tap connections, public tap connections and water vendors. As of September 2008, KIWASCO had 7,704 domestic water connections (9,300 total including commercial and institutional) and 287 water kiosks. However, the current billing and revenue collection system of KIWASCO is ineffective and needs to be replaced by an up-to-date customer database (LVSWSB, 2008). In addition, many water connections in informal settlements are illegal, resulting in financial losses for KIWASCO.

To improve the quality and increase the supply water in Kisumu City and thereby reduce the water deficit, several projects have been initiated. The Agence Française de Development (AFD) has pledged a Kshs. 1.7 Billion [20 Million Euros] soft loan aimed at upgrading and expanding the existing water infrastructure. The project is being implemented in two phases. The first phase, known as the Short Term Action Plan (STAP), for which 30 percent of the loan (6 Million Euros) was allocated, sought to rehabilitate water intakes, water treatment plants, water storage facilities, sewers and sewerage treatment plants and has been completed. Under STAP, a new 600mm pipe was built to bring water from the Dunga treatment plant to Kibuye reservoir, and improvements in waste stabilization ponds were also undertaken. The main achievements of STAP have been: 1) the extension of the water network to informal settlements; 2) the construction of more water kiosks, and 3) bringing the plants up to their original design capacity, as previously the plants had been operating below capacity due to poor management.

The main goal of the second phase of the AFD project, known as the Long Term Action Plan (LTAP), is to increase water and sanitation coverage by building new intakes, new treatment plants and a new sewerage system. Seventy percent of the loan [14 Million Euros] has been allocated to LTAP.

Another project supported by AFD is a pilot program to study and finance the provision of water and sanitation services in the informal settlements of Manyatta and Nyalenda. The project seeks to provide connections to water services and public bath houses/sanitation facilities for inhabitants in these two communities, but is still in the early stages. The eligibility for Global Partnership on Output Based Aid (GPOBA) subsidy funding for the project, known as Extension of Water and Sanitation in Low Income Areas, was approved in March 2006, but no funds have as yet been disbursed.

Non-governmental organizations such as World Vision, Sustainable Aid in Africa (SANA) and Undugu Society are also currently involved in water and sanitation programs in Kisumu's informal settlements. World Vision operates child-focused programs in Obunga and Bandani, while SANA's focus has been hygiene education and community-based water and sanitation provision in peri-urban and low income settlements of Kisumu City. SANA particularly for the last six years, SANA has supported community-based WATSAN projects in Kisumu City, serving a total of 31,000 consumers directly (see details per project in the annex below). The Undugu Society came to Kisumu in 2003, initially as a youth and street children education program. Since 2005, the society has developed a water and sanitation component and has built more than six public latrines in Manyatta (LVSWSB, 2008).

Additional Challenges

Solid waste management also needs to be addressed. It is estimated that only 20 percent of the solid waste generated in the municipality is collected (MCK, 2004). Many households, particularly in the peri-urban areas, have no access to public or private waste collection and have resorted to burning or burying their waste. Some common dumping grounds have developed on open lands within densely populated neighborhoods. The poor management of solid waste blocks sewers and drainage systems and contributes to the generation of leachates, which pollute the ground water and soil. Fortunately, about 63 percent of the waste generated in Kisumu is organic; hence there is enormous potential for recycling for farm use (UN-HABITAT, 2008). Additional recycling possibilities affording micro-enterprise opportunities for a significant number of city inhabitants include the reuse and recycling of paper, plastic and metals.

Recommendations

The environmental problems afflicting Lake Victoria are trans-boundary and therefore require an ecosystem approach and unified commitment and action by all five countries in the catchment. The framework to take forward the necessary management is largely in place, with the East African Community (EAC), the Lake Victoria Fisheries Organisation (LVFO) and the Lake Victoria Environment Management Project (LVEMP). In particular, the three riparian countries have already demonstrated that they can work well together with the coordinated approach to Lake-wide fisheries management, when they were threatened with fish export bans to the EU. However, the five countries now need to demonstrate similar resolve towards the environment, specifically, eutrophication, infestation of the water hyacinth, dropping water levels, loss of biodiversity and associated impacts for any medium to long-term future of the Lake.

For example, while the impacts of eutrophication should not be underestimated, a number of relatively simple management measures could significantly reduce the extent of eutrophication. These include:

1. Enforcement of riparian boundary protection and management. Land is generally cultivated to the edge of the Lake and to the edge of all rivers in the catchment. Laws exist limiting cultivation to within +/- 6m of a river edge and the high water mark of the Lake shoreline. These laws need to be urgently enforced and the fringing papyrus and wetlands within the catchment actively managed. Kiwango and Wolanski (2008) go as far as to suggest that the future of the Lake will actually be determined by how well the fringing papyrus is managed.

2. Enforcement alone will fail without major social change in the catchment. There are excellent examples of community involvement in the rearing and distribution of the weevils to control the hyacinth. The community in the catchment needs to brought on board to manage sediment and pollution into the Lake, among the other key environmental issues. Programs need to be implemented starting in Kisumu and the other primary towns, radiating out to the secondary towns and finally aiming to reach all communities in the catchment.

3. It has been clearly shown that with sufficient resources, the water hyacinth can be controlled and managed with either mechanical and/or biological methods. Practical uses of the hyacinth need to be thoroughly reexamined. In Bangladesh, both paper and fiber board are made using the hyacinth. In the Far East, the hyacinth is used as a component for particular animal and fish feeds. It is also an excellent green manure. At one stage in Kenya consideration was given to the manufacture of charcoal briquettes, and in other places it has been considered for biogas production. A Nairobi-based African crafts firm has trained hundreds of farmer women and others to make beautiful handicrafts (e.g., baskets, bags, frames, sculptures) out of the hyacinth and has offered to do so in Kisumu.

4. Other priority recommendations include continuing the research to better understand the sources of increased atmospheric nitrogen and phosphorous absorption; mitigation options against future Lake level declines, and protection of the Lake's and catchment's biodiversity. In order for policy makers to make informed decisions, much more economic information is required on the costs and benefits of environmental programs. For example, it is frequently stated that there are insufficient resources to control the hyacinth. However, if the costs of improved water treatment, the costs of decreased fish catches and the costs of increased water-borne diseases are calculated, it is likely that resources needed for hyacinth control are modest in comparison.

Specifically, for Kisumu City, the recommendations include:

5. Planning for water supply to actually meet water demand. A dam should be built on the Kibos River to provide approximately 120,000-390,000 m^3/day through a gravity system, which could satisfy the demand of 3-9.75 million people. This is vital because it is estimated that the water demand in Central and West Kolwa, Central and East Kisumu, East and West Kajulu, parts of East Kolwa, Manyatta and Township totaled 43,462 m3/day in 2006, and it is forecast that by 2011, the demand will increase to 49,413 m3/day (LVSWSB, 2008). KIWASCO simultaneously needs an effective billing and revenue collection system.

6. A special initiative needs to be undertaken to support Rehabilitation/Augmentation of the Community Managed Micro Water Systems with potential for wider coverage. This would include Rabuor Water Supply, Wandiege Water Supply, Asengo Water Supply, Gita Water Project, Paga Water Project etc. This can be done through a combined grant and credit scheme, using the SANA Credit for Water Development Programme or Output-Based Aid approach.

7. Improved water supplies need to be matched by improved sanitation and wastewater treatment facilities. Sold waste collection, transport and disposal also requires improved management. The UN (March 2008) has observed that, for every $1 invested in sanitation, $9 are returned, in terms of improved productivity, health and other benefits. Sanitation levels normally lag well behind water supply, and Kisumu is no exception. MCI Health Center and Dispensary water, sanitation and solid waste recommendations must be implemented, at a cost of Kshs. 11.23 million [ca. $150,000]. In addition, the by-laws of Kisumu from 1954 should be urgently amended to facilitate and encourage the proper construction, operation and maintenance of pit latrines for the City.

8. Mass media campaigns should be introduced, publicizing the proper use of water treatment products, especially during the rainy season, when contamination of water sources and cholera outbreaks are most likely. Arrangements need to be made to ensure that water treatment products are available at an affordable price in all communities. In addition, awareness and education programs need to deal with other key environmental issues in the City.

9. As a first step, primary school urgent action items, estimated at Kshs. 31.8 million [$425,000], include the following: a) supplying all 48 schools that currently use an unimproved water source with a rainwater catchment reservoir; b) providing enough toilets so that the toilets are not overused; c) providing urinals and hand washing facilities for schools that currently lack them (based on responses to questionnaires submitted by 67 of 114 primary schools), and d) conducting a workshop, to be led by public health officials, for all school headmasters and one teacher per school, to prioritize hygiene education in schools and to work with teachers to develop low-cost methods of implementing hygiene interventions (estimated at Kshs. 353,600 [$4,715]). All Constituency Development Funds (CDF) might be approached to allocate a "ring-fenced" budget amount (say 5 percent of their total annual budget) to support water, sanitation and hygiene promotion in primary schools.

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ANNEX: COMMUNITY MANAGED WATSAN PROJECTS SUPPORTED BY SANA IN KISUMU

Project Name	Techno-logy	Population Served	Donor	Potential For Expansion / Higher Coverage
Wandiege Water Supply (Manyatta B)	Borehole	7,500	Cordaid, French Embassy, CDF, Community	Require approximately 10million to triple coverage to 25,000
Rabuor Water Supply	Borehole	3000	Dutch Embassy, SANA/WPI/USAID, CDF, Redcrosss	Require 13.2 Million to Tripple coverage to 10,000 people
Asengo Water Supply	Spring	3500	SANA/WPI/USAID, Polish Embassy, CDF and Community	Require 5 Million To Double Coverage to 7000
Kamrongo Water Project	Borehole	2000	MWA/CocaCola Africa Foundation	Require Electrification and minor extension at a cost of 3 million to double coverage
Chiga Water Project	Borehole	2000	MWA/CocaCola Africa Foundation	Require Electrification and minor extension at a cost of 3 million to double coverage
Mayienya Water Project	Borehole	2000	MWA/CocaCola Africa Foundation	Require Electrification and minor extension at a cost of 3 million to double coverage
Mbeme Water Project	Borehole	2500	MWA/CocaCola Africa Foundation	Require Electrification and minor extension at a cost of 3 million to double coverage
Nawa Water Project	Borehole	2000	French Embassy	Require Electrification and minor extension at a cost of 3 million to double coverage
Orongo Water Project	Borehole	1000	Simavi	Require Electrification and minor extension at a cost of 3 million to double coverage
Nyaimbo Water Project	Borehole	1000	Simavi	Require Electrification and minor extension at a cost of 3 million to double coverage
Buoye Water Project	Borehole	1000	Simavi / Big Lottery Fund	Require Electrification and minor extension at a cost of 3 million to double coverage
Gita Water Project	Spring	1000	Cordaid,	Spring can be upgraded to a reticulated system and double coverage at a cost of 5million
Bandani Watsan Project	Shallow Wells and Spring	3000	Dutch Embassy	Require electrification and a borehole to augment current source at a cost of 3 million to double coverage
Obunga Water Project	Kiwasco Pipeline	3000	Cordaid	Require 4 million to adopt Delegated Model Approach and double coverage
Total		**34,500**		Approximately Kshs 65m (866,667 US$) is needed to double the current coverage in the informal and periurban settlements using community managed water schemes.