WASPA Youth and Women Water & Sanitation Conference 2021

Sustainability of Water Supply Reservoirs Located in Urban and Peri-Urban Areas

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Abstract

Dams in Kenya play a very vital role in provision of water for domestic use. When such dams are located in urban and peri-urban areas, issues that affect their sustainability are therefore important since they further reduce fresh water availability, which currently is less than 500 cubic meters per capita per year in Kenya. Studies have shown that publicity and media reporting of environmental concerns has a great impact on how the environmental resources are managed. However, not all environmental concerns get the same level of attention and reporting by media in Kenya. People abundantly turn to media to help make sense of the many complexities relating to environment.

A content analysis of media publications on Nairobi and Kiserian dams, located in an urban and peri-urban areas, respectively was carried out. Using Google and Google Scholar search engines, keywords and related words from the study objectives were used to extract information from media publications with regard to prohibited activities on riparian land and in the reservoir, economic activities, people and organisations involved, intervention measures taken and their effectiveness.

It was established from the content analysis that solid waste and wastewater disposal on a riparian land have the most influence on reservoirs in urban and peri-urban areas. The ecological, social and economic impacts arising from the activities on the two reservoirs include deterioration of water quality, changes in the aquatic ecosystems, degradation of riparian land, loss of water supply, loss of recreational value of the dams, loss of aesthetic and recreation values of the dams, negative health outcomes and risks, human conflicts, lost productivity, cleanup costs, increased water treatment costs, among others. The media reports highlighted the intervention measures needed to address the challenges facing urban and peri-urban water supply dams including addressing sanitation and wastewater management, upstream and riparian land use, participation of stakeholders, enforcing legislation, use of data in decision making, financing and lastly, sustained rehabilitation &restoration of the dams.

The study establishes that Environmental Management Plans are not followed after project implementation and therefore seen as a failure of the regulators to perform their important roles. Media is therefore trying to fill this gap through publicity on prohibited activities, impacts and preventive measures.

Keywords: Riparian; water supply reservoirs; Sanitation; media content analysis

1.0 Introduction

The need to maximize the benefits from existing as well as new dams in a water scarce country like Kenya cannot be overstated. Dams are useful in the management of water resources in the country as well as in water supply (UN-Water, 2006).However, a number of factors within a catchment work against obtaining maximum benefits from them; the main being increasing population and economic activities. Uncontrolled population growth and economic activities result in water degradation mainly from poor disposal of wastes such as solid, industrial and human wastes. When the reservoirs border informal settlements as the case is for the Nairobi and Kiserian dams, lack of adequate sanitation worsens the situation for water reservoirs (UNEP, 2009). Water resource degradation therefore exacerbates the costs arising from climate variability and climate change. Such costs include ecological and social effects.

This study focused on two dams; Nairobi and Kiserian Dams located in urban and peri-urban areas, respectively. Though the dams were constructed and operational at different times, both suffer the consequences of unsustainable land use sanitation practises in their respective catchments. Rapid urban population growth in the catchment that does not match and sanitation infrastructure provision is responsible for deteriorating ecosystems (Mazhindu, Gumbo &Gondo, 2012). The purpose of this study therefore was to establish the influence of dam riparian land use on sustainability of water supply reservoirs located in urban and peri-urban areas. The objectives of the study were: To establish the reservoirs riparian land use activities; to analyze their effects on the water reservoirs and to analyze the interventions made to address the challenges facing the reservoirs.

The Water Resources Management Rules of 2006 outlines activities prohibited on a riparian land. These activities include: cultivation, clearing of indigenous vegetation, building of permanent structures, waste disposal, soil excavation, development of quarries and planting of exotic species. A riparian zone as defined by the Water Act 2016 is ‘the dynamic complex of plant, animal and micro-organism communities and their non-living environment adjacent to and associated with a watercourse’. Though the required width and structure of riparian zones are often defined by local or national laws, the zone should ideally retain the vegetation that was present prior to any disturbances. The width of the zone can vary from 3 to 50 meters on both sides of the water body (Grebner, Bettinger, & Siry 2013). For instance, in Kenya the width of

the riparian land adjacent to a lake, reservoir or stagnant body of water is minimum of two metres vertical height or thirty metres horizontal distance, whichever is less, from the highest recorded water level (quote the document with WRA rules, 2006).

2.0 Study area

The Nairobi dam was constructed in 1953 to provide emergency water supply to some parts of Nairobi in addition to providing recreation uses. The dam was also useful in providing important ecosystem services as an artificial wetland and also as source of fish for food. Due to the challenge of pollution, the dam was abandoned and all the initial uses and values lost. Attempts have been made to rehabilitate and restore the dam (UNEP, 2004; Reuters, 2019).One of the proposals put forth for ensuring sustainable clean-up of the dam is addressing the sanitation and drainage facilities in the catchment(Mulligan, 2018). Kiserian Dam on the other hand was started in 1992 to check flooding but stalled due to lack of funds. Later, it was completed and commissioned in 2013 to supply drinking water in Kajiado. This was seen as an opportunity in agriculture, recreation and other business ventures due to water availability. The dam is situated in an area that is not serviced by conventional sewerage systems and the population use pit latrines and septic tanks. The main risk that has faced the dam therefore is poor sanitation in its catchment. Figure 1.1 shows important timelines for the two dams.

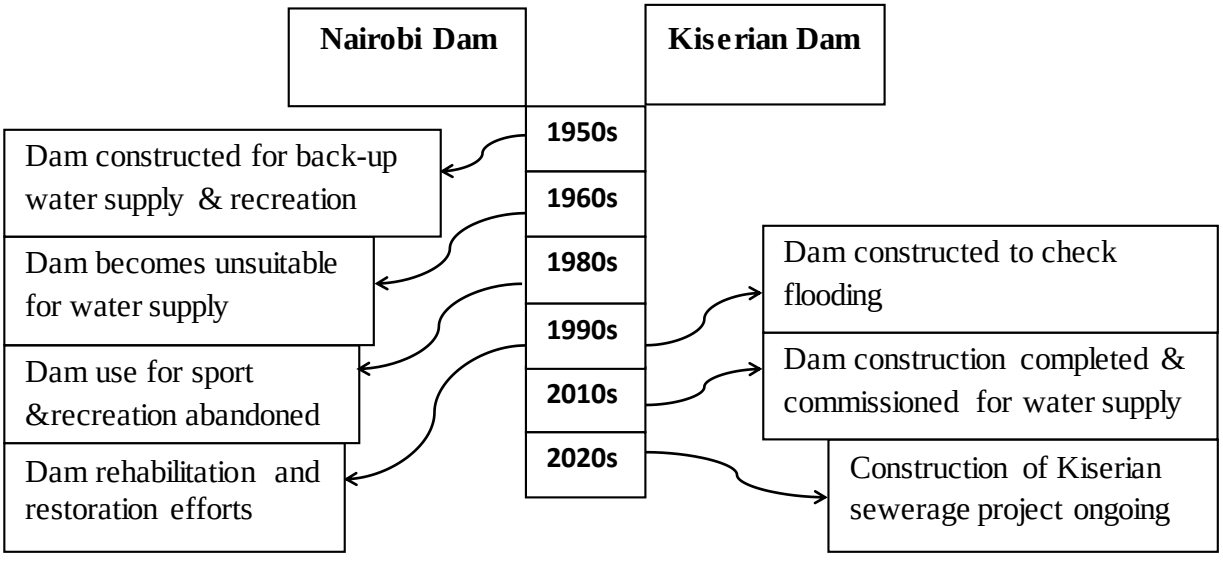

Figure 1.1. Important timelines for the dams under study

2.1 Data sources and analysis

Qualitative content analysis methodology according to White & Marsh, (2006), Mayring,(2014), and Kohlbacher, (2006) was followed. This methodology is appropriate for use in a case study research (Kohlbacher, 2006). It uses material which already exists in a finished form and due to its flexibility, it can be applied either as a method by itself or in conjunction with other methods (White & Marsh, 2006). Media publications were the main sources of data. The steps that were followed in this study are as described below;

Step 1: Data and information gathering using the three guiding questions below:

i. What are the prohibited land use activities within Nairobi and Kiserian dams' riparian land?
ii. What are the effects of these prohibited activities?
iii. What intervention measures are proposed or implemented to address the challenges?

Step 2: Identification of source of data/ information

Step 3: Establishment of key search categories and Information abstraction

i. Nairobi dam/Nairobi dam riparian
ii. Kiserian dam/Kiserian dam riparian

Step 4: Formulation of new categories

The new categories formulated were based on the findings from the first search. Three prohibited riparian land use i.e. waste disposal, building of permanent structures and cultivation. These terms were combined with either Nairobi dam or Kiserian Dam and this yielded further results.

Step 5: Material reduction through abstraction, paraphrasing or summarizing

The objective was to reduce the material while picking the essential content which still reflects the original material.

Step 6: Collation and interpretation of the results

3.0 Results and Discussions

3.1 Prohibited riparian land use activities

Activities prohibited as per the water resource management rules, 2006namely, waste disposal, building of permanent structures and cultivation are still being carried out on the

riparian lands of Nairobi and Kiserian dams. And they have been reported in various media publications and other reports as presented in Table 3.1.

Table 3.1: Reporting on prohibited riparian land use activities

Prohibited activity	**Nairobi**	**Kiserian**
Waste disposal	Dumping grounds for solid wastes/garbage (Okande, 2015; Reuters 2019) Overflowing pit latrines in Kibera (Mulligan, 2018; Kenya Engineer,2014) Flying toilets from Kibera (Kenya Engineer,2014) Draining of raw sewage (Okande, 2015) Upstream pollution from rivers that flow into the reservoir (Mulligan, 2018; Reuters 2019)	Dumping soil around the dam which ends up in the water when it rains (Obegi, 2018). Sewerage discharge from a slum, surrounding settlements into the dam (Correspondent, 2019; NECC, 2015;Ndungu, 2014) Wastes from slaughterhouses is directed to the dam(Obegi, 2019) Drainage of effluent from slaughterhouses into rivers that drained into Kiserian dam (NECC, 2015)
Building of permanent structures	Encroachment by human settlements, structures, apartment blocks, flats (Reuters 2019; Owino, 2019; Mueni, 2018; Achuka , 2017;Koech,2019; Okande, 2015)	Encroachment due to structures constructed next to the dam (NECC, 2015;Obegi, 2019)
Cultivation	Reclamation of the dam (Mulligan, 2018; Achuka ,2017).) Greenhouses (Reuters 2019) Agricultural activities (Okande, 2015	The dam boundaries are not fenced hence water is shared by livestock and locals (Obegi, 2018)

According to statistics from UNICEF and WHO (2019), only 29% of Kenyans have access to safe sanitation services. The effects of this inadequate sanitation coverage in the surrounding settlements have contributed greatly to negative consequences in the dams. This study shows that wastewater from the settlements find its way into the water reservoirs hence polluting them. Additionally, lack of proper solid waste management in the surrounding settlements leads to dumping on the riparian land which is then washed into the dams when it rains. Rivers have also been noted to contribute greatly to pollution of the reservoirs by carrying solid wastes, soil and even human wastes into the dams. For Kiserian dam, the inflowing river receives wastewater from slaughterhouses which eventually drain into the dam.

The dams have suffered significant encroachment from residential units ranging from informal settlements to middle class estates, some of which are suspected to be located on the dam riparian land. The encroachment may have been due to several factors including; disputed ownership of land around the reservoir and rapid population growth that created a high demand for housing. Both dams are not fenced off, and this encourages encroachment that has contributed to dumping of waste in the dam riparian land.

To a large extent the Nairobi dam has been reclaimed for farming activities. The availability of solid waste deposits in the dam and water in the reservoir provides favourable farm conditions where vegetables, root and stem tubers are grown for sale. Further, agricultural activities upstream pollute the dam through inflowing rivers which carry nutrients, silt and solid wastes. For Kiserian dam, the lack of fenced boundaries encourages encroachment by livestock, which contaminates the water with animal waste.

3.2 The effects of prohibited activities in riparian land

The ecological and social effects of the prohibited activities on the two reservoirs under study are presented inTable3.2.

Table: 3.2. Identified ecological and social effects

	Ecological	Social
Nairobi Dam	Receding waters/ part of the dam solidified due to siltation/drying dam (Reuters 2019; Achuka, 2017;Koech, 2019) Water hyacinth infestation (Mulligan, 2018; Okande, 2015) Eutrophication rendering the dam unusable (Okande, 2015) Dam's water course changed (Achuka, 2017).	An increase in mosquitoes since the outflow of water from the dam had been reduced (Mulligan, 2018; Achuka, 2017). More people being treated for malaria (Achuka, 2017). Risk of flooding in Kibera and the estates on the lower side (Achuka, 2017).
Kiserian Dam	Dam in danger of drying up due to siltation (Obegi, 2018; Obegi, 2019)	Water shortage (Obegi, 2018) Risks to buildings along the dam embankment from overflowing (Mutanu, 2018)

Both dams suffer risks associated with siltation they are therefore in danger of drying up. In fact, part of Nairobi dam has already solidified due to silt deposition and solid waste accumulation. Secondly, human waste contamination as a result of limited sanitation in riparian settlements such as Kibera, an informal settlement bordering the Nairobi dam has contributed to eutrophication of the dam. This eutrophication is responsible for water hyacinth infestation of the dam. Such macrophytes are indicators of high nutrients in the catchment area. Few other organisms can survive in the reservoir

Similarly, Kiserian Dam faces declining water quality attributed to poor water quality of inflowing rivers, dumping of excavated soils, and disposal of untreated sewage, slaughterhouse wastes and runoff from the town. The residents living close to the dam also pump wastewater from their septic tanks into the dam to avoid costs associated with exhaustion services. Pit latrines located close to the dam also pollute the water during heavy rainfall when they fill up and overflow.

The societal effects associated with prohibited activities on the riparian land of Nairobi dam include loss of water supply source to the city of Nairobi, loss of recreational and aesthetic values of the water resource. The main effect however is the threat it poses to the health of people. The reservoir has become a breeding ground for vectors causing waterborne and water-related diseases. Other health effects are associated with exposure to hazardous chemicals and microbial contaminants from consuming foods irrigated with contaminated water. The prohibited activities on Kiserian dam riparian land on the other hand has mainly contributed to conflicts between the dam management and the neighbouring community. These conflicts can be attributed to unsecure dam boundary, lack of buffer zone hence trespass and access to the reservoir by locals for livestock watering.

3.3 Interventions to address the challenges facing urban and peri-urban dams

The interventions proposed and implemented to address challenges facing the dams located in urban and peri-urban areas of Kenya are presented inTable3.3. The intervention measures are grouped into four i.e. restoration and rehabilitation, enforcing regulatory measures, dam decommissioning and resource recovery.

Table3.3: Intervention measures

Restoration and rehabilitation
• Restoration and rehabilitation efforts for Nairobi dam (VOA , 2018 ; Koech , 2019; Achuka ,2017)
• Plans to desiltKiserian dam (Obegi,2018; WatsupAfrica, 2019), Managing sedimentation (Estate Cloud,2014)
• Clearing dam of waste (Estate Cloud, 2014; Reuters 2019)
• Removing water hyacinth(Reuters, 2017)
• Tree planting (Reuters 2019; Africa Nazarene University, 2015)
• Addressing upstream issues including sanitation challenges (Mulligan, 2018)
Enforcing regulatory measures
• Demolition notices by National Environment Management Authority (NEMA) **(**Reuters 2019;Njuguna, 2018; Ngechu, 2018; Mueni, 2018**)** and Water Resources Authority (WRA)

(Ngechu, 2018) for buildings constructed on Nairobi Dam riparian land

- Inspections and closing premises that do not comply with the relevant regulations such as riparian reserves, waste management and disposal (Ambani, 2018)
- Slaughterhouses to be shutdown if they do not comply (Obegi , 2019)
- Take action on those dumping waste in the dam (Obegi, 2019)

Decommissioning the dam

- Proposals to fill-upNairobi dam as a way of dealing with pollution (Reuters 2019) and to save the residential buildings (Ngechu,2018; Wanjohi, 2019)

Resource recovery

- Plans to recycle wastes collected in Kibera and dam's riparian land (Reuters 2019)
- Plans to recycle polluted water for use in car washes and sanitation services(Reuters 2019)
- Plans to set up a plant to produce biogas (Reuters, 2017)
- Remove the water hyacinth choking the dam and process it into products such as mats and baskets (Reuters, 2017)
- Turning human waste to biogas, as well as a fertilizer by-product, through a bio digester system (Kenya Engineer, 2014)
- Slaughterhouse manage their waste by producing bio-gas (Obegi, 2019)

i. Restoration and rehabilitation

The restoration and rehabilitation efforts established from the study include; desilting dam, managing sedimentation, clearing wastes, tree planting efforts and addressing upstream issues. Agriculture and poor sanitation have been identified as the main upstream issues affecting the two dams hence the need for soil conservation measures and addressing the sanitation challenges in the informal settlements.Further efforts include recovery of encroached riparian land, clean-up of the dams through desilting and eliminating the solid waste on riparian lands.

ii. Enforcing regulatory measures

The regulatory measures that became apparent from the study are more of reactionary than preventive and they included demolition notices served by two regulatory institutions NEMA and WRA, closing down of those businesses responsible for dumping wastes and releasing effluents to water reservoirs. Others include reactionary inspections instead of a continuous monitoring process. The main challenge appears to be the enforcement of existing legislation.

This includes the ignoring notices issued by relevant government authorities to stop construction of apartments on Nairobi dam riparian land and orders issued by the Government of Kajiado County requiring that the slaughterhouses comply with public health act in waste disposal.

iii. Decommissioning the dam

This is a proposal by the legislature. The politicians' proposal to decommission the Nairobi dam rather than demolish buildings encroaching on riparian land is not based on any scientific data but on reasons such as the dam having outlived its usefulness or the need for land for real estate development or as a way of dealing with the issue of pollution. Data availability for decision making is important. The proposal therefore to undertake a study on safety and economic viability of Nairobi Dam so as to give recommendations on its existence has been proposed.

iv. Resource recovery

The different forms of resource recovery that were established among the intervention measures include recycling of solid wastes and wastewater, energy and nutrients recovery. Most of the wastes that enter the dams are organic and thus can be turned into a resource for instance, production of biogas from the wastes from abattoirs which would have otherwise ended up polluting Kiserian Dam.

4.0 Conclusions

The three main activities prohibited on a dam riparian land that have the most influence on the two reservoirs are waste disposal, building of permanent structures and cultivation. Lack of clear dam boundary demarcation and lack of proper solid waste and sanitation management in the catchment encourages these polluted activities. These prohibited activities have resulted in ecological and social economic effects such as declining water quality and quantity, loss of water supply source, health threats and risks of flooding for those who have encroached on the riparian land. In addressing the challenges facing these reservoirs four measures were established from the sources reviewed i.e. resource recovery, rehabilitation and restoration, enforcement of regulatory measures and dam decommissioning.

5.0 Recommendations

The study establishes that Environmental Management Plans are not followed after project implementation and therefore seen as a failure of the regulators to perform their important roles.

Media is therefore trying to fill this gap through publicity on prohibited activities, impacts and preventive measures.

To effectively manage the challenge of effects of prohibited riparian activities on the two dams' land, there is need for enforcing regulatory measures, Restoration and rehabilitation and Resource recovery.

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