

MANAGEMENT STRATEGIES FOR RESTORATION OF NAIROBI DAM

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Requirements for the Award of the Degree of Master of Urban Management,
University of Nairobi**

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DECLARATION

This project report is my own original work and has not been submitted for examination at any other university or institution.

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This project report has been submitted for examination with our approval as university supervisors.

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DEDICATION

I dedicate this study to my father Mr. James Oude and to my late mother, Mrs. Joyce Atieno Oude for their support and encouragement even amidst pain and illness during the preparation of this research report.

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ABSTRACT

Nairobi Dam has over time attracted many organizations, public and private, who have attempted to rehabilitate it, and as a result, four restoration attempts have been made so far. These efforts have been in vain, and the restoration course is still far from being realized.

The time to time failures have indicated weaknesses in the approaches which have been used in the past, indicating that the Government, local authorities, planners and professionals in the land profession have not yet deciphered the correct approach that can effectively and sustainably put the issue of encroachment and degradation of vital urban wetlands, in our case Nairobi dam, to a rest.

This project explores past strategies from published articles and studies on Nairobi dam rehabilitation, and the results of these past restoration efforts critically examined. The researcher endeavors to identify gaps and challenges in past rehabilitation measures and propose new management approaches in rehabilitating the dam. Land use in Nairobi and particularly around the dam is also investigated by this study to identify if a relationship between land use and the condition of the dam exists. In addition, the researcher seeks to identify potential opportunities that may result from the rehabilitation of the dam.

On past restoration strategies and efforts towards restoration, the study established that all the previous efforts failed in restoring Nairobi dam. The failures were in all aspects of sustainability that included social, economic and environmental aspects and also on the enabling aspects that included legal, institutional and infrastructural aspects.

Continued degradation and pollution of Nairobi dam characterized by expansive permanent slums settlements and massive grabbing and encroachments of adjacent land by developers

amidst four previous attempts by various powerful government agencies and institutions to restore the dam, serve as indicators of the true situation. This coupled with negative perceptions towards dam restoration efforts due to the inability of such efforts to involve and integrate the surrounding communities in restoration plans and programmes and their failure to enhance the communities' socio-economic status. Overall, past restoration strategies have been of little significance towards achieving sustainable management and improve the social, economic and environmental quality of Nairobi dam.

ABBREVIATIONS

ANOVA	Analysis of Variance
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
QWI	Queensland Water Infrastructure
FAO	Food Agriculture Organization
WCD	World Commission on Dams
WRUA	water resource user association
IWRM	Integrated Water Resources Management
WRMA	Water Resources Management Authority
WRA	Water Resources Authority
NIUPLAN	Nairobi Integrated Urban Use Master Plan
RCMRD	Regional Centre for Mapping of Resources for Development
NEMA	National Environment Management Authority
NCC	Nairobi City County
KDI	Kounkuey Design Initiative
KEBS	Kenya Bureau of Standards
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

There is rapid growth of cities globally and it is estimated that nearly 2.5 billion people would have migrated to cities by the year 2050 accounting to up to 68 per cent of the world's population. This will, in turn, lead to great strain on the natural resources and destruction of ecosystems (UN, 2018). More land, among other resources, is required to support the growth of cities, leading to changes in land use. Some of the inevitable effects of such changes include ecological complications such as air and water pollution, loss of open spaces, negative impacts on biodiversity, and increase in urban heat island effects, among others (Lambin et al, 2006).

Founded in 1899, Nairobi is the youngest city in the eastern Africa region, but apparently, it has experienced some of the highest growth rates among African cities. Though founded later than most cities in the region, Nairobi has grown to be the largest city in East Africa (Rakodi, 1997). World population Review (2018) estimates the city's population growth rate at 4.2% and that by the year 2020, 5 million people will be residing in Nairobi. Scarcity of land has resulted in an encroachment on forests and wetlands (Lambin et al, 2011). Water resources have been greatly affected due to increased pressures from a wider range of different and, often, conflicting urban activities. Particularly, wetlands receive many polluting substances which act as sinks for all forms of solid and liquid wastes as the cases of Nairobi River and Nairobi dam (Okoth and Otieno, 2001). Severe effects of pollution have been beheld in recent years this is resulting from rapid urbanization and industrialization. The increase in the population has increased the rates of

effluent generation from the domestic sector as has the industrial development increased industrial effluents in urban areas threatening Wetlands as the case of Nairobi Dam (Rugo,2015).

Nairobi dam has been invaded, initially, it covered an area of 31 acres (356,179 m²) with carrying capacity of 98,422 m³, but developments, waste, as well as urban agriculture are continually eating into this resource. These illegal activities being carried out around the area have rendered the initial purpose of the dam unachievable. (Forster, 2006).The Public Works Department of the British colonial government in Kenya and the Uganda Railways and Harbors Service in 1953, worked together to build the Nairobi dam, the storage capacity of its reservoir is 98,000m³, surface area of 350,000 m² and an average depth of 2.76 m. It was to provide potable water for the residents of Nairobi City. It attracted major recreational, sporting, fishing and bird watching activities in turn being a destination for both foreign and domestic tourists. Over the years intensive encroachment of human settlements, agricultural activities, draining of raw sewer and dumping of garbage led to eutrophication and infestation of hyacinth rendering the dam unusable. The dam now receives its inflow from the Motoine River, rainfall and waste water from the un-sewered Kibera settlement and the outflow is mainly through evaporation and over the spillway into the Ngong River (Odipo, 1987). Currently, the dam is heavily silted and most areas have been reclaimed for agriculture as a result of dumped solid waste.

By the year 1998, the dam's use for sport and recreation was wholly abandoned; this resulted from severe contamination caused by pollution. The dam has now become practically an open sewer; a danger to humans; a trouble on the landscape and an obstacle to urban planning and economic development. When the dam functioned well, there were social-economic benefits, not only to the people living around the dam but also to over a third of Kenyan population, that have

now been lost due to its destruction (Namale, 2013). Clean water to area residents and recreational functioning will not be the only profits to be achieved if restoration and sustainability of the dam were attained, but increased insecurity will have been tremendously reduced as well by taking out gangs using the dam as a hideout. Therefore the dam is an invaluable asset and can be used as a tool of social and economic growth of Nairobi city and its surroundings. For instance Odongo et al, 2013 explains that if the dam is restored, the foul smell emanating from it would be restrained consequently landlords would regain value from their houses in Kibra as currently, the smell given out by the dam is an unwelcome sight to potential buyers or tenants.

In the year 2004 Moody Awori who was by then the Vice-President of Kenya, made an endeavor to restore Nairobi dam and its waterway bowl, which fizzled in light of the fact that its accepted to have been damaged by basic issues that were more political than social; the previous Prime Minister Raila Odinga additionally put forth an attempt towards a similar reason yet even with all the force that accompanied that office he couldn't reestablish the dam. The late Mutula Kilonzo set out to try and dream of one day swimming in the dam, his push to reestablish it, while the Nairobi Metropolitan Minister, hit the stopping point as well. The main Governor of Nairobi City county In 2014 – Evans Kidero, set deadlines to Rehabilitate the Dam inside three years, he consequently fabricated a taskforce with a the order to achieve this goal. Wangui, 2004 notes that not a lot was achieved by the taskforce after the slip by of three year time span in 2017. These four endeavors in the past to restore the dam have fizzled, more endeavors will be made later on yet how they will be made will direct the achievement or disappointment of the procedure.

1.2 Statement of the problem

Nairobi Dam was once a treasured leisure ecosystem offering a variety of essential services consisting of hosting more than a few plant life and fauna species. During the years the Dam has encountered a series of challenges which encompass; intensive encroachment of human settlements, agricultural sports, draining of raw sewer and dumping of garbage which has brought about eutrophication and infestation of hyacinth rendering the dam unusable. Despite lifestyles of laws and establishments concerning the safety of such urban wetlands and the diverse attempts that have been made to repair the recreational facility, Nairobi dam remains experiencing a persistent hazard to its existence .The importance of Nairobi dam is obviously enormous; that is recreational in addition to economic in nature. It therefore requires set off action to decide why deterioration of the dam continues to be happening in view of all the restoration attempts, and in what better manner can the rehabilitation be achieved to restore Nairobi dam to its lost glory.

1.3 Objectives of the study

1.3.1 Main objective

The overall objective of this study is to develop a management strategy pegged on the past restoration efforts.

1.3.2 Specific objectives

The specific objectives are:

1. To undertake a situation analysis of Nairobi Dam and its surroundings
2. To evaluate past rehabilitation strategies in order to draw lessons from their successes and failures.
3. To develop indicative strategy for sustainable restoration of Nairobi Dam.

1.4 Research Questions

The following research questions will guide the study:

1. What is the status of Nairobi dam and its surrounding?
2. What are the successes and failures from the past rehabilitation strategies?
3. What is the suitable management strategy for sustainable restoration of Nairobi dam?

1.5 Hypothesis

This study will test the following hypothesis: Two Tailed test

1. H_0 : there is no significant relationship between land uses and dam degradation.
2. H_1 : there is a significant relationship between land uses and dam degradation.

1.6 Assumptions of the Study

The following assumptions were made to guide the study:-

1. There is insufficient clear policy, legal and institutional structures supporting dam restoration and rehabilitation in Kenya.
2. The contemplated main objective of the Past efforts in restoring Nairobi dam has not been fully actualized.
3. The designed and implemented programs from the past restoration efforts in Nairobi dam are both spatially deficient and economically unattainable in relation to sustainable development.
4. The societal perception of the residents living around Nairobi dam towards Dam restoration and rehabilitation programs is negative.

1.7 Justification of the study

The Nairobi dam is one of the few recreational facilities remaining in the neighborhood of Kibera and Nairobi County, the Capital City of Kenya. The dam used to serve a myriad of functions and provided values and services including income generation. It is also an important area of biodiversity and was being used for sailing which is a source of income. The rehabilitation of this constructed wetland would potentially yield socio-economic benefits from recreation use, especially by residents of Kibera informal settlement, which has a population of about half a million people with no recreational facility.

The urban sprawl phenomenon on wetlands is a challenge to cities of developing countries and consequently efforts to sort out challenges associated with these informalities have been left to

planners and the planning authorities. In the process, various approaches to urban constructed wetland rehabilitation have been tried with the primary goal of improving the living conditions of urban dwellers and, most importantly, preventing proliferation of slum settlements. Occasional failures have indicated weaknesses in the past approaches, indicating that the Government, local authorities, planners and professionals in the land profession have not yet deciphered the correct approach that can effectively and sustainably put the issue of encroachment and degradation of vital urban wetlands to a rest. Nairobi Dam and its environs reflect this deficiency despite the fact that the dam has significant advantages like, proximity to the city -3km from the city, proximity to close to over half a million slum dwellers who can act as visitors to the facility. Nairobi Dam have over time attracted many organizations, public and private, in an attempt to rehabilitate it, resulting in four failed attempts. These efforts have been in vain, and the restoration course is still far from a success. The findings and recommendations will be beneficial to the national government, county governments, civil society organizations, NGO's and international organizations concerned with rehabilitating the dam. It is envisioned that the research findings and recommendations will also provide a benchmark for planning and rehabilitating other urban constructed wetlands within urban setups. In the future other scholars may want to research on a related issue and therefore the findings are a significant addition to the body of knowledge that can be referenced.

1.7 Scope of the study

The study will cover the entire catchment areas of Nairobi dam including the dam and the surrounding neighborhoods and the dam's water source - Motoine River. The study will be focused on the Spatial-Temporal changes, Water quality analysis, investigating the causes of deterioration of Nairobi dam and finding out gaps in the past rehabilitation measures, to propose

new management model for sustainable restoration of dam. Local residents, County Government, Ministry of Environment, and Local NGOs will be involved in my research.

1.8 Definitions of Terms in the study

Land Use is economic use of a piece of land such as agriculture, industrialization, residential, transportation, recreational and educational purposes.

Restoration is an attempt to bring back degraded constructed wetland back to a healthy state of ecological integrity, taking into account political, technological and socio-economic constraints with an aim of ensuring sustainability that meets societal need.

Rehabilitation is described as stabilization of degraded constructed wetlands, taking into account surrounding land-use activities already present within the target catchment with an aim of achieving balance between wetland ecosystem integrity and wetland utilization by humans on a sustainable basis.

Sustainable development is the capacity of a country or state "to address present issues while keeping the capacity of future ages to address their issues" (World Commission on Environment and Development 1987. It is therefore correct to conclude that a nation cannot accomplish lasting achievements economically and socially increases when the condition of its environment is constantly degraded.

sustainable wetland management Includes the various administration that manage all features of wetlands, whereby their ecological, monetary, and social qualities are incorporated and endeavors made in integrating them thus ensuring that the future is sustainable.

Sustainability is described as preserving wetlands because of the uncertainties the future presents, for example, living, working, and overseeing in manners which are ecologically "maintainable," advancing biodiversity, et cetera.

Constructed Wetlands are man-made wetlands that include irrigated lands, livestock and agriculture ponds, aquaculture ponds, rivers and reservoirs which have been dammed for water supply, irrigation or hydroelectric power generation, flooded excavations, certain wastewater treatment facilities and salt pans. The differentiating characteristic of constructed wetlands to a natural wetland, even where they are of a common size, is that they are usually designed for a specific purpose and seldom have the full range of wetland functions and values.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Applicable literature on the topic under consideration is presented in this chapter and includes two subjects, particularly: the theoretical and conceptual frameworks. This will aid to foster a better understanding of the variables associated with the study and to suggest an ideal method as per the perspective of the study. It is in this chapter that relevant literature nationally, regionally and internationally is presented giving successful and failed projects and the factors that could have led to such situations.

2.2 Functions of wetlands

Presently, the importance of wetlands in hydrological and ecological functions is widely acknowledged as it is significant in the life of the local. Wetlands play a substantial part in; curbing floods and its effects, it can reduce erosion, recharge groundwater, maintain and improve water quality, store carbon dioxide and ameliorate micro-climate conditions. From an ecological point of view, wetlands are fundamentally important for maintaining bio-diversity. Different species are adapted to different habitats and wetlands are excellent habitats where the conditions for reproduction and growth for aquatic and terrestrial species are optimal. Therefore wetlands contribute to the food web within the basin-wide 'ecological network'. According to de Groot et al (1990) within a wetland different species can spread and occupy other parts of the basin using the riverine 'corridors' of the ecological network as transport routes and thus the functioning as 'generator areas'. Moreover Wetlands are being re-discovered as a method of expanding the income of the people living there, through agriculture and fisheries as in the case of Lake Naivasha in Kenya that supports a big flower industry and fishery. Wetlands can even be a

source of food, medicine, shelter, energy, tourism and recreation. Efforts that have thus far been made in East Africa on the matter of the mixing of crop production and fisheries in wetlands by adjusting to the natural hydrological have been fruitful (Denny et. al, 2004). An example in this sense that Kagawa, 2006 identifies, is Uganda's Finger ponds project whose purpose was to boost the production of fish from East African papyrus swamps while preserving the integrity of wetland. In Europe also, occupational functions of wetlands have been rediscovered. For example plans have been considered in Hungary whereby over historic adaptive fisheries; methods have been reintroduced about the riparian wetlands on the River Danube (Zsuffa, 2001).

Today, the world takes keen interest in the ability of wetlands to purify water, the entire river basin will increase in the volume and purity of water if nutrient removal in the wetlands is effective. The Horizontal Guidance document on wetlands of the European Union Water Framework Directive, further abbreviated as WFD (EC, 2003) stresses the impact wetlands have on achieving the WFD's environmental target in the whole basin. Research has been done regarding the ability of wetlands in nutrient removal in the temperate zone and has shown that their maximum capability of rate of nitrogen and phosphorous discharge may range from 1000 up to 3000 kgNha⁻¹ y⁻¹ and from 60 to 100 kgPha⁻¹ y⁻¹ (Kaika ,2003). According to Verhoeven et al. (2006) these values show a degree that is of an order which is higher than that of fertilizer usage in places where farming is done in large scale. Several wetlands in Uganda are now utilised for the purpose of waste water treatment and has been proven to be cost-effective and been recognized far and wide within the county. (Kansiime & Nalubega, 1999). For example, an estimation as high as US\$ 1.3 million per year is placed upon The Nakivubo wetland purification value bordering Kampala. (Zsuffa et. al., 2016). As a result, a growing interest is developing especially in Africa, in utilization of wetland's purposes for drinking water

and sanitation through wetland's capacities for water purification (Abebe, 2003). In comparison to artificial waterworks, Wetlands are proving to be cost effective means with limited maintenance for for water purification, which make them most viable measures for developing countries. Researchers, NGOs, and government institutions are keenly studying wetland's potential in improving and supporting livelihood conditions, the ecological and hydrological functions and therefore, recognize the need to preserve, sustainable manage and integrate basin wide approach of wetlands for peoples' benefits and the river basin host ecosystem hence need for Rehabilitating degraded Nairobi dam.

Summary of Functions of constructed wetlands

Ecological importance

Curbing the impacts of Floods and reducing
Soil Erosion

Releasing Water and Recharge

Purifying Water, Nutrients and Natural and
elimination of Pollutants.

Reducing the rate of Climate Change

Wildlife Habitats and Centers of Biodiversity.

Socio Economic importance

Energy Production:

Tourism and Recreation

Research and Education

Sources of water for both domestic and
industrial use i.e. irrigation

Religious and Cultural Significance:

Transport and Sports

Fish and other food products

Source: Mwaura, 2005

2.3 The rate and extent of wetland loss

According to Dugan 1993, it is estimated that about half of the wetlands that have been since 1900 worldwide are no more. This loss is supposed to apply to inland wetlands and possibly mangroves, and not so much of the marine wetlands. It is estimated that much of wetland loss happened about the first 50 years of this century with the northern countries experiencing much of it. In the 1950s, tropical and sub-tropical wetlands are progressively degraded, while others are gradually being lost through conversion to be used in agriculture. Wetland loss worldwide has been attributed to Agriculture as the principal cause. As of 1985 North America as well as Europe had converted 56–65% of their wetland to be used for intensive agriculture. An estimated 27% loss occurred in Asia, about 6% occurring in South America and Africa experiencing 2% loss amounting to a worldwide aggregate of 26% loss to agriculture (OECD 1996). As wetland loss to agriculture and other uses is continuing, indeed intensifying, in regions such as Asia, the Neo-tropics and Africa, it is necessary to update these statistics with new quantitative studies.

Water allocation and distribution is the other factor inseparably connected with how fast and how much of wetland loss and degradation occurs worldwide, this subject has become extremely important recently and there is no chance it will lose its significance in the future. The increasing need for irrigation and hydropower has led to the level of many rivers in the world to be severely reduced due to the construction of dams to gratify this rising need. Increased salinization, diminishing underground water reserves, have been among the many consequences on rivers and other similar water bodies, such as the swamps as well as marshes. Biodiversity is also on the decline and fish stocks are reducing due to hindered migration and a destroyed habitat are some of the problems that have resulted (Gopal & Wetzel 1995). Surprisingly, the problem of siltation

of reservoirs is facing most of the countries. In Japan the demand for water has led to construction of many artificial lakes on many of the river systems but siltation reduced the volume of water by between 70% and 80% in a period of 20-30 years (Taub. 1984).

The growing population has caused more pollutants from homes and industrial discharge, which are being dumped into wetlands. Yet, in many developing countries such as Kenya, little effort has been made to research on how pollutants affect wetlands, especially on fisheries, (Gopal & Wetzel 1995).

Moser et al (1996) observed from the data provided by Ramsar Contracting Parties released data that more than 80% of its listed wetlands had either experienced or were on the verge of ecological change. In Asia and the neo-tropics a similarity in threats to wetlands was also observed (Scott & Carbonell 1986). Information from 734 wetland sites was accessible in Asia which recorded a threat level of 85%, and for 81% of 620 wetlands in the Neo-tropics. Moser et al 1996, ranks Hunting, pollution, drainage for agriculture, settlements and urbanisation among the five major threat categories in these regions. The top five hazards affecting these regions are majorly categorized as; draining wetlands for agriculture, settlements, hunting, pollution as well as urbanization.

In Kenya, as delicate as Wetlands are in the ecosystems and even with several direct and indirect benefits they present, a decline in these wetlands has been witnessed at concerning rate whereby the 6.8 % of total land mass at independence had reduced to about 2.6 % by 2010 (Chikomo 2014).. For example in Nyandarua County we had 432 dams at independence, but now only 287 dams are remaining in a good state. Nairagia Enkare is a dam that is found in the county of Narok, which is now complete siltation due to wheat farming in the nearby Suswa (Kinyariro

2016). In Elgeyo Marakwet County a similar problem is seen whereby Lake Kamnarok is in danger as result of group ranching causing a change of land use previously used as individual holdings thereby overburdening the ecosystem and as a result the lake is on the verge of extinction. Such a condition is evident in Kimana wetland of Kajiado which going out as a result of a change in the land use from group ranching to individual agricultural use (Githiga et al 2003).

Despite the fact that wetlands can considerably contribute to development socio-economically in Kenya, they still are exposed to diverse and severe threats. Among the many threats faced by wetlands are inappropriate human activities within the catchments and in the wetlands, lack of coordinated and holistic policy guidelines, and climate change. These threats have prompted modifications which have resulted in erosion of ecological and socio-economic benefits obtainable from wetlands. Basically lack of appreciation to how important wetlands are and their significances to the national economy as well as community livelihoods (Muriithi, 2009)

2.4 Historical framework on rehabilitation strategies of Nairobi dam

In 1953 the Public Works Department of the Kenya's British colonial government and the Uganda Railways and Harbors Service jointly constructed Nairobi dam which holds a reservoir with a storage capacity of 98,000m³, 350,000m² in surface area and depth of averagely 2.76 m. This was to provide potable water for the residents of Nairobi City. It attracted major recreational, sporting, fishing and bird watching activities in turn being a destination for both foreign and domestic tourists. Over the years intensive encroachment of human settlements, agricultural activities, draining of raw sewer and dumping of garbage led to eutrophication and infestation of hyacinth rendering the dam unusable. The dam receives its inflow from the

Motoine River, rainfall and waste water from the unsewered Kibera settlement and the outflow is mainly through evaporation and over the spillway into the Ngong River (Odipo, 1987).

The dam suffered severe pollution attack to the extent that by 1998, its use for sport and recreation was abandoned. The destruction of the dam has brought both social-economic effects not only to the people living around the dam but also to over a third of Kenyan population (Namale, 2013).

There have been four attempts in the past to rehabilitate the Nairobi dam and its river basin system. Initially an effort was made by Moody Awori, in 2004, who was the Vice-President then but it failed because of issues whose origin were more from political influence than social influence; another effort was made by the former Prime Minister, Raila Odinga, but also failed despite of him holding an influential office. Yet another attempt was made by the late Mutula Kilonzo when he was the Nairobi Metropolitan Minister, he is even quoted saying that he would swim in the dam one day, but he also failed. In 2014 a fourth attempt was initiated by Nairobi City county through, the first governor, Evans Kidero ,and a taskforce was formed with a mandate of Rehabilitating the Dam in a period of three years, with nothing much coming out of the taskforce after the elapse of three year period in 2017 (Wangui, 2004).

3.1.1. Summary of the Past Rehabilitation Strategies of Nairobi Dam

The office of the vice president, headed by Moody Awori, in collaboration with UNEP and UN-Habitat, initiated a programme- Nairobi Dam Trust Initiatives 2004, with an aim to recondition the Nairobi Dam and place it in a position where it will be a crucial supply of fresh water for human consumption and at the same time act as great place for recreational activities. Strategies

were set up to upgrade the slums and build substantial infrastructure for controlling waste, eliminate the hyacinth and upgrade the slums.

In the year 2008, Nairobi River Cleanup programme was initiated by the ministry of Nairobi metropolitan steered by Mutula Kilonzo. This programme, under the Nairobi Metro Strategy, aimed at cutting on pollution so as to safeguard the dam. The programme endeavored to tidy up the stream and stall the entry points of waste, (Rugo 2015).

In the year 2011, another attempt was made by The Office of the Prime Minister in the Kazi Kwa Vijana Initiative to rehabilitate, restore and sustainably manage Nairobi dam in order to provide improved livelihoods, enhance environmental quality and values through well regulated economic and recreational ventures. In this programme, strategies to mobilize the youth as well as ways to remove the hyacinth and use it to make fertilizer were planned (Julius,2013).

Nairobi City County Taskforce Restoration Initiative is another programme that was initiated by Nairobi's first Governor Dr.Evans Kidero that was to enable and supervise exercises intended for reclamation of the dam. The activities that were intended include; Aversion of illicit releases into the dam, usage of fitting incorporated strong waste administration plan through the participation of the society, and arrangement elective waste accumulation focuses a long way from the riparian, Sewer line services development, provision of sustainable economic activities, slum upgrading and development of a master plan for economic, aesthetic, recreational and social utilization of riparian land (Kenya Gazette, 2014)

Despite all these efforts, the Nairobi dam still remains degraded and without any social or economic value. This is an indication that there were flaws, either in the strategies employed to rehabilitate the dam or their implementation was faulty causing the rehabilitation efforts to fail.

2.5 Sustainable Wetland Management

In the quest of developing in the economy, farming activities and development improvements have kept on debilitating life in and around wetlands as well as the wetlands themselves. These dangers primarily are composed of activities such as reclaiming land; for cash crop growing, to develop road networks, to build of dams that are used to store water for the generation of hydropower, irrigate agricultural land, to secure against flood; contamination resulting from pesticides; overfishing; overgrazing by domesticated animals and change to aquaculture lakes (Ojoyi, 2006). The (Ramsar Convention, 1991 defined best use of wetlands as —their sustainable employment to the advantage of humanity in such a way as to make them in harmony with the aim to maintain the natural aspects in the ecosystem they exist in. Therefore wise use of the wetlands means, to provide benefits to the community without endangering its existence. It also seeks to give greatest possible benefit to those in the present without thwarting its ability to provide for the coming generations. Wise use therefore is part of sustainable development and puts emphasis on how economic, social and ecological scopes can be incorporated in the management of resources (Jyoti P. & Hemant D., 2003).

According to Day Jr et al 1997 in Managing wetlands, the following aspects will be helpful if put in consideration:

- Productivity – the returns or income gained for each unit of the resource.
- Stability - the degree to which productivity will change if faced by small disturbances caused, for example, by normal fluctuations of climate.
- Sustainability - the system’s ability to continue being productive even when faced with a major disturbance for instance an unexpected drought, soil erosion or even new pest.
- Equitability – how resources are distributed in the system, for example how far agricultural products are shared among the community.

Therefore, wise use of any wetland can have high in stability, equitability as well as sustainability yet be low in productivity.

Wetlands can be managed and protected by three groups – bodies involved in national decision making, the local community and conservationists. Strong policy is needed to realize sustainable wetlands Management. Hence, it is important that both large-scale investors and local individuals to employ wetlands well. A need exists for surrounding wetland communities to be enabled to exploit and enhance wetland resources more sustainably.

2.6 Evaluation of restoration success of Constructed Wetlands

According to Wortley et al (2013) it is very important to evaluate restoration success of any project in order to determine its efficiency, justification and for future restoration efforts. In the recent years positive developments have been reported in the restoration evaluation literature (Wortley et al. 2013), however, according to Schiff et al (2013) low resources have been allocated to monitoring programs, hence efforts to conduct a standard before and after sampling programs remain limited. As articulated by Buchanan et al. (2014) studies extending over 10 years and which can be used to identify long term trajectory of the Dam restoration programmes are rare, mainly because they tend to exceed the original project schedule and funding.

According to Wortley et al. (2013) there is an ongoing debate on the features that characterize successful restoration and how best they can be measured. However a successful evaluation means assessing whether the initial targets have been met, in this case indicators serve as tool to quantify the conditions of a constructed wetland in light to the restoration goals (Woolsey et al. 2007).) also indicated that indicators used to evaluate restoration success of any project should be easy to measure, cost-effective, sensitive to responses, ecologically and socially relevant, reliable and ideally and should provide information on more than one project objectives and a suitable indicator should be adopted depending on the restoration objectives (Woolsey et al. 2007).

Currently, the debate on the restoration success of wetlands primarily depends of the objectives and measurable and abiotic indicators (Barthélémy & Armani 2015).

Aspects that are socio-economic in nature still are significant regarding how restoration success is perceived and communicated (Jähnig et al. 2011). Evaluation of changes in the provision of ecosystem services and societal benefits would ameliorate our cognizance of restoration outcomes. Certainly, more research is required on the veritable socio-economic effects of restoration. Hitherto, the main focus of socio-economic studies have been on issues related to resource input going into projects, the scope of community participation and imputations for restoration projects in the future, whereas the authentic socio-economic end results gaining condescending attention (Wortley et al. 2013).

It remains widely unaltered how well the conjecture of various stakeholders are met, the rationale for sundry local experiences or whether ecosystem services disappeared are truly recovered through ecological restoration (Schaich 2009,). Additionally, if perceptions about stakeholder groups as well as different restoration sites were compared it would give an explanation for social success or failure of the restoration process (Barthélémy & Armani 2015). One of the major impediments towards restoration of degraded wetland is the absence of information of previous projects because the results of many of such results remain unpublished. If projects that have employed sufficient monitoring were brought into consideration and analyzed, very valuable information would be obtained which would give a great contribution towards future restoration projects (Nuruzzaman et al. 2017). Reasons identified as potential reasons for undesired outcomes from previous studies regarding wetland restoration includes insufficient incorporation of socio-economic aspects, short time employment of monitoring programmes than necessary and poor long-term performance of restoration measures. (Nilsson et al. 2015)

Moreover it has been indicated from various authors that it has been impossible to restore wetland function as well as ecological communities because often the scale to which restoration is done most of the times is at variance with the scale of human alteration (Schiff et al. 2011,). In numerous cases, the explanations to larger-scale variables that could give to why species either have not responded to restoration activities or are doing so sluggishly stay generally unidentified, (Nilsson et al. 2015).

2.7 National perspectives on wetlands

A rich ancient history, a beautiful landscape, nice climate, diverse people, and wonderful wilderness areas, is the reason that Kenya is praised as a 'land of splendor' (Ministry of Environment and Natural Resources, 2000). Recently, Kenya has been commended as a model for the progress in the conservation of the environment regionally after the enactment of the new constitution which contains specific mechanisms for the management of the environment. Kenya designated the Kenya Wildlife Services to be the principal administrative authority for the Ramsar convention when it became a signatory for the convention in 1990. Five Ramsar sites have been set aside thus far for instance , lake Nakuru was designated on 5th june, 1990 with an average of 18800 ha, lake Naivasha on 10th april, 1995 with an acreage of 30000 ha.

Mwaura (2005) notes that studies have been piloted in Kenya whereby recommendations have been made showing the significance of wetland resources.in the year 2007 the government of Kenya drafted a national session paper which serves as an evidence that the government is committed to set legislative guidance regarding sustainable use that will conserve these resources countrywide. When there is no proper control in land use wetlands suffer degradation (Mwaura 2005). Gichuki 1998 observed that the ever increasing population has resulted in an increase in development activities; consequently, wetland resources have ended up being strained.

The Development journal 2012 outlines that land resources are not being utilized sustainably and prudently, showing us why Nairobi dam is its state of damage occurring from human activities. In spite of the recommendations given by previous studies no progress has been made to rehabilitate the dam. This intention of this study therefore, was to evaluate the past efforts to rehabilitate Nairobi dam and come up with an approach that will lead to the conservation and sustainable use of the Dam. Economic significance such as given by Sahel is an example of what could become of Nairobi dam if conserved (Adams, 1993).

Kenya initiated a long-term strategy to enhance the quality of life of its citizens and build a prosperous nation that meets the global standards, famously known as in Vision 2030; this blueprint aims at moving Kenya to a middle income country and making it industrialized.

Article 42 of the Kenyan Constitution (2010), has a provision of right to clean and healthy environment to every person, which includes the rights to protection of the environment for the benefit of present and future generations through legislation and other frameworks, Article 69 particularly, contemplates this measures with environmental related obligations fulfilled under Article 70.

2.8 Existing Legislative and Institutional frameworks for Constructed Wetland conservation and management in Kenya

There is an existing legal and institutional framework; notwithstanding, degrading activities being carried out by people threaten the existence of Nairobi dam (Issaias, 2000). Ndunge, 1999 has attributed the challenges in the restoration of Nairobi dam to the absence coordination amongst the stakeholders creating a gap and inter- sectoral conflict. The restoration of Nairobi Dam calls for immediate attention because of the great potential it has to solve some of the

problems facing the people of Nairobi and therefore it is an avenue of sustainable development (Muchiri, 2012).

2.8.1 Constitution of Kenya 2010

Pursuant to Chapter five of the Constitution which pertains to land and environment especially in Part 2 of Chapter 5, that is about the environment and natural resources, article 69 commits the state to steward and respect the environment by ensuring sustainable – exploitation, utilization, management and conservation of the environment and natural resources, and ensuring the equitable sharing of the accruing benefits by eliminating anthropogenic activities that are likely to cause the environmental degradation. It also state that it's a duty of every person to partner with state agencies and other persons to protect and conserve the environment and strive for ecologically sustainable development and use of natural resources.

2.8.2 Environmental Management and Coordination Act, 1999

Section 72 of the EMCA makes it an offence and liability by providing a prison sentence for water pollution of either two year or below sentence term or one million shilling or below in fines or a combination of the two and particularly makes it an offence and a liability, to any poison, toxic, noxious or obstructing matter, radioactive waste discharge or application by any person or contravening water pollution control standards by permitting dumping or discharging of such matter into the aquatic environment. The offender in addition, if found guilty of water pollution, shall pay for removal of any toxic, poison, noxious or obstructing matter, radioactive waste or any other pollutants plus cost of restoring the damaged ecosystem as an additional imposed sentences or fines. Section 142 of the Act provides for offences relating to pollution generally. Section 72 and 142 of EMCA are of particular importance in the management and conservation of water bodies and specifically the Nairobi dam. The provisions prohibit water

pollution and imposes a hefty penalty to any person who discharges any pollutant .However, despite the provisions this study seeks to establish whether EMCA has been successful in implementing these provision or the extent in which the provisions of section 72 and 142 has been applied.

Regulation 14 of the Environmental Management and Co-ordination (Wetlands, River banks, Lake Shores and Sea shore management) Regulations, 2009 requires Land owners, occupiers or any such users of land near or adjacent to a wetland to, in liaison with Authority, stop the degradation and avoid damage that may result to the wetland as a result of their activities, they are also required to maintain the functioning of the wetland ecologically. Therefore, a person that fails to, disregards or intentionally refuses to give reasonable care to a wetland commits an offence.

Regulation 21 of the Environmental Management and Co-ordination (Wetlands, River banks, Lake shores and Sea shore management) Regulations, 2009 requires any intended development project which may have a significant impact on a wetland, river bank, lake shore or the sea shore shall carry out an environmental impact assessment in accordance with the provisions of EMCA. An environmental audit as provided for by EMCA shall be carried out by the developer, and the Authority to monitor such activities in accordance with EMCA.

The Environmental Management and Coordination Act (1999) also include a section on wetlands regulations which dispense for the conservation, sustainable use and management of wetlands, riverbanks, lakeshores, and seashores in Kenya. It also provides a framework for public participation particularly in the management of wetlands resources. Nonetheless, EMCA 1999 is a good reference point for the management and governance issues of Nairobi dam wetland

because it provides a legal framework for effective conservation of water catchments, control of floods and prevention and control measures aimed at reducing pollution and siltation.

2.8.3 Physical Planning Act Chapter 286

This is an act by the parliament which basically provides for the preparation and implementation of physical planning and the country's progress. The main aim of the Act is to regulate the physical planning and foster development countrywide. It requires developers to obtain approvals towards a project they intend to undertake before they begin it. The county governments have been mandated to control development in open spaces, urban forests, parks and green parks according to the approved physical development plans. While wetlands are not directly mentioned in this act, yet it can be used as a foundation to preserve and maintain wetlands, by the local authorities, as fragile ecosystems in circumstances whereby it is deemed necessary in the bid to design and approve physical plans, the Act also provides for balancing of various interests. If the local authority has reason to believe a proposal for industrial development undertaking will have detrimental effects on the environment, this Act requires for EIA to be conducted. In an attempt to fulfill the requirements of this provision considering the unique nature of wetland ecosystems, it is necessary to carry out EIA on every case of proposed projects on wetlands. The benefits of such developments are then compared with their effect on the environment and the ecosystem.

2.8.4 The Water Act, 2016

The water act 2016 technically repealed the water Act 2002. The management, protection, usage and regulation of the water resources as well as procurement and control of rights towards usage of water, are provided for in this act in line with the constitution of Kenya; and to make

provision for the control and create room to manage the supply of water supply and provision of sewerage services. This Act therefore is relevant to the administration of wetlands in Kenya.

In this Act issues to do with ownership, management and usage of water resources are dealt with. Also provided for is the protection with regard to water catchment areas. Also, useful towards the managing of wetlands, is the institutional structure which is created in the provisions of the act.

2.8.4 The Wildlife (Conservation and Management) Act

The Act mandates the minister with the power to pronounce an area as a protected area, in reliance to the Ramsar Convention, wetland spots of international significance can and may be declared protected areas to improve their position thereby enhancing their conservation.

2.8.5 Agriculture Act Chapter 318

It is in this act that wetlands are protected from unlawful and unsustainable agriculture which has a detrimental effect and invades on wetlands. It demands that land that is within two meters near watercourse should not be cultivated. A land equal in width to the water course should be left uncultivated around a water course that is wider than two meters but only up to 30 meters.

2.8.6 Dams and Sustainable restoration

Dams are a source of vital development to humanity, and substantial benefits have been acquired from them (World Commission on Dams, 2000). With the population growth worldwide there is need to improve the quality of life, and therefore dams are conspicuously placed as supply of water for hydropower, navigation in addition to many such uses to the planet. What's more, the future climatic regime is still unpredictable placing dams at an important position to provide water resources. it is anticipated that the areas affected by drought areas are probable to rise in

extent and risks flooding are likely to augment due to the increase in frequency of heavy precipitation events (IPCC, 2007), these effects of both of which dams can curb greatly. At the same time, there is a growing trend of removal of dams; a concern should be raised over their impact upon the ecological, social, and economic aspects of life (Pejchar and Warner, 2001). Old constructions, which are a risk to safety of the public, are progressively done away with under the new policies and funds are being directed towards the support of removal schemes (Heinz Center, 2002). So as to reconnect habitats, dams are now being removed in the bid to restore continuums for species fish which are migratory in nature, such fish include anadromous salmon, which have been listed as endangered in the U.S. by the federal government (Gregory et al. 2002). Still, a lot of uncertainty exists with regard to the consequences to come about when dam removal is done. (Hart et al., 2002), particularly the uncertainties are about the extent, the magnitude, as well as the timing of results to physical and ecological aspects (ibid). Thus, to the resource managers, scientists and administrators; dams are becoming an important issue where it is now necessary to advance knowledge about them and make informed decisions in their management.

A minimum six of the world's 292 large river basins, their reservoir storage goes beyond the annual discharge: they include; Manicougan, Colorado, Volta, Tigris-Euphrates, Mae Khlong and Rio Negro (Nilsson et al., 2005). It is therefore applicable that global dams distribution is wide and the effect dams have on the world's rivers are immense, this demonstrates how serious it is to understand how the social, economic, and environmental influences interact over time and space.

2.9 Thematic areas On Constructed Wetland restoration and sustainability

Key concepts influencing restoration and sustainable management of constructed wetlands are built around the three key themes of Sustainability (social, economic , and environmental) as described by the 1992 United Nations Conference on Environment and Development (United Nations Committee on Economic Development, 1993). Basiago (1998) also agrees that the model on sustainable development as explained in Agenda 21, actually, is built on the foundation of three conceptual pillars; economic sustainability, ‘social sustainability’, and ‘environmental sustainability. To achieve sustainable wetland Restoration and management, many commentators agree that economic, social and environmental sustainability framework must be integrated and interlinked in a well-coordinated and compressive manner in order to achieve successful results (Basiago, 1998).

2.10 Social Sustainability and Wetland Restoration

In Social Sustainability, McKenzie 2004 identifies common definition attempts on social sustainability and he makes a general conclusion to mean “a societal elevation as a result of improved condition of a community, and a process within which communities aspire to attain these positive conditions.” This definition is anchored on the corresponding principle that includes: equity to access to basic services, equity between generations, citizenry and stakeholder participation particularly at the local level, sense of community ownership, education and community awareness, and finally political support and advocacy to fill the gaps where community action cannot be met.

Rugo (2015) showed that engaging stakeholders and particularly the community was vital if success was to be made towards restoration and sustainability of Nairobi Dam because

accountability would be promoted, as well as transparency. It would also build trust, partnerships and empowerment.

The analyzed data tallied with what Scott (2007) identified which cited that involving communities in a community-based sustainability, leadership, planning and communication approaches were essential and can only be attained if the people involved are willing to recognize and bring on board the existing community, organizations and resources, knowledge and skills. Similarly Gozo (2011) concluded that stakeholder institutions who made decided efforts to include all stakeholders led to successful development and sustainability of water resources projects. The same conclusion is made by Borrini-Feyerband (1996), who confirmed that stakeholder involvement fostered concerted partnership that led to sustained success to projects and achieved a community centered wetland restoration and management.

In Kenya, one of the effective restoration examples, is the Nyando wetland which employed a community focused initiative and a broader collaborative stakeholder partnership. Mobilizing the communities and building their capacities to restore the wetland were based on five critical anchors which included; community empowerment both economically and politically, equity by ensuring the entire community benefit but not a few, sustainability by ensuring a balance between the present and future generations on extraction and use of resources, supportive legal framework and women involvement in the restoration and management of the wetland resources. This method of rehabilitation exceeded the usual unsustainable top- down strategy of knowledge transfer, skills and technical advice, rather the training, knowledge transfer and capacities development was done at the community level thereby permitting the communities to come up with resolutions in the development and restoration programs, ensuring the project remained sustainable even after the restoration program ended. (Raburu *et al*, 2012).

2.11 Economic Sustainability and Wetland Restoration

To appreciate Economic Sustainability Foy (1990) explains from an economic perspective, whereby he indicates that the present economic activities should care for the current generation's needs while being careful not to burden future generation. He further contrasts this with what ecologists mostly choose; to preserve environmental resources in their whole without allowing human activities to extract environmental value (in this case wetland values) for economic use. He finally points out that an ecological restoration approach should permit the resources to be open for economic use and therefore an approach that does not allow this is unsustainable hence need for economic reasoning and integration to ensure sustainability.

Sustainable restoration considers human and capital development by integrating natural, social and human capital. Control of economic growth and consumption which depletes environmental resources is critical. In addition, preservation of the environment through economic growth and the alleviation of poverty by promoting economic incentives and diversification of the engine propelling the local economic support base and community livelihood (Kahn, 1995)

Pezzoli, 2002 points out that logical relationship exist between livelihood attainments and sustainability goals. Change is driven by economically endowed communities which are able to supply the necessary energy for transforming the community and ensuring its well-being. Evans, 2002 discusses this further by pointing out that in every restoration and conservation approach it is vital to integrate other livelihood creation means particularly in places that the community is poor. This idea of alternative livelihood was useful in Nyando wetland restoration program that was effective in sustaining a number of community members. It took care of the concern of project's sustainability beyond its life span. Alternative livelihood undertakings, are exposed to abuse if they are implemented without an emphasis on the conservation agenda. Nonetheless

they are useful in diverting attention from the stressed wetland resource, (Raburu *etal*, 2012). Three critical principles that help in the management and restoration of water infrastructure projects were developed in Australia by the Queensland Water Infrastructure (QWI) restoration program. These experienced challenges with regard to social, economic and environmental sustainability. The principles were coined around sustainable communities, enterprises and ecological catchments (Fieldings *et al*, 2012)

Consideration of the social and economic impacts of urban constructed wetlands and physical infrastructure associated to it complement restoration schemes of the ecological impacts in sustainable conservation programs. In conclusion, policymakers have to balance the perceived ecosystem and economic benefits associated with wetland restoration including habitat restoration and benefits to wetland values and functions with other potential economic impacts on residents and communities.

2.12 Environmental Sustainability and wetland Restoration

Environmental sustainability encompasses three factors that include; ecosystem integrity, carrying capacity and biodiversity. It is defined as meeting the current and future generations' services and resource needs without compromising the vitality of the ecosystems that provide them and more particularly, as a state of balance, resilience, and concatenate that allows community to satisfy its needs while striving to balance them to ensure their extraction does not exceed the capacity of its supporting ecosystems as they continue to regenerate services necessary to meet those needs (Morelli, 2011).

Callicott and Mumford 1997, for instance, illustrate the meaning of the term “ecological sustainability” as a practical concept for conservationists; In “Ecological Sustainability as a

Conservation Concept,” they advance an ecological definition of sustainability that links human needs and ecosystem services: “a balance in meeting human needs without compromising the health of ecosystems.” They propose that, wherever human activities takes place, this concept should be a guiding principle.

One of the least anthropogenic affected river basins is Cubango-Okavango river basin on the African Continent which flows through Angola, Botswana and Namibia pegs its success on sustainable management of the Basin that integrated the economic, social and environment aspects of the basin. Central to the conservation program was the improvement of livelihoods through sustainable utilization of the shared resources. Areas identified included: basin conservation management founded on shared vision; focused environmental and social economic monitoring programs; integrated planning sustainable development of water resources; and capacity building and involvement of shareholders in implementation. Through this process, the wetland resource was able to achieve environmental sustainability in conservation and management of the basin (FAO Report, 2012).

A study on participatory, holistic approach to on the integrated effects of dams is now needed, especially in relation to the three components (economic, social and environment) on how their synergistic relationship impact wetland communities (McCully, 1996)

2.13 Case Studies on Constructed Wetland Restoration and Sustainability

According WCD Report, 2000, Dams are vital constructed water management wetlands of international concern that affects and impacts close to half of the world’s rivers. Dams support nearly close to 20% of the world’s electricity generation, 30-40% of the world’s irrigation: and have resulted to displacement of near 40 to 80 million people around the world. Therefore the

report acknowledges the need for sustainable restoration in management and utilization of natural resources.

Mau Mara Serengeti - Kenya sustainable water initiative confirms that water affects the three aspects of sustainability that is social, economic and environmental sustainability. After decades of degradation this vital ecosystem as a result of encroachment, deforestation and poor agricultural practices that polluted rivers, Mau Mara Serengeti initiative came up with an effective restoration plan that encompassed a river basin management strategy through participation process that ensure both the people and the ecosystems benefit; Provision of alternative livelihood and facilities that enhances sustainable economic activities and are environmentally sustainable accomplished through innovation in agricultural practices and sustainable tourism practices, and protection of key ecosystems (Ochieng,2016)

Sustainability has informed both policy and practice on water ethics and management in many parts of the world, for instance there are diverse opportunities that exist as a result of integration of ecological considerations in watershed management and allocation systems in South Africa and Australia. In California USA innovation and urban water management are integrated with Conservation management, water efficiency and water reuse and recycling as fundamental aspects of water management. Across Europe, new experimental and modernized governance systems are applied, In France, for instance, the government shifted its role from being the central power to facilitation of decisions to the local context of watersheds hence from the local setup is where decisions and plans are developed anchored on local condition for sustainable urban watershed management and restoration (Desveaux, 1994).

In addition, the creation of Water User Associations element has played a key role in integration approach, by providing a platform for community participation and role in management and restoration programmes (Wenger et al, 2003). Lake Jipe -River Lumi basin just like Nairobi dam is an example of a wetland that has experienced appalling catchment degradation attributed mainly to anthropogenic activities. Precursory efforts in addressing the degradation of Lake Jipe basin adopted a top-down approach similar to the four rehabilitative attempts to Nairobi dam (Wangui, 2004). In this case state organs excluded local communities from the project design, planning and decision making process, which resulted to alienation of community needs and aspirations that led to further marginalization of the poor and wetland degradation. Advocating for public participation on natural resource management is strongly visible on current policies; however, there are challenges to actualize this collaboration into practice due to limited capacity (human and institutional). This is especially evident for Lake Jipe basin as far as adequate consultation and engagement in planning and decision making processes is concerned whereby it is evident that local community and other stakeholders are not adequately involved hence need for incorporating water resource user association (WRUAs) to enhance community participation in management and restoration activities (Njiriri, 2016).

According to Nellemann (2010), without innovative financial arrangement involving Public Private Partnership, it would be difficult to undertake a carefully planned and phased wetland restoration. A good example is The Little Pine Island in the USA. Recognizing the ecological importance of the Island now which is strategically located within the 40,000 acre Charlotte Harbor State Park in the State of Florida, acquiring funds to cover the anticipated cost was a daunting task. In the early 1990's, a concept of mitigation banking appealed to both the State of Florida and a private developer. In 1997, restoration activities began, undertaken as a Public

Private Partnership that was formed between Marina Properties Development Inc., and the State at the Little Pine Island Wetland Mitigation Bank. One of its kinds in the US, the bank privately financed over 12 million US Dollars in habitat restoration and its perpetual sustainability, ultimately from the sale of bank credits (Reiss et al 2009)

According to Bäckstrand (2003), Sustainability is dependent on citizens assuming their roles and responsibilities and working out modalities in protection and management of wetlands and their environments. A good example is Safilguda Lake in Hyderabad India. Just like Nairobi dam this wetland after years of degradation as a result of impacts of rapid urbanization and anthropogenic activities had failures in the initial restoration efforts. The failures were attributed to lack of interest and involvement from stakeholders and community and conflicting interests from various stakeholders. However after a catastrophic event in the area as a result of heavy flooding, there was realization of wetland restoration and sustainable management, which saw resident based initiatives in active participation in wetland restoration and development in order to ensure sustainability of the various interventions. In addition, with public confidence established, efforts such as laying of sewer lines, storm water drains, demarcation of land on riparian reserve and stoppage of construction on wetland and provision of door-to-door garbage collection facilities was carried with massive community support. In addition community policing to prevent land encroachment and anti-social activity (Ramachandraiah 2011)

The Safilguda Lake development experience through creation of recreation activities such as Public Park, boating activities and provision of alternative livelihoods has brought stakeholders together to keep vigil on the wetland environment. With this experience, Safilguda wetland has redefined its responsibilities in wetland restoration and sustainable Management that is citizen based.

2.14 Theoretical framework

Theoretical framework of Integrated Water Resources Management

The Global Water Partnership defines IWRM as: “a process which fosters a synchronized development and administration of water, land and related resources, without compromising the sustainability of vital eco-systems” founded on three principles of social equity, economic efficiency and ecological sustainability by maximizing on the resultant economic and social welfare in an equitable manner (Dukhovny, 2000). Integrated Water Resources Management (IWRM) is being promoted nearly across the entire globe towards achieving sustainable development, through an integrative wetland approach that enables better understanding, protection and development of wetland resources. IWRM is seen as a framework for an elaborative approach towards sustainable management and use of wetland resources in relation to global increase in pressure on wetland resources due to population growth, pollution and possible impacts of climate change,

Social equity is a principle that takes into account various wetland users’ consequences on their decisions and actions with a focus in particular, on ensuring equity in access to, and use of, wetland resources and the derived benefits. Application of this concept regardless of economic status, spatial location and individual characteristics of its members such as their gender, age, health conditions or level of income is viable to all social groups. However, Social equity can, be increased through: involvement and consultation of wetland users and stakeholders in resources decision-making to ensure more equal opportunity is given to voice needs and expectations, independent of economic power or social status; fairly distribution of economic benefits through equitable allocation of available water amongst all users, alleviation of poverty ultimately through improved and enhanced livelihoods; and reduction of negative impacts from

anthropogenic activities up or downstream areas of the catchment in and outside Local the cities and urban boundaries (Robertson,2017).

On the other hand, economic efficiency as a principle predicates that, to attain the highest value returns there is need to make the most economic use of wetland resources thus bringing maximum benefit for the greatest number of people. This value should both include issues dealing with price plus social and environmental costs and benefits for the current and future. Economic efficiency principles in water resources management can take the following measures in their application: avoiding shifting costs into the future by adoption of a precautionary approach; within the domestic, agricultural, and industrial and public sectors there should be a reduction or redirection demands on water resources; and usage of a unit of water with optimum efficiency through recycling of wastewater (Barbier *et al*, 1997).

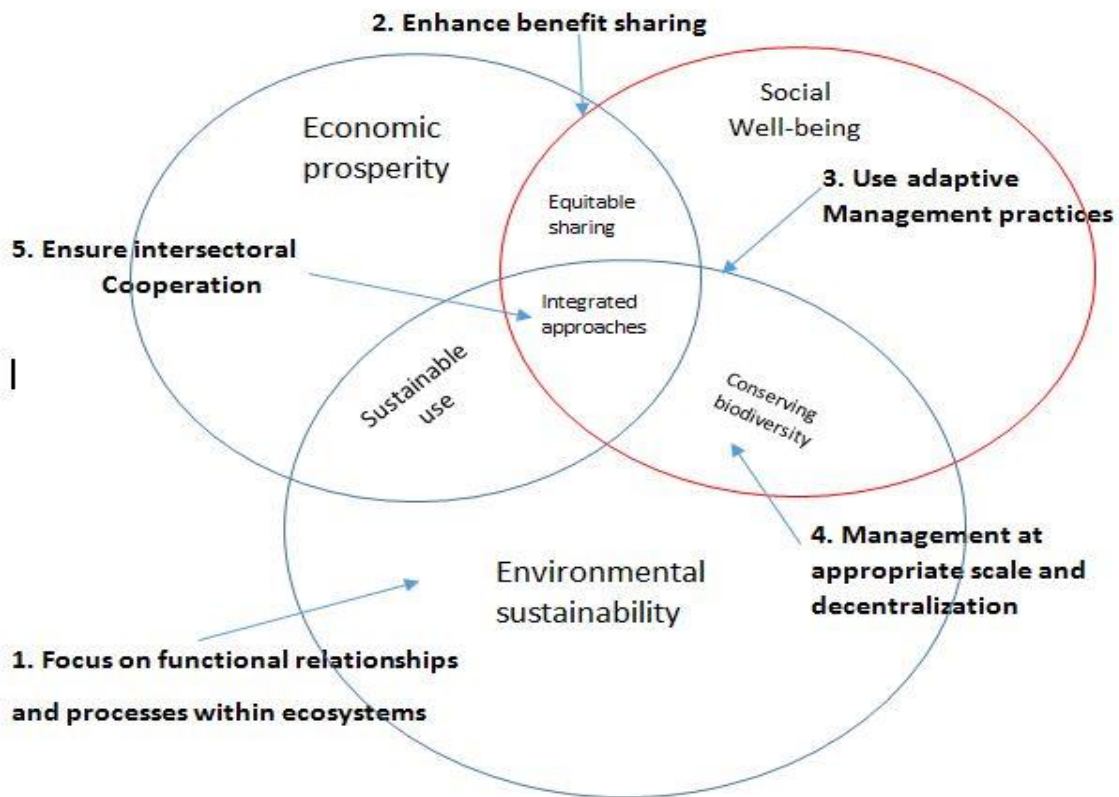
Ecological sustainability maintains the services that ecosystems provide by recognizing the environment as a user in itself. Therefore, wetland resources should be maintained without depletion within the limits of replenishment by natural processes or human intervention. This should apply both to the current and future generation. The following measures can help achieve wetland resource management pegged on ecological sustainability, and that includes: widespread awareness creation and enhancement of the vulnerability of ecosystems and the services they provide; promotion of economic activities with minimum damaging effects on wetland ecosystems; protection of local ecology by passing and enforcing regulation (Philip *et al*, 2008)

Simultaneously, the characteristic of the Integration element of IWRM will take into consideration the various aspects of water resources management. From an urban management perspective, there are different ways in which integration occurs, such as: social, economic and

ecological integration and considerations into the mandates of urban or city governments that are either directly or indirectly related to water resources; and an increase in performance efficiency and effectiveness through the integration of activities by various Urban Government departments; generation of a broad basis of knowledge and resources via the integration of the views of a wide range of local stakeholders, development of more viable interventions and building of stronger ownership; local activities integration both up and downstream; and ensuring current planning processes integrates future needs. This integrated approach is essential because it enhances decision-making process that is informed and takes into consideration the impacts of actions by water users and ecosystems – and, vice versa, and how other usage of water and functions of ecosystem impact urban water use (Mehtonen et al, 2008).

IWRM is one policy for the integrated management of land, water, and living resources, it is a form of the ecosystem method that encourages conservation and sustainable usage in a fair manner (Millennium Ecosystem Assessment 2005 quoted by Roy et al., 2011).

Figure 2. 1 Theoretical framework of Integrated Water Resources Management



SOURCE: IWRM Ecosystem Approach Model: Roy et al., 2011

2.14 Conceptual Framework

As shown in the figure 1 below: The success of any Urban constructed wetland rehabilitation strategy programme geared towards promotion of urban sustainable wetland restoration is founded upon the presence of a clear policy, legal and institutional framework that supports and favors community intervention measures . Any rehabilitation undertakings globally are mainly driven the universally accepted citizens’ rights to clean and healthy environment. For the above measures to be achieved,it is is necessary for community needs assessment to be carried out by governments and other stakeholders and afterwards adopt an enabling bottom-up approach to

wetland restoration and community improvement programme that includes community empowerment aspects that includes job creation and upliftment of socio-economic conditions of targeted beneficiaries. Supported by requisite legislation and political good will slum constructed wetland restoration and redevelopment measures should endeavor to achieve high conservation and management measures by the community from unsustainable extraction practices to sustainable better practices, offer tenure security, provision of supportive infrastructure and gradual reduction and eventual disappearance of wetland degradation due to anthropogenic activities.

An ideal slum constructed wetland rehabilitation and restoration process includes gradual improvement, formalization and incorporation of informal settlements into the land adjacent to the wetland itself, by extending land, services to slum dwellers. Successful dam restoration and rehabilitation should therefore not be simply about removing hyacinth, cleaning the river upstream, improving drainage or housing or enhancing the public amenities surrounding the dam but rather about community activities that are needed to turn around downward trends in the area by putting into motion the economic, social, institutional structures . In the context of urban wetland restoration and rehabilitation, the above measures when constantly undertaken with public/community participation, can lead to the achievement of Sustainable development goals target 11 on sustainable cities and communities and successful restoration of Nairobi Dam.‘

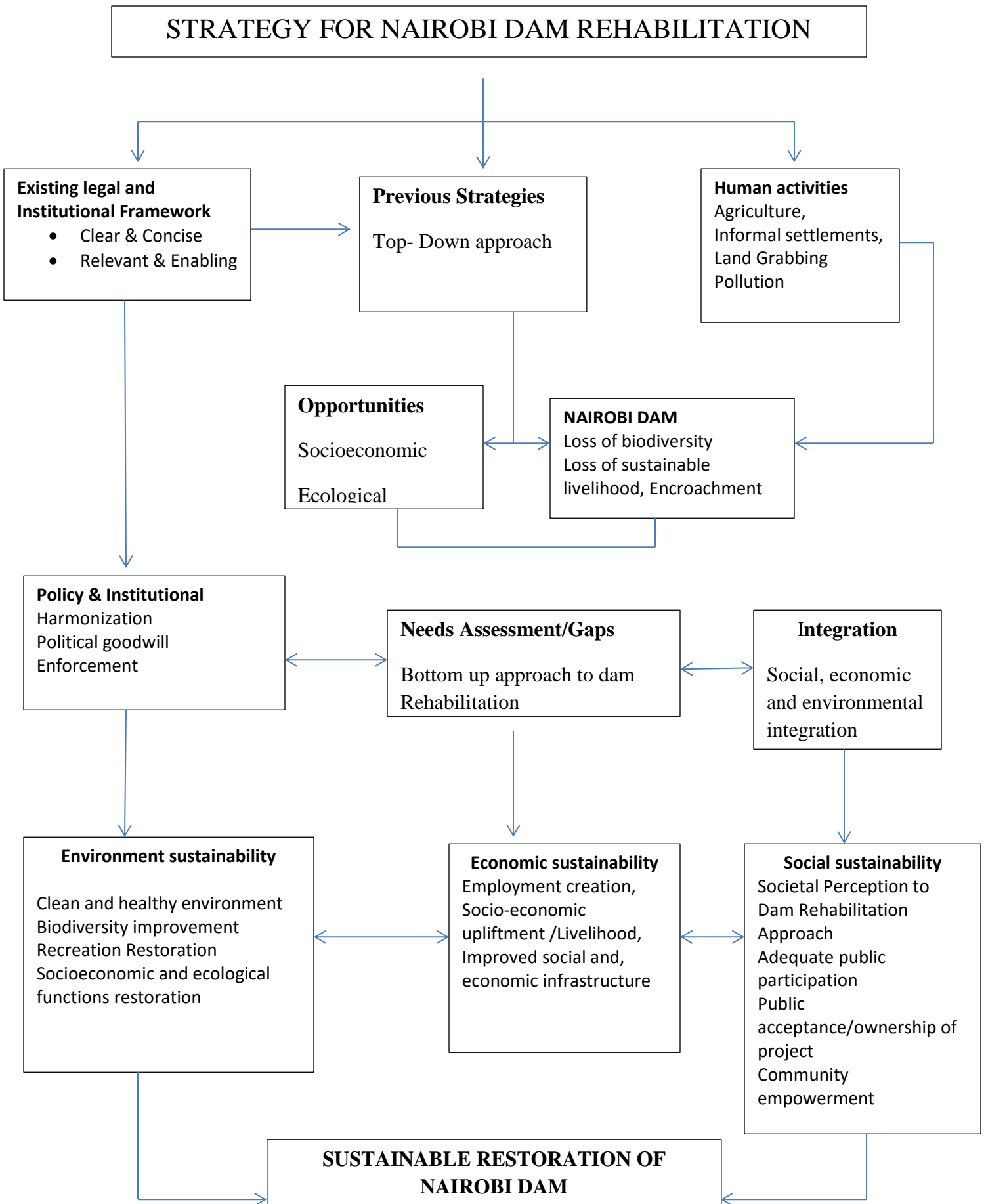


Figure 2.2 Conceptual Framework *Source: Author, 2019*

2.16 Knowledge Gap

Muriithi (2009), in a study to assess human-induced impacts on urban wetlands: a case study of the Nairobi dam, found out that the environmental policy dealing with pollution, was applied selectively and this was the main reason pollution was a friendly activity to the residents. From the findings the study policies need to be harmonized if we are to achieve a socio-economic development. Therefore wetlands management requires multi-disciplinary or multi-sectoral approach. The study however leaves a gap in assessing the influence of corruption and other challenges on conservation and management of the dam.

Investigation of Social Economic Activities and Their Implication for Wetland Conservation in Nyando Wetlands, reveals existence of a massive challenge from overuse and over exploitation, reduction of the biodiversity within these wetlands as a result of lack of application of new management technologies and weak institutional policies (Maithya, 2011). The study though, does not show the necessity of an establishment of eco-tourism within the Nyando wetlands so as to assess strengths, opportunities, weaknesses and threats.

In a study to identify the factors influencing restoration and sustainability of the Nairobi dam in Nairobi county, Kenya, Rugo (2015), recommends stakeholders engagement, governance structure and legal framework on water resources management should be strengthened, environmental education integration into school curriculum and the consideration of government in defining and delegating the mandate of Nairobi County Government in gaining autonomous control of the dam and prevention of political interference. This study also fails to address the previous restoration plan challenges.

In another study by Macharia (2000), which seeks to identify the impact of water hyacinth (*Eichorniacrassipes*) in an man made wetland: a case study of Nairobi dam, shows that it is imperative for sustainable utilization of water hyacinth to be based on both the varied environmental and economic costs which include reducing the water hyacinth to manageable levels. This study too fails to consider other factors like the socio-economic pressure that contribute to the degradation of the Nairobi Dam.

Whilst the above studies under review provide informative perspective with regards to sustainability of dam and river restoration projects, they are very limited to specific fields and do not provide cross-cutting analysis of factors affecting sustainability and gaps from different failed restoration strategies. On the restoration of dams, they are inclined to ecological restoration which much defines biodiversity but not the maintenance and sustainability of the dam in relation to the opportunities it can provide to communities. Further, most of the past studies focus mainly on dams' removal due to their adverse environmental impacts on the biodiversity.

From the past studies reviewed, it is evident a critical review of past restoration strategies in identifying gaps and weaknesses so as to provide viable alternative and sustainable mitigation plans as not been highlighted. This is the result of the adverse failures in efforts geared towards restoration, a good example being the Nairobi Dam.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The chapter describes the major elements of the study environmental area, encompassing the physical, biological and social environment as well as the state of Nairobi dam. Additionally, it describes the methods of data collection and analysis and materials used during the study. Key informants' interviews and questionnaires will give the historical and present perspectives of the failure or success on the Dam's rehabilitation.

3.2 Description of the Study Area

3.2.1 Location and size

Nairobi Dam is located in Kibra and Lang'ata Constituencies in Nairobi City County of Kenya (see map 3.1). It lies between latitudes 1° 19' South and longitude 36 ° 48' east and at an altitude of 1,700 meters above sea-level. Nairobi City County lies at an elevation of 2,300m to the west and 1,500m to the east. Bordering the north eastern side of the Nairobi Dam is Nyayo High-rise estate and Seefar buildings, on the southern side is the Nairobi Sailing club and Nairobi Dam Estate, on the Northern side is Lindi, Silanga, Soweto East Villages Kibera slums while on the western side are Ngei, Otiende, Southlands, Uhuru and Onyonka estates and on the eastern shore is the Langata Women's Prison.

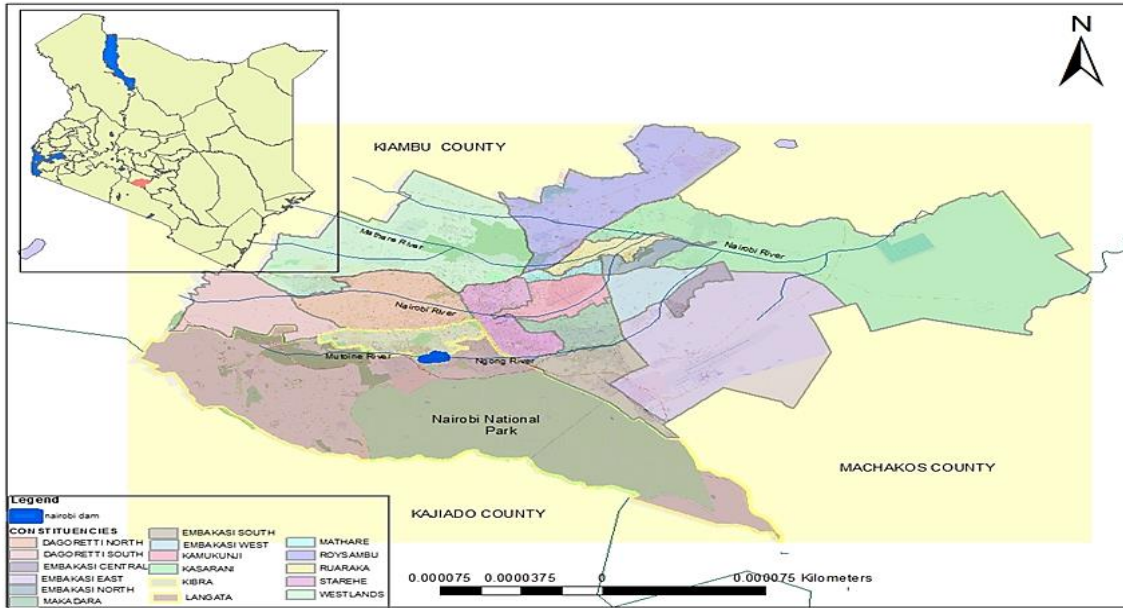


Figure 3.1 Location of the Study Area

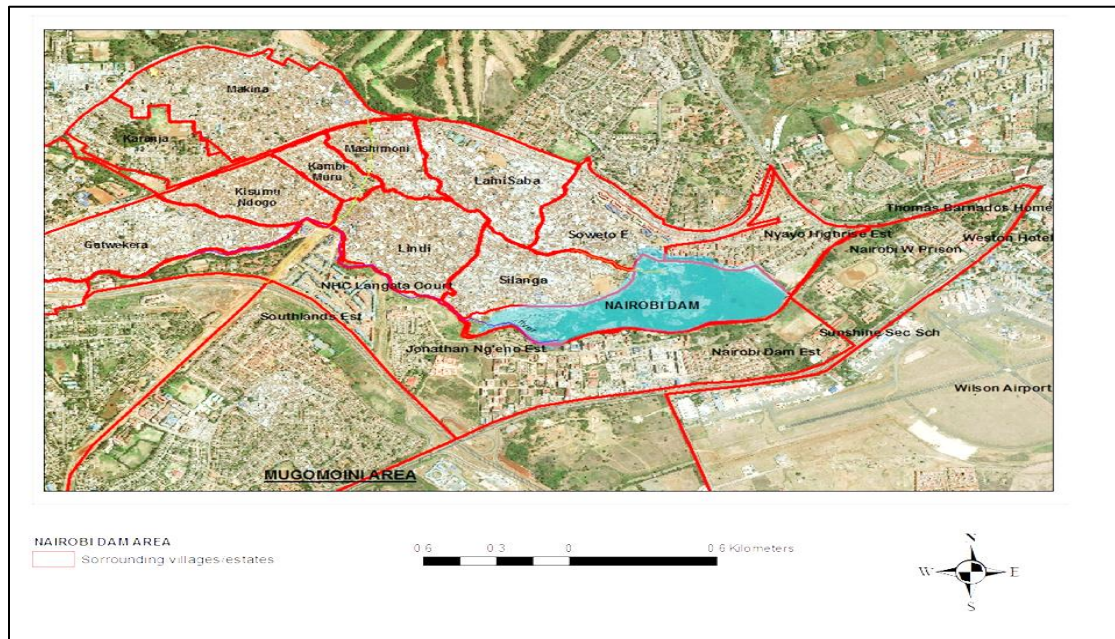


Figure 3.2 Map of Nairobi dam and the surrounding villages/estates

3.2.2 Rainfall and climate

Nairobi County area has two rainy seasons, the long rains occur in March and May and the short rains occur in September and November (Kahara, 2002). The mean annual rainfall range is 500-1,500 mm (UNEP, 2003). Temperature ranges between a high of 30°C to a low of 12°C have been recorded depending on the season of the year (UNEP, 2003). The humidity ranges between 40% and 97%.

3.2.3 Geology, soils and hydrogeology

Geologically, Nairobi City County is close to the Eastern border of the East African Rift Valley and is on a large depression filled with volcanic rocks and sediments of Cainozoic times, which lie on basement complex rocks. This volcanic rocks and sediments of Cainozoic times dominate Nairobi's geology. The volcanic rocks (phonolites) have gentle eastward slopes from the rift Valley (Kahara, 2002).

The lava flow in the project area is considered hard and impervious while the tuffs and trachytes are relatively permeable allowing for water percolation (UNDP, 2007). Most of the Nairobi area is underlain by volcanic and volcano clastic rocks of Pliocene age, which has bearing on the area's hydrology. Regarding ground water, Nairobi is underlain by volcanic rocks of Pliocene age, which have bearing on ground water. Major aquifers in the area are usually beneath the confining and deeply seated Upper Athi series. The Upper Athi series comprises of a heterogeneous combination of lakebed, re-worked sediments, air-fall tuffs, ashes and occasional intercalated lava flows (UNDP, 2007).

3.2.4 Hydrological Characteristics

The Nairobi Dam gets its water from the Motoine River while Ngong River is the outlet from the dam. Both Motoine and Ngong River systems are sub catchments of the Nairobi River Basin. The Motoine River rises from Ngong hills and flows through the Dagoretti forest, before pouring its waters into the Nairobi Dam, about 4 kilometers away from the source waters. The presence of clay sandy soils is derived from volcanic activities which result in good infiltration. Ngong stream referred to as Silanga river rises from just above Jamuhuri International Trade Fairgrounds at about 1,850 meters and drains into the Jamuhuri Dam (Kahara, 2002). Other five streams namely: Gatwereka, Olympic, Banker, Golf Course and Undungu, flow into the Nairobi dam through the Kibera slums (Primož, 2010).

3.2.5 Biophysical environment

Most of the indigenous vegetation near the reservoir is dry semi-deciduous (Trump, 1967) with *Croton megalocarpus* and *Calodendrum capense* as the dominant species. Other vegetation include *Themeda triandra*, *Eragrostis pynostachys*, *panicum maximu*, *setaria applicatalis* and other scattered bushes and stunted trees, including the *Barleria micrantha*, *Grewia similis* and *Acacia* species particularly on the western side. The Nairobi Dam is covered by Water hyacinth which is invasive species that thrive on the eutrophication of the dam caused by pollution from the surrounding area. However, it is important to mention that the hyacinth also plays a role in purification of the water before it drains into the Ngong River (Muriithi 2009)

3.2.6 Population size and distribution

According to the Kenya Population and Housing Census, (2009), Kibra and Langata constituencies formerly Nairobi west district have a total population of 355,158 people. Nairobi Dam is located in the three wards (Mugumoini, Lindi, and Nyayo Highrise) out of ten wards of

these constituencies having a population of 106,386 people according to Kenya Population and Housing Census (GoK, 2009).

Table 3.1: Population Structure of Lan’gata and Kibra Constituencies.

CONST/DISTRICT	MALE	FEMALE	TOTAL	HOUSEHOLDS	DENSITY
LANGATA- KIBRA/NAIROBI WEST	185,832	169,356	355,188	108,477	1,591.63

Source; Kenya Population and Housing Census (Population Census, 2009).

3.3 Research design

Research design is the theoretical structure whereby research is carried out. The role of research design is to offer a way for relevant data to be collected without a great deal effort, time and resources (Bryman, A., 2004). This study employed a descriptive survey research design to make an intensive investigation of the opportunities and constraints in the rehabilitation of Nairobi dam. Therefore, the following steps were employed to ensure the design manifested the basic characteristics of both the qualitative and quantitative research and also maintaining triangulation in its findings, they include: Pre field work, Field work, Review of relevant documents, Data collection, Data analysis and interpretation.

3.4 Target Population.

The study targeted all households in the neighbourhoods and villages of three wards of Nairobi's Lang'ata/Kibra Constituencies fronting Nairobi dam which include: Langata Paradise Apartments, Dam Estate, Jonathan Ngeno estate (Mugumoini ward), and High rise Estate, Seefar Apartments, and a section of Soweto East village (Nyayo Highrise ward) and Kiberas' lindi and Silanga villages (Lindi ward) . Going by the population census of 2009, these settlements had a total of 10,028 households with a population of 55,158 persons. It also includes the Nairobi City County, NEMA officials, WARMA and the Civic authorities advocating for dam restoration.

3.5 Nature and Sources of Data

3.5.1 Type of Data

Two types of data were collected that is, primary and secondary. The primary data was collected from the field and it gave firsthand information about the opportunities and constraints that exists in restoration of Nairobi dam.

Secondary data in form of documented information was sourced through archive retrieval of documents such as collateral information from the various Government and Non-Governmental institutions reports that carried conservation study on the dam, Publications, relevant environmental and wetland books and journals, government ministries records and research reports, documents such as city indices, fact data sheets, maps and development plans to give information about the demographic, socio-economic patterns, GIS generated Landsat 5 TM 30 Multispectral satellite images on land cover changes and land use trends in zone 9,10,11,20C,20E,20D and 20J of Nairobi county over time from the Regional Centre for Mapping of Resources for Development (RCMRD) and water quality analysis of the dam from water quality and pollution monitoring unit of NEMA.

3.5.2 Methods of Data Collection

Both secondary and primary data was collected. Structured questionnaires collected information on household characteristics, land tenure, availability of public services, Nairobi dam use and opportunities, perception and attitudes, level of community participation

Oral interviews were used to collect information from the key informants. These included people with specific functions in the wetlands.

Observation verified the physical state of the dam, size and vegetation on the dam, uses, erosion, developments, infrastructure, and wildlife. Photographs were used to capture data which was then referred to during the analysis of data to provide useful visual interpretations of different phenomena such as encroachment, Dam and river conditions, human socio economic activities, development and settlement patterns around Nairobi dam and Motoine River encountered during the research study.

The tools for data collection included questionnaires, a camera, maps, and a handled GPS.

3.5.3 Pilot Study

A pilot study was carried out before the main study just to help in testing the clarity, effectiveness, adequacy and relevance of the research instruments and their viability in the study.

This helped me familiarise myself with the area of study.

3.5.4 Sample Size

The population of the study consists of households, institutions, plus pressure groups with interest to Nairobi dam and settlements surrounding the dam. The following formula determined the sample size of the study; Nassiuma Coefficient of Variation formula (Nassiuma, 2000).

$$n = \frac{NCV^2}{CV^2 + (N-1)e^2}$$

Where n= sample size

N=population (10,028 households)

CV=Coefficient of variation (take 0.5)

e= standard error of 0.05 at 95% confidence level.

On the basis of the formula above and the variables indicated, the sample size $n = 99.0224$ rounded off to 100. Therefore, 100 households on the basis of housing typologies criteria was field data gathered from comprising existing slum who constituted 70 respondents from Kibera slum (Lindi, Silanga and Soweto East villages) and 30 respondents from the formal housing

neighbourhood of High rise flat, Langata Paradise Apartments, Seefar Buildings, Dam Estate, Jonathan Ngeno residents. In addition, key relevant institutions were interviewed that included WRA, NEMA, NCC, and Green Card CBO.

3.5.6 Sampling Techniques and Procedures

Probability and non-probability sampling techniques were both employed in the study with the unit of analysis being the household. The total sample was 100 households

The population was divided into two homogenous strata on the basis of housing formality fronting the dam using Stratified random Sampling. Therefore, the two different sub-groups comprised of the already present informal housing settlements of Kibera slums on one section of the dam and the formal housing settlements of Highrise and Seefar Building on Eastern side of the dam, Dam estate and Jonathan Ng'eno estate in the adjacent section of the Nairobi Dam. In identification of transects along settlements fronting Nairobi dam and main rivers and drainages draining into the dam, Systematic Random Sampling method was also used. Simple random sampling was used to obtain samples for initial households, whereas systematic sampling formula N/n was used to arrive to subsequent households. Where total number of households along the transect was represented by N while the administered number of questionnaires was represented by n .

On the achievement of the study objectives, key informants believed to be resourceful and possessing crucial information relevant to the study were targeted using Purposive sampling technique. Relevant institutions of various interest groups were identified through employment of this method such as the Nairobi City County (NCC), National Environment Management

Programme (NEMA), Water Resource Authority (WRA), UN-Habitat and other NGOs/CBOs in the study area.

3.5.7 Description of the questionnaires

One questionnaire with three sections was administered randomly to 95 people residing in the scheme. The first section captured their personal data like age, level of education and employment; the second and third section was intended to collect data on Nairobi dam rehabilitation and use information (opportunities and constraints) in Kenya. Section three captured the information on past restoration efforts. In total the questionnaire has 14 questions.

3.5.8 Methods of Data Analysis and Presentation

Qualitative and quantitative methods were incorporated to analyse the information gathered from the field. SPSS, R statistical software and Excel spreadsheet were used for the analysis. GIS processing of satellite images was used in measuring spatial temporal changes in land uses in Nairobi dam area on objective. Landsat 7 Thematic Mapper (TM) was used to provide data for land use and land cover. Selection on the basis of availability and suitability of images were obtained with an interval of 10 years from one image to the next from 1988, 1995, 2004 and 2017. 1988 was chosen on the suitability of the images, since the dam water began being unusable for water supply and recreation in the 1980s as result of the waste emanating from Kibera and influx of population into Nairobi and especially Kibera where the dam is located immediately after independence in 1963 and the 70s (Johan,2005). The empty contested land around the reservoir became residence to thousands of new city dwellers, and this massive growth of informal housing was not matched by infrastructure or services for these new residents. Data processing was carried out using ArcGIS 10.1. Landsat 5 TM and ETM+

Imageries of 30 M resolution was adequate for change analysis of Nairobi dam over a 30 year period.

Data processing and analysis; Processing of data was performed during and after data collection. In accordance with the objectives, the information obtained was recorded in summary notebooks and presented. Usage of descriptive statistics mainly in terms of percentages, tabulations and so on in analysis of collected data so that data could be. For ease in comparison and drawing inferences of data, frequencies were expressed in percentage terms. After every data collection, editing was done to eliminate errors. Application of descriptive statistics is key as it was instrumental in achieving the objectives of the study through a systematic collection, analysis and interpretation of data.

The nature of the data collected prompted the use of multiple linear regression analysis. Degradation of Nairobi dam was as a result of the various uses into which land was put that are connected by a linear relationship. The dependent variable was denoted as y while the independent variables were denoted as x_0 . The relation between x and y was given by;

$$y = b_0 + b_1 x + b_2x + \dots + b_nx$$

Where y is the dependent variable value in our case Nairobi Dam

Finding the regression line: the method of “ordinary least squares” was done. Beginning with assumed values for b_0 and b_1 and b_2 and it was proposed that the relation between x (Land uses) and y (degradation of Nairobi dam) was given by;

$$y = b_0 + b_1 x + b_2x$$

Analysis was done with the help of R statistical software and Microsoft Excel data analysis. The data collected was used to test the null hypotheses. The nature of the data which was collected

prompted the use of regression analysis. This was because regression analysis is used when two or more variables are thought to be systematically connected by a linear relationship. The R value was calculated and R^2 . Analysis of variance (ANOVA) was carried out and the calculated value was compared with the tabulated value.

Reading from critical values of the indicators, T- table was tested at 95% significance level ($p = 0.02$), in 3 degrees of freedom ($n-1$). The hypothesis was tested using the value that was calculated. The calculated value was less than the tabulated value hence the null hypothesis was rejected.

3.5.9 Classification of Land-Use and Land Cover

Definition of training data set (or signature) indicating pixel types for land-cover categories selection, a supervised classification procedure was used in analysis of land-use/cover changes. A classification decision rule was used in sorting image pixels into classes based on the signatures identified. The classes identified in this way were agricultural land, forest, wetlands, shrub land and built up land. Polygon method was used in sampling these classes from the satellite image. Classification of the rest of the image to provide a meaningful data classes were generated by class signatures with usage of training data sets.

3.5.10 Descriptive Statistical Analysis

The information captured through observation, interviews and discussion was analyzed by Descriptive analysis. In analysis of objective one and objective two; frequency tables, charts, photographs and maps were used. While in the analysis of guided questions data the SPSS technique was also used. Using this technique, computation of frequencies, percentage and other statistical data measures were derived and then used for analysis.

Depending on the type of data under consideration and the intended output to be relayed, the data collected was presented using instruments such as tables, pie charts, photographs as well as text formats. The primary determinant on the presentation techniques is the nature of data.

Table 3.2: Summary of Research Methodology

Objective	Variables	Types of Data	Source of data	Methods used	Analysis
1. To undertake a situation analysis of Nairobi Dam and its surroundings	Patterns and trends in changes of land uses. Water quality. Security of tenure. Legal and institutional framework. Solid and Liquid waste Management mechanisms.	Primary Secondary	RCMRD, USGS, NEMA, Site Visit (transect walk), Photos and GPS, Households Resource persons Literature review Referred publications	ArcGIS 10.1 and Map digitization. SPSS, R and Ms Excel	Landsat images Classification ,Change detection analysis, analysis on chemical pollution loads, descriptive statistics , Content Analysis
2. To evaluate past rehabilitation strategies in order to draw lessons from their successes and failures	Level of awareness and community involvement of previous efforts. Perception on Effectiveness of Strategies.	Primary Secondary	Focus groups discussion, Key informants interview, Observation, Literature review Referred publications	SPSS, R and Ms Excel	Descriptive statistics. Content Analysis,
3. To develop indicative strategy for sustainable restoration of Nairobi Dam.	Output from objective two	Primary Secondary	Focus groups discussion, Key informants interview,	SPSS, R and Ms Excel	descriptive statistics Content Analysis

Source: Author, 2019

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND RESEARCH FINDINGS

4.1 Demographic Characteristics of the study area

Table 4.1: Demographic Characteristics of the Sample population

Characteristics	Number	Percentages (%)
<u>1.Gender</u>		
Female	41	43.2
Male	54	56.8
Total	95	100
<u>2.Age</u>		
18-35 years	42	44
35-52 years	28	29
52-70 years	14	15
70 & above	11	12
Total	95	100
<u>3.Education level</u>		
Never been to school	6	6.3
Primary	28	29.5
Secondary	32	33.7
Tertiary	29	30.5
Total	95	100
<u>4.Sources of income</u>		
Formal Employment	28	29.5
Farming	8	8.4
Seasonal contract	13	13.7
Self employed	12	12.6
Daytime/casual jobs	34	35.8
Total	95	100
<u>5.People per household</u>		
1-3 people	14	14.7
3-8 people	36	37.9
8-10 People	33	34.7
10 & above	12	12.7
Total	95	100

Source: Field Survey, February 2019

In Table 4.1, of all the respondents who participated in household data collection, 54 (56.8%) were males while 41 (43.2%) were females.

On age level, the survey found majority of the residents at 70% of the respondents are in youthful bracket (youths and middle aged persons representing 42% and 28% respectively) .This age structure if properly tapped can provide a good resource for future conservation strategies. Gibbs et al 2012 notes that youthful structure of a population causes high dependency ratios and is responsible for high unemployment rates and demands for education, housing, health, transport and other social amenities.

On education level, out of 95 who responded, 6 (6.3%) had no level of education, 28(29.5%) had primary education, and 32 (33.7%) had secondary education and 29(30.5%) had tertiary level of education. Given that education and awareness plays a critical role in restoration and conservation efforts, a 61% rating of having secondary and tertiary education provides possibilities and ray of hope towards restoration efforts.

On income sources, only 28 (29.5%) of the respondents are formally employed either in the public or private sector and the majority of these response came from the formal neighborhoods, while 67 (70.5%) of the remaining respondents engage in informal income generating activities ,with majority coming from the kibera (Silanga ,Soweto East and Lindi villages)slums. From the results, it is clear that a large proportion of the population are in poverty, This state of affairs may also pose a challenge in the restoration because majority of the population occupying the riparian land of the dam are within this category, showing that they could be encroaching because life is affordable in the slums. Removing them might pose even a greater challenge.

On number of persons per households, Majority of the households were considerably overcrowded with 47.7% of respondents having more than 8 persons per households as compared to the national threshold of 4.4 people per household as recorded in the 1999 Population Census .The number of people per household in relation to the type of housing typologies as observed especially in Lindi, Silanga,Soweto East villages of Kibera slums reveals overcrowding in houses which are one roomed iron sheets and mud walled structures, Population being a major driver of environmental degradation, poses a threat to adjacent Nairobi dam due to encroachment, because overcrowding and lack of space for housing development not only put pressure on the wetland but a challenge to restoration efforts, strategies in slum housing upgrading is essential in order to achieve sustainable utilization of space and to tackle the encroachment problem in Nairobi dam.

4.2 Situational Analysis of Nairobi Dam and its surroundings

The research sought to find out challenges and constraints to sustainable restoration of the dam in the past, present and future of the study area.

Figure 4.1: Map of Kibera settlement, Nairobi Golf course, and Nairobi dam in 1953



Source: Courtesy of KDI

As shown in the figure 4.1 above, it indicates, at the construction of Nairobi dam, there was no human settlement (Kibera and the surrounding neighbourhoods) around or adjacent to the dam.

4.2.1 Trends in Land Use and Land Cover Change for Nairobi Dam Area (Zone 9, 10, 11, 20C_D_E, and J) for the Period between 1988 to 2017

The land use and land covers of Nairobi dam area (Zone 9, 10, 11, 20C_D_E, and J) for the years 1988, 1995, 2004 and 2017 are shown in Figures 4.2, 4.3, 4.4 and 4.5 respectively. Whereas areas for the various land uses and land covers is summarized in Table 4.2, with similar trends presented in Figure 4.6.

Land use in area on built-up and transitional land cover has increased tremendously from 27.09 km² in the year 1988 to 67.19 km² in the year 2017. While agricultural, grass and riparian vegetation which occupied 22.5 km² of the area in the year 1988 maintained a steady decline of 0.1 km² margin after every 10 year period until 2004 and then a massive decline to 14,7 km² in the year 2017; Ngong forest as shown as a forest land use cover have experienced massive loss throughout the years. In the year 1988, Ngong forest cover was 9.53 km². There has been a massive decline of the forest covers with a margin of close to 1 km² for every 10 year timespan; with the 2017 margin being 6.67 km². The declines is attributed to the clearance of the forests for urban development and agriculture which characterized the periods between the years 1995 to 2017.

In addition, the area under rangeland and shrub vegetation cover tremendously declined from the year 1988 when it covered 17.22 km² of the study area to 3.76 km² in the year 2017.

As shown by Figures 4.2 to 4.5 and Table 4.2, there have been changes in land use and cover over the years within the study area and timeline. Nobly, there has been an observable decline in agricultural, grass, riparian; rangeland as well as Ngong forest covers which is attributed to the expansion of the urban built-up and transitional areas. The massive encroachment by agricultural and riparian land uses into Ngong forest and wetlands; Steady decline of Ngong forest in relation

to the area under urban built-up and transitional lands has significant implications on the quality and health of Nairobi dam wetland.

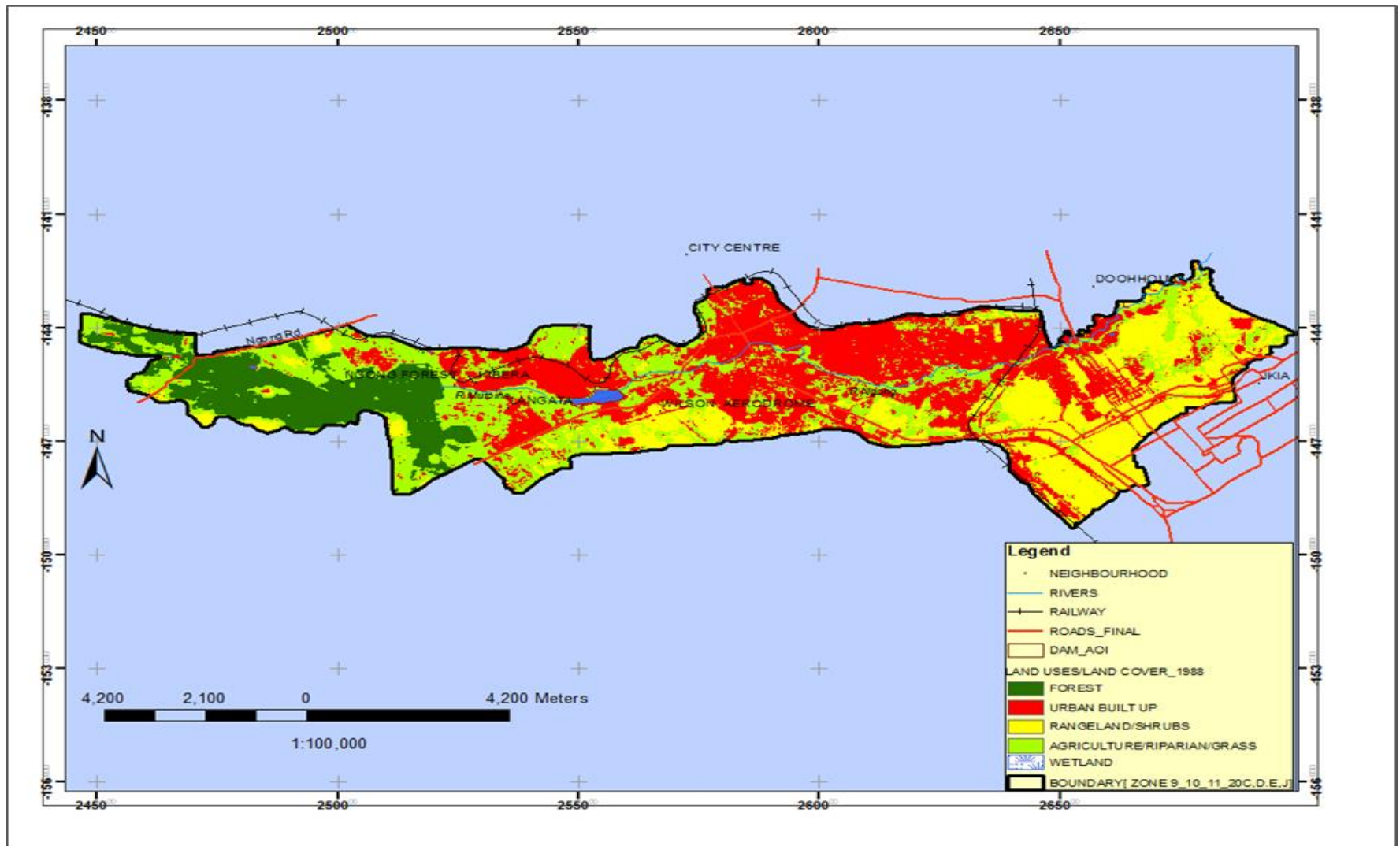


Figure 4.2: Classified Land Use and Land Cover Map of Nairobi Dam Zones for the Year 1988.

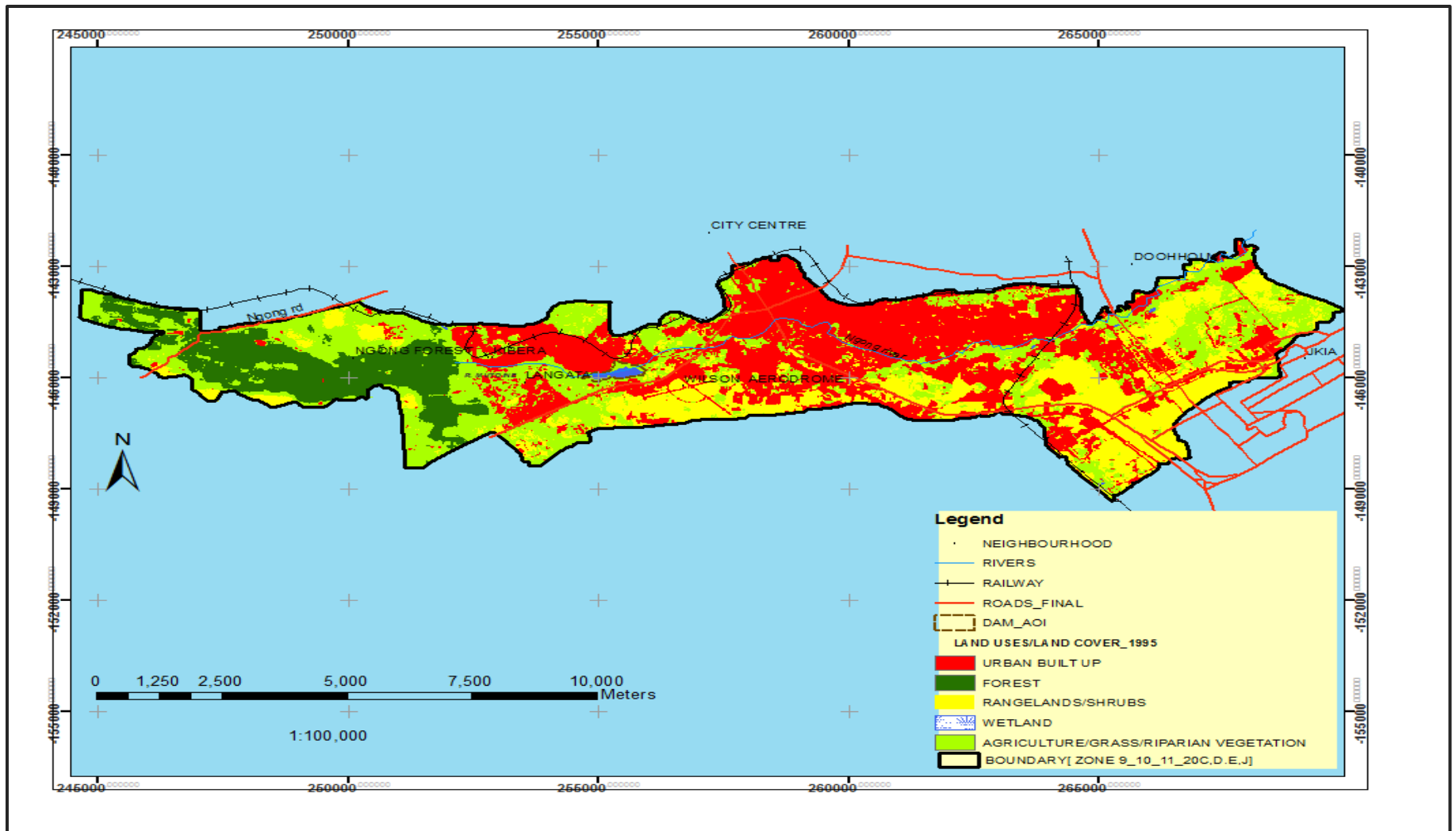


Figure 4.3: Classified Land Use and Land Cover Map of Nairobi Dam Zones for the Year 1995.

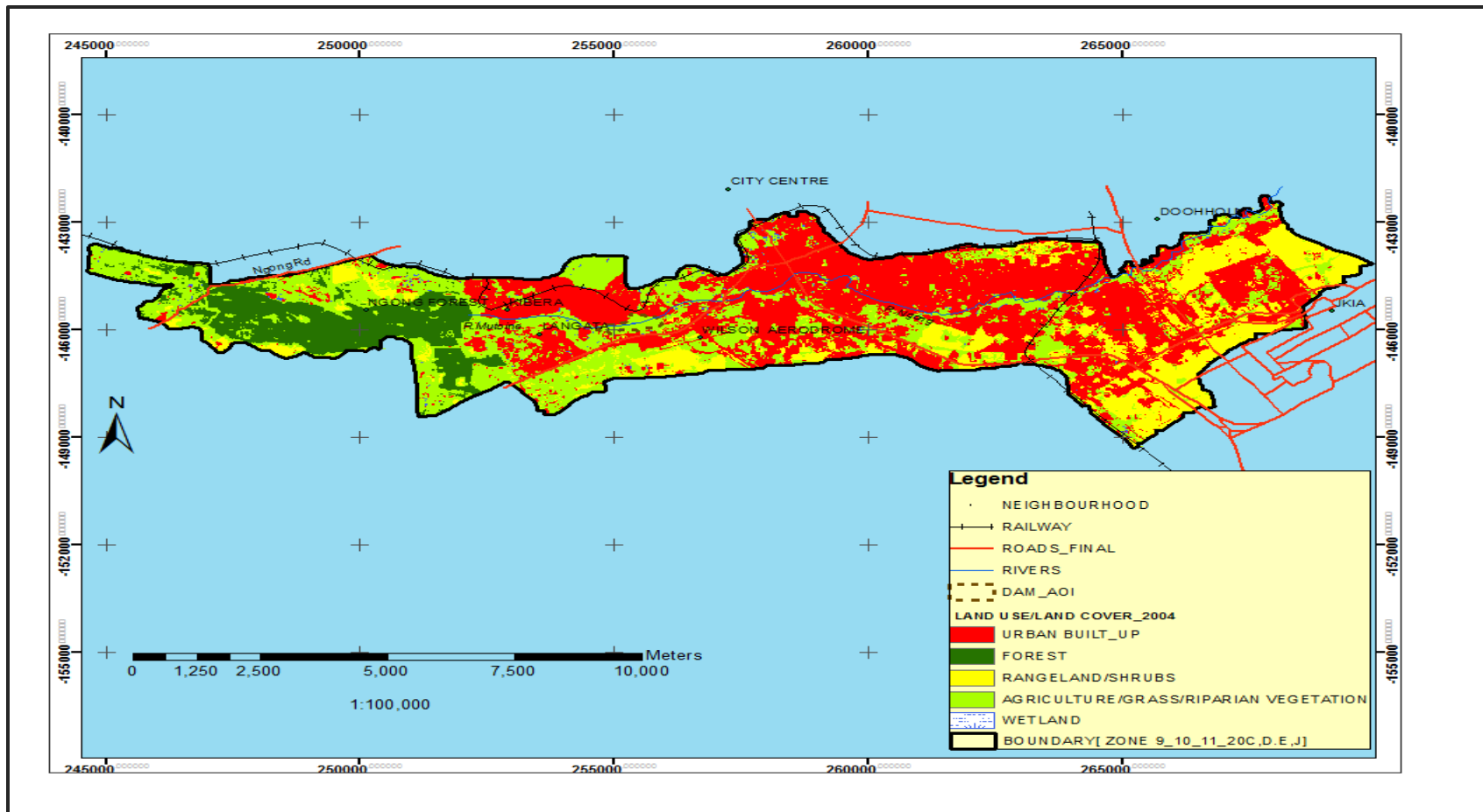


Figure 4.4: Classified Land Use and Land Cover Map of Nairobi Dam Zones for the Year 2004.

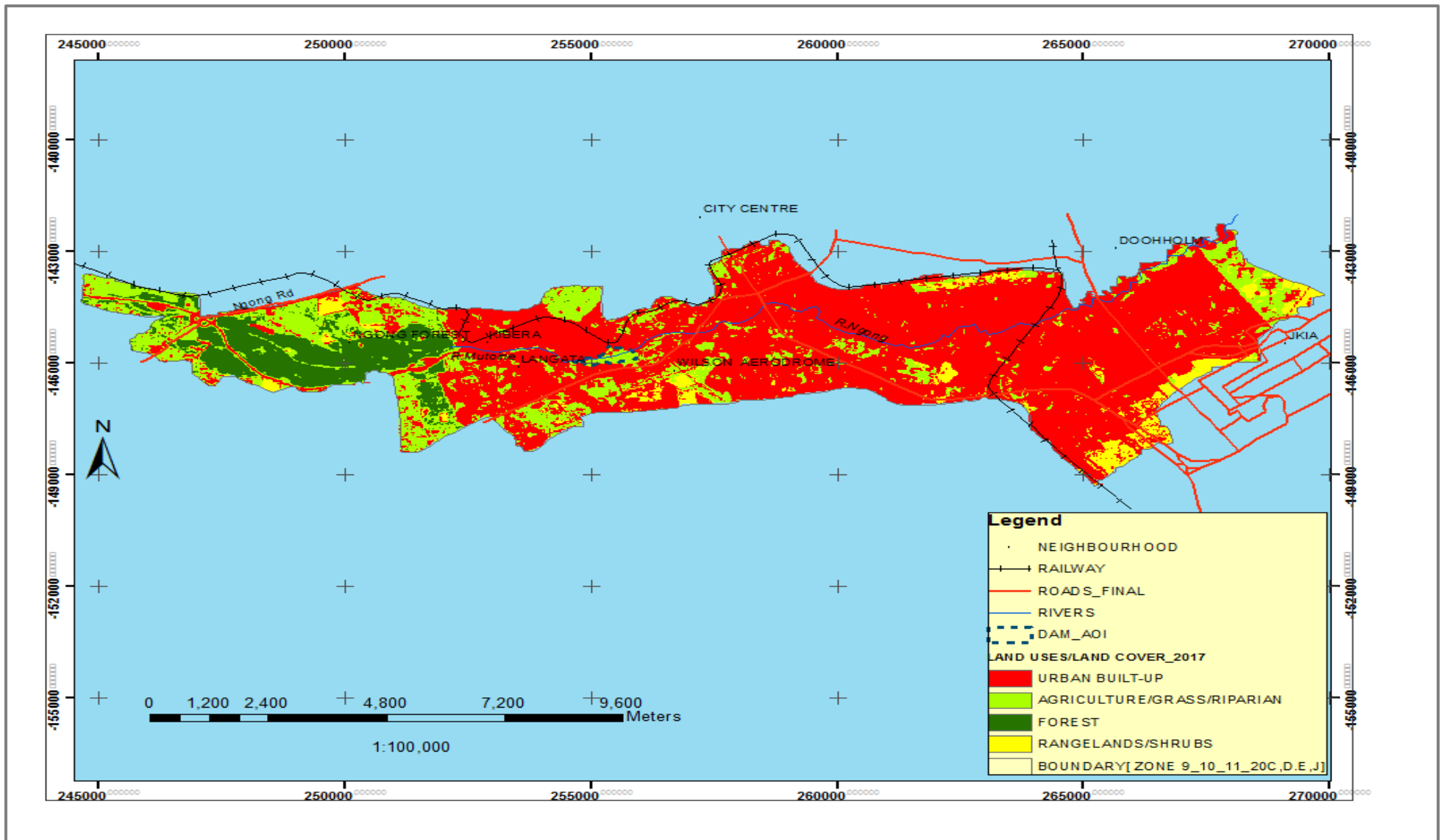


Figure 4.5: Classified Land Use and Land Cover Map of Nairobi Dam zone for the Year 2017

Table 4.2: Area of Land Use and Land Cover in Nairobi Dam Zone between the Years 1988 to 2017

Land Use and Land Cover Classes	Years							
	1988		1995		2004		2017	
	Area (km2)	Percentage	Area (km2)	Percentage	Area (km2)	Percentage	Area (km2)	Percentage
Urban Built- Up/Open/Transitional Areas	27.09	35.36	28.40	37.08	33.08	43.19	51.47	67.19
Forests	9.53	12.44	8.64	11.28	7.73	10.09	6.67	8.71
Agriculture/Grass/Riparian Vegetation	22.51	29.39	22.47	29.33	22.34	29.16	14.70	19.19
Rangeland and Shrubs	17.22	22.48	16.88	22.04	13.36	17.44	3.76	4.91
Water Bodies(Nairobi dam)	0.25	0.33	0,21	0.27	0.09	0.12	0.0	0
Total	76.6	100	76.6	100	76.6	100	76.6	100

The study reveals massive encroachment and degradation of the gazetted and protected areas such as Ngong forest and the Riparian areas such Nairobi dam by the urban built-up developments and other anthropogenic activities such as agriculture. This has reduced the forest covers to either rangeland and shrubs or farmlands or transitional areas. The anthropogenic encroachments over the years have led to unprecedented fragmentation and degradation of Nairobi dam and its water source which is Ngong Forest.

Notably, the study reveals a massive decline in size of Nairobi dam, with the dam covering approximately 0.25 km² of the study area in 1988, an early indication of decline and degradation in the 80s as compared to the original size of the dam of 0.35 km² when it was constructed in 1953. Continued discharge of untreated waste water and surface run-offs from slum and agricultural activities have increasingly polluted and eutrophicated Nairobi dam, leading to a massive decline of the visibility of the dam to a size of 0.12 km² in 2004. In addition the situation is further exacerbated by siltation, water hyacinth and reclamation of sections of the dam for agricultural purposes. This is revealed in figure 4.4 and table 4.2, where the study shows that in 2017 Nairobi dam is totally covered by riparian vegetation and agriculture land uses.

In addition, Illegal loggings, farming and construction of southern bypass passing through Ngong forest has put massive pressure on the source of Nairobi dam that have massively increased the level of siltation and pollution of Mutoine River hence Nairobi dam.

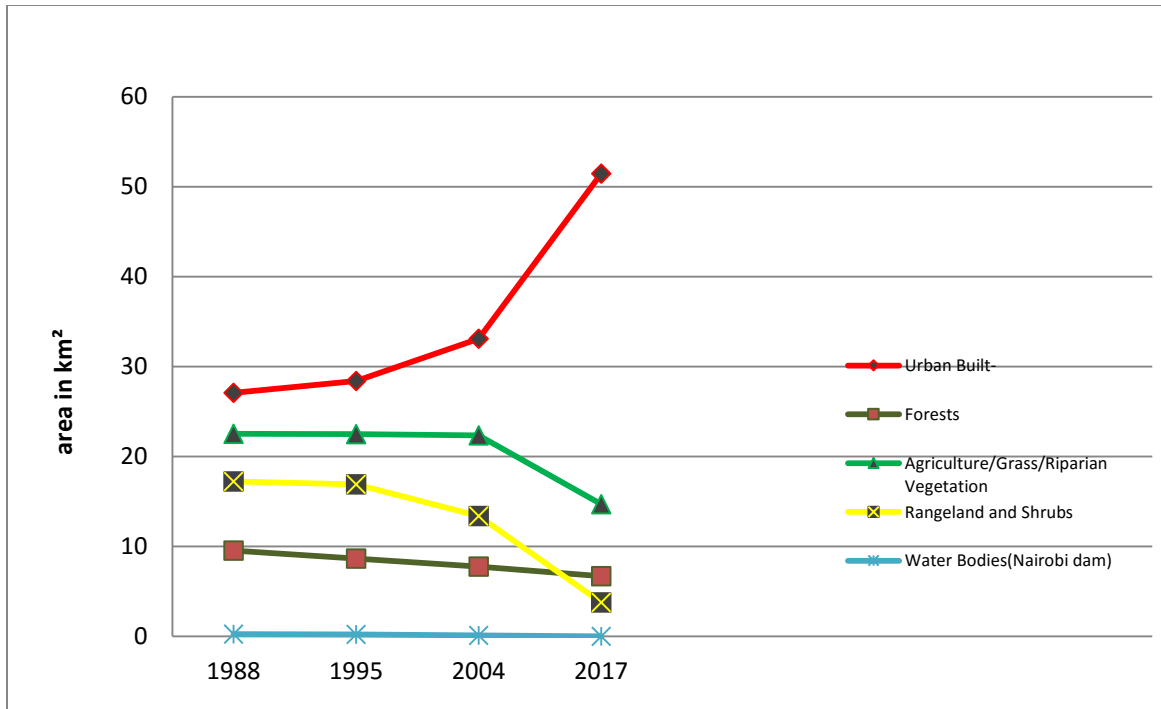


Figure 4.6 Land Use and Land Cover Change Trends of Nairobi Dam and its surrounding between the Years 1988 to 2017.

4.2.2 Water quality assessment of Nairobi dam

In order to ascertain if the water contained some of the polluted mineral elements and to achieve the objective of water analysis, the study analyzed data on requested water samples from water quality and pollution monitoring unit of NEMA. The samples were then analyzed for pH, turbidity, suspended solids, heavy materials, BOD, and COD. The study found that the river water was heavily polluted with both organic and inorganic loadings and mainly due to household discharge into the river which flows into the dam and as a result pollutes the dam.

Table 4.3: Water quality analysis for water Samples of Nairobi dam

Parameter/Sampling points	Main Inlet (Motoine River)	Result of the in the Dam at Soweto Inlet(Silanga stream)	Outlet	Threshold Value
Ph.	7.59	7.98	7.34	6.5-8.5
Turbidity, F.T.U	7.12	7.78	5.5	5
Iron, mg/l	0.87	0.8	0.4	0.3
Lead	17.32	17.06	10.34	0.01
Copper	5.4	5.6	3.19	2
Nickel	2.5	2.65	1.34	0.02
Cadmium	6.18	6.28	4.45	0.005
Biochemical Oxygen Demand, mg/l	241	264	45	30
Chemical Oxygen Demand	372	392	48	50

Source: Water quality and pollution monitoring unit (NEMA Jan 2019)

On pH, the study found that the water was moderately basic with a higher pH of 7.98 at the inlet, linked to organic pollution and the domestic waste discharge draining into river Motoine and Nairobi dam system as the river flows through Kibera slums. The pH values obtained in this study ranged from 7.34 to 7.98 which are within the acceptable natural water limit of (6.0-8.5) provided by World Health Organization (WHO) and Kenya Bureau of Standards (KEBS). Lower pH value of 7.34 recorded at the outlet may be attributed to purified water as a result of hyacinth within the dam.

On Turbidity, The first sampling point at the inlet had a turbidity of 7.12 (N.T.U). This high turbidity is as a result of Ngong farms in the uplands where the river Mutoine originates from; the high sediments is attributed to soil erosion from farming activities and other anthropogenic activities such as the construction of a bypass cutting through Ngong forest. The value rose to 7.78 within the dam and gradually decreases along the dam with the outlet records low turbidity of 5.5. This is attributable to the capacity of the dam to self-purify itself as a result of hyacinth infestation. It can therefore be deduced that the water channel has self-purifying properties and capacity as observed between point of inlet and outlet. 6.8 (N.T.U) is the average turbidity for Nairobi dam area, thus making both the rivers draining into the dam and the dam itself becoming poor source of water based on the W.H.O standards.

On Biochemical oxygen Demand for the study area, the BOD at the inlet was 241 mg/l and 264 mg/l within the dam. The BOD increases steadily at the inlet and within the dam due to constant increase in effluent discharge from various channels from the slums. At the outlet the BOD decreases sharply as a result of presence of hyacinth that act as a purifying agent within the dam. The average BOD is 182.5mg/l. The BOD level exceeds allowable set Kenyan standards of the public sewers set by the government and the Nairobi city county revealing extreme pollution.

On Chemical Oxygen Demand results, there is gradual then steady increase in the COD from inlet and in the dam and a steady decrease in COD as the water leaves the dam attributable to hyacinth self-purifying mechanism. The COD is highest at the dam and inlet attributable to massive sewerage disposal from the slums into Mutoine River and Nairobi dam. This is much higher as compared with maximum of 50 mg/l standard measurements allowed by the natural water courses, this means that the waste disposal mechanisms in Kibera is polluting the Nairobi

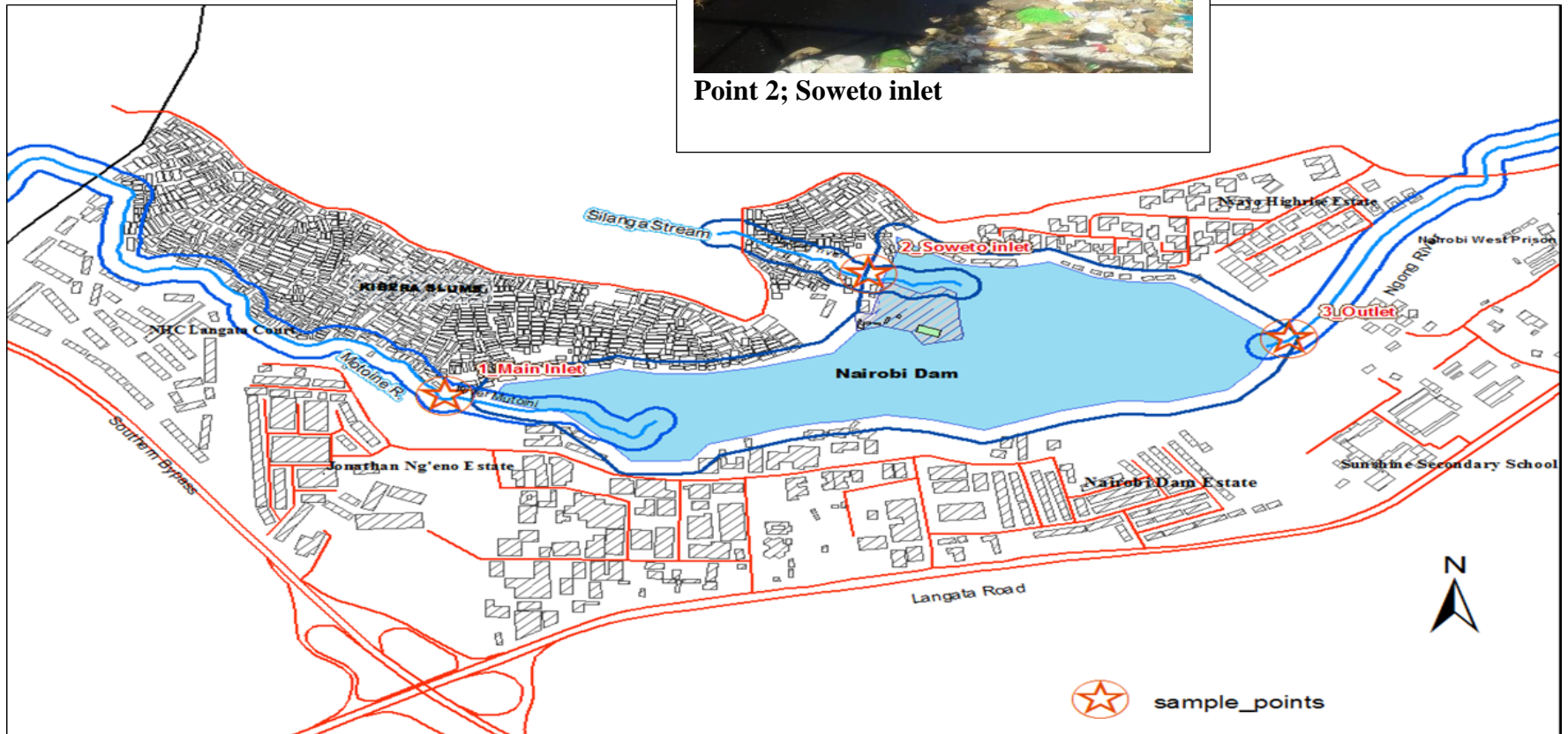
dam by releasing higher concentrations of possible toxins into the Motoine river and Nairobi dam.

On heavy metal(s) accumulation, the sequence of metals accumulation was lead, Cadmium, Copper, Nickel and then iron, which are significantly higher in Nairobi dam water. The study notes significant reduction of contaminant heavy metal(s) in the outlet point water as compared to inlet point waters. This reveals that water bodies do have pollution removal mechanisms. Nairobi dam water therefore, is highly polluted by Pb, Cd, Cu and Ni, based on WHO and KEBS standards for drinking water. Therefore, the water is not fit for human or animal consumption or any agricultural activities rendering the agricultural activities ongoing within the dam illegal, unhealthy and harmful to human life.

Figure 4.7: Pictorial Description of Sampling Stations



Point 2; Soweto inlet



Point 1: Main Inlet



Point 3: Outlet



4.2.3 Perceptions

According to Rugo 2006, Muriithi 2009 and a report by the Dam Restoration Taskforce, 2015 the perception towards Nairobi dam is that of neglect. Nairobi dam area is used by anti-social groups for illegal activities such narcotics and hideout for criminals .Hence people agree on restoration of the Dam in order to bring back sanity and put an end to these activities .According to the survey, 96 % of the respondents agree that Nairobi dam is polluted and they are not satisfied with the condition of the dam. Majority of the residents agreed that the pollution has been contributed by the residents.

Table 4.4: Perception towards Nairobi dam

	Satisfied with Pollution		Would visit if pollution is sorted	
	N	%	N	%
Strongly Agree	0	0	33	43.4%
Agree	0	0	20	26.3%
Neutral	3	4%	12	15.8%
Disagree	32	42%	8	10.5%
Strongly Disagree	44	54%	3	4%

Field survey February 2019

To understand Kibera and Lang'ata residents' perception towards Nairobi dam in a case where it is restored and revitalized for recreational use, 70% of the residents would visit the dam if the pollution challenge is sorted out in the dam. The survey questionnaire assessed the importance the residents assign to this constructed wetland, whereby it assessed resident's perception on flood and pollution reduction values of Nairobi dam. 68% of the respondents agreed that

restoration of Nairobi dam will lead to reduction in pollution ,whereas 75% stated restoration will ensure flood reduction .It is interesting to note that a section of the respondents did not know the flood control and pollution reduction values of the constructed wetland, however ,almost everyone at (94%) agree Nairobi dam wetland is an essential part of Nairobi city's recreational requirements in meeting the social needs of the huge population surrounding the dam.

To achieve better management of Nairobi dam wetland, there need to be an improved understanding of the ecosystem functions and the flow of ecosystem services. Advanced and improved hydrological, biophysical and socio-economic data that satisfy stakeholders and decision makers' needs and requirements will better achieve this plan. Significantly, demonstration of the important role of Nairobi dam in society and economy can enhance its protection, restoration and sustainable use through valuation of ecosystem services in monetary form. Boyer & Polasky 2004 notes that wetlands provide a flood protection service that is of greatest value to densely populated urban areas, where the service help in limiting damage to properties and human life by flood waters. According to (Bolund & Hunhammar 1999), cities at risk of flooding benefit more from wetlands than those without. Wetlands will take up water on behalf of cities; hence minimize destruction by flood waters. Planning specialists from Nairobi City County, agrees with the findings that Nairobi dam is a very important natural water shade and a floodplain for the various rivers and streams in Nairobi and a sponge for run-off water when it rains.

4.2.4 Influence of Security of tenure on the implementation of Wetland Restoration projects

The study sought to investigate security of tenure as a possible constraint that could affect efforts towards wetlands restoration programme in the past and future. The study found that nearly all the residents 98% residing on the Kibera side of the dam neither own land nor possess title deeds and this scenario according to Mutisya & Yarime 2011 is replicated to majority of the villages in Kibera slums. In addition, out of the 30 respondents from the formal surrounding neighborhoods of Nyayo Highrise, Kenya Prisons Staff, Jonathan Ng'eno, Nairobi Dam estate and the new developments of Seefar, Lang'ata Portal homes and Chelsea Marina Court; 83% of the respondents have legal documents of the land their homes are built on while 17% do not.

Table 4.5 Distribution of respondents with land tenure

Response	STUDY AREA			
	Kibera Slums		Formal Surrounding Settlements	
	Frequency	Percentage %	Frequency	Percentage %
Yes	0	0.0	25	83%
Not sure	2	3%	0	0
No	63	97%	5	17%
Total	65	100	30	100

Field survey February 2019

According to Opa et al 2012, lack of security tenure discourages residents to participate in wetland conservation and restoration activities such as shelter improvement: undermine costs for land and administrations and constraints efforts from relevant institutions in supplying basic infrastructures to the slums.

In addition the study found, not only lack of security of tenure to be an impediment to restoration efforts of Nairobi dam, but also the study found that developers perceived to having encroached the riparian reserve of the dam such as Seefar buildings have legal documents on land developed. This lawfully perceived security of tenure of these developments has rendered previous efforts by relevant agencies powerless against demolition of encroached buildings for sustainable restoration of the dam. The study sought to find out the willingness of the residents to vacate land to allow for restoration efforts if found culpable to have encroached the wetland.

Table 4.6 Willingness of residents to vacate land

Response	Willingness to Vacate			
	Kibera slums		Formal Neighborhoods	
	N	%	N	%
No	20	30.8	23	76.7
Not sure	18	27.7	4	13.3
Yes	27	41.5	3	10
Total	65	100	30	100

Field survey February 2019

From the survey, it came out that a majority (76.7%) of the residents living in the formal neighborhoods adjacent to Nairobi dam are resistant to the idea of acquiring their lands for conservation purposes. Only 39.5% supported the idea thus making it difficult to carry out conservation of the wetlands. In order to effectively conserve the wetlands, the government may have to reclaim adjacent lands from the community an idea that is likely to meet resistance from community owing to the cultural attachment to their lands. In the interest of conservation, the

County government may have to compulsorily acquire the lands adjacent to the wetland for conservation purposes.

4.2.5 Influence of Legal and institutional framework on wetland conservation and management

Policies and institutions play a major role in management and conservation of urban land uses that include wetlands. Policies control both peri-urban and urban developments that may negatively or positively impact constructed wetlands. Legal instruments provide the foundation upon which growth and development occurs in an urban space. The study sought to find out the residents knowledge on various policies influencing urban development around Nairobi dam

Table 4.7: Awareness to Acts influencing urban wetland development and management

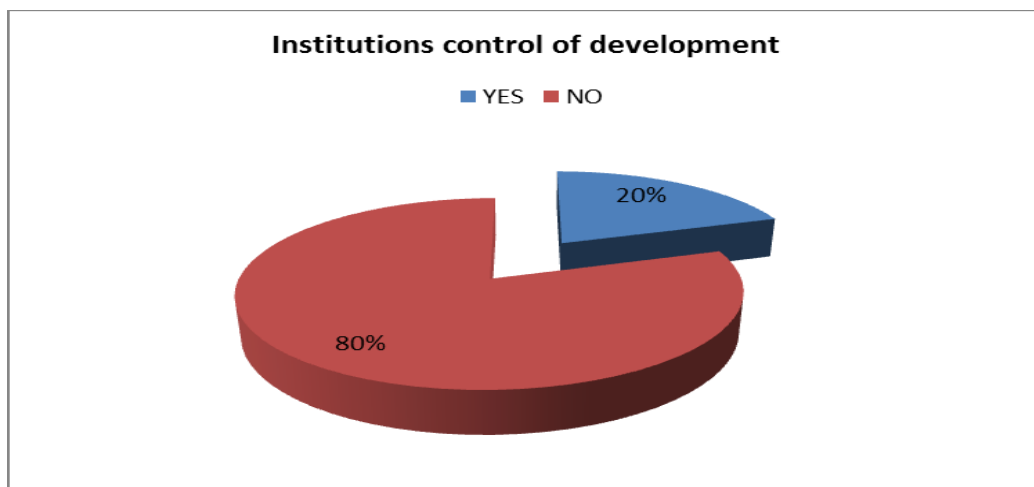
Acts Governing Wetlands	Awareness to Acts			
	Yes		No	
	N	%	N	%
Physical planning Act	28	36	50	64
EMCA 1999	34	44	44	56
Water Act 2002	23	30	55	70
Agriculture Act	0	0	78	100

Field survey February 2019

Results from the respondents reveal that the residents Knowledge on Laws and regulations influencing urban land use development around Nairobi dam was varying among the Acts. In general, the majority were unaware of these Regulations, with a few of the respondents showing awareness about various regulations. EMCA and Water Act was the most known regulatory instrument especially by the residents living in the formal neighborhoods of High-rise and Ngei estates. The survey therefore established that, the level of awareness among various Laws

affecting development around Nairobi dam was low. With 74% of the respondents stating neither the laws nor regulations influence the way they did develop in the area. 26% of the respondents admitted to having their development influenced by the existing legal instrument having sought approval pertaining developments of respective buildings through the county Government and NEMA. No respondent claimed to have been stopped for coming up with an illegal development or encroaching into the wetland. In addition, The survey found majority of the residents 80% of the respondents believe the mandated institutions such as NEMA, County Government and WARMA neither control or influence development and land uses around the dam, whereas 20% agreed to having sought approvals from these institutions before they develop.

Figure 4.8: Institutional control of developments around the dam



Field survey February 2019

The survey concludes, lack of awareness, ignorance to various laws and policies by a great majority of the population has contributed to the unplanned and unsustainable development around Nairobi dam wetland. In addition this phenomenon has been exacerbated by gaps that exist in terms of enforcement legislations in the various Acts and policies, lack of compliance

with environmental regulations and weak institutional frameworks in various institutions. This has led to the following illegal activities as observed that contravenes these Acts.

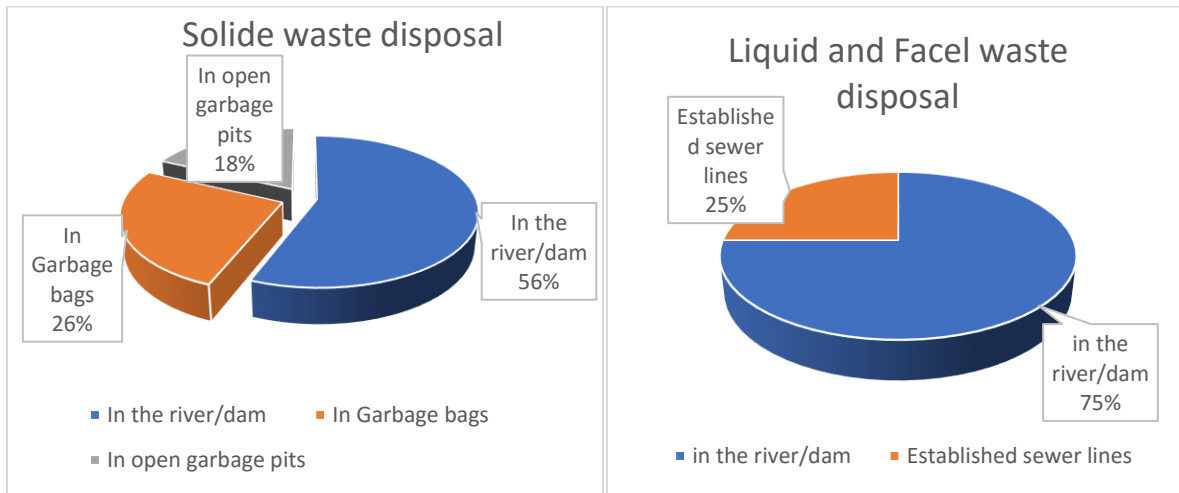


Plate 4.1: Human activities contravening various acts/policies

4.2.6 Influence of Solid and Liquid waste Disposal and Management mechanisms on wetland Restoration.

Unfortunately, a great proportion of people are unaware of the value and importance of urban wetlands. In fast-growing cities, wetlands are often viewed as wasteland; places to dump rubbish, fill in or convert to other uses (Rhyner et al.2017). This is also evident in the study as majority (80%) of the respondent view Nairobi dam wetland as wasteland, with a few viewing it as a farming space and a dumping site. The study therefore sought to find out the mechanisms used for solid, liquid and fecal waste disposal in the area and came up with the following conclusion in the chart below.

Figure 4.9: waste Disposal



Source: Field Survey,

On solid waste management, the study shows more than half of the residents (56%) dispose their waste on rivers and Nairobi dam, with the rest using garbage bags (26%) and open pits (18%) for waste disposal. On liquid and facel disposal, the study reveals majority of the residents (75%) dispose their facel matter into the Nairobi dam and rivers, with 25% of the residents having

access to established sewer lines. The study observed, the adjacent formal neighborhoods of Nyayo Highrise, Kenya Prisons Staff, Jonathan Ng'eno and Nairobi Dam estate are connected to a sewer system.



Plate 4. 2: Pictures showing plastic waste dumped inside the dam



Plate 4.3: Discharge of liquid waste from Kibera slums into the dam using rivers and drainages

In addition the study observed a blatant environmental degradation and violation whereby it established that Kibera slums direct all its sewage into Nairobi Dam via rivers passing through the slums. This is as a result of lack of proper waste management infrastructure within the slum that has exposed the dam to filth making it an economic and health hazard to city residents. This is also confirmed by the water quality analysis obtained from the water monitoring unit that reveals that the water is highly contaminated and harmful to support life.

The waste disposal mechanisms and management of solid, liquid and fecal waste will remain a major challenge and setback to the restoration efforts of Nairobi dam. It was observed that unless the problem of waste water management is addressed in Kibera, the rehabilitation process of Nairobi Dam will not be successful. All waste water generated from as far as 400m distance from the dam is drained by two streams (Silanga and what used to be Motoine River). Silanga stream collects wastewater from Makina, Lindi and Silanga villages. The Motoine River collects waste water from Kianda, Soweto, Gatwekera, Kisumu Ndogo and Raila estate.

4.3 Lessons on successes and failures from the past Rehabilitation strategies

4.3.1 Knowledge on Wetland Restoration and Management

For sustainable restoration and management of Nairobi dam, it is established that a broad spectrum of parties be involved and engaged in various activities. The study notes a significant momentum from previous restoration initiative have been drained out and risk of sabotage at the very worst, as result of, failures to take on board the various stakeholders, and more so the local community. The study predicates that, currently, there is lack of community involvement and interest by Kibera and lang'ata residents riparian reserve conservation, although, initially the community was responsible for ensuring that the reserve was free from building and construction activities.

Table 4.8 Level of awareness and community involvement of previous efforts

Past Efforts	Community awareness and involvement				
	Response	Awareness		Community involved	
		n	%	N	%
Nairobi Dam Trust initiative by Moody Awori	No	70	74	21	84
	Yes	25	26	4	16
	Total	95	100	25	100
Nairobi River Clean up initiative by Mutula Kilonzo	No	95	100	0	0
	Yes	0	0	0	0
	Total	95	100	0	0
Kazi kwa Vijana initiative	No	44	46	31	70.5
	Yes	51	54	13	29.5
	Total	95	100	44	100
Dam Restoration Taskforce initiatives	No	29	30	44	67
	Yes	66	70	22	33
	Total	95	100	66	100

Source: Field Survey, February 2019

The survey found that only three out of the four efforts have been initiated in Nairobi dam, with the Nairobi clean up initiative by Mutula Kilonzo only appearing on paper without any implementation on the ground.

On level of community awareness, the study found, majority of the residents (70% of the respondents) have a knowledge of the Taskforce initiative by Evans Kidero, which the study slightly attributes this to the fact that it is a recent restoration effort. In addition, more than half of the residents (54%) have knowledge about Kazi kwa Vijana Initiative by the then Prime Minister Raila Odinga attributed to the fact that the initiator was the area member of parliament.

However, Most of the respondents at 74% are not aware of efforts of Nairobi Dam Trust initiative by Moody Awori.

On whether the community was involved on the previous restoration efforts, the study found that there was little community involvement in all the restoration efforts, with partly below 30% response on involvement in all the previous efforts. This implies that the success of any restoration effort in Nairobi dam might be constraint, because relevant community members are supposed to be aware and actively involved in the wetland restoration process.

The study found that the surrounding community was only involved in the implementation or activity stage of the various restoration initiatives, meaning that all the efforts were Top-down approach, where institutions sat down in boardrooms planned and came up with restoration strategies of the dam that were not community owned or driven,

Though representative from the Taskforce initiative through the Nairobi City County tends to disagree by stating that community representative were appointed to the taskforce by the area Member of Parliament, most of the respondents gave a contrary opinion that all the appointed representatives were political appointees representing the interest of the Area leaders but not the community.

4.3.2 Respondents perception on implementation and success of the past dam restoration project outcome and activities in the current location

The respondents were asked to assess the general outcome of the previous restoration efforts in meeting the project objectives and community's expectations by implementing the various projects for sustainable restoration and the results are presented in table 4.11 below. The results reveal various restoration efforts have failed in achieving most of their intended objectives with only three activities having been initiated that include hyacinth removal at 90% of respondents,

job creation by provision of alternative livelihood at 57.2% and community mobilization to participate on restoration programmes at 33.4% of the respondents.

Table 4.9: perception on implementation and success of the past dam restoration project outcome and activities

Outcomes	Project outcomes /Activities				
	Response	Initiated		Successful	
		N	%	N	%
Job creation and alternative livelihood	No	24	42.8	18	56.25
	Yes	32	57.2	14	43.75
	Total	56	100	32	100
Removal of Hyacinth	No	6	10	44	81.4
	Yes	54	90	10	18.6
	Total	60	100	54	100
Slum upgrading	No	48	100	0	0
	Yes	0	0	0	0
	Total	48	100	0	0
Basic infrastructure improvement	No	68	100	0	0
	Yes	0	0	0	0
	Total	68	100	0	0
Community mobilization	No	32	66.6	12	75
	Yes	16	33.4	4	25
	Total	48	100	16	100
Demolition of building on riparian reserve	No	78	100	0	0
	Yes	0	0	0	0
	Total	78	100	0	0

Source: Field Survey, February

On hyacinth removal, 81% of the respondents say the outcome haven't been successful in two of the past efforts of Kazi Kwa vijana initiative and Dam trust initiative. The residents claim removal of hyacinth in the dam could not be successful if the ongoing activities in the dam such as; agriculture and pollution from solid and liquid waste were not stopped. This was supported by NCC, NEMA and WRA officials interviewed who stated past efforts failed in dealing with the hyacinth menace in the dam because they failed to tackle the root cause of the problem of hyacinth that to them was pollution and agriculture.



Plate 4.4: Pictures showing hyacinth removed from past efforts but dumped near the dam due to lack of mechanisms to deal with the menace.

On job creation and provision of alternative livelihood, 56% of the respondents say alternative livelihoods provided were not sustainable. During the kazi kwa vijana initiative, youths were trained on turning of hyacinth into fertilizers but the programme was short-lived after withdrawal of the project financiers. Even though agriculture is an ongoing economic activity inside the dam providing livelihood to a good number of kibera residents, respondents from NEMA and WRA claimed Agriculture as an activity is a threat to restoration of the dam and contravenes agricultural Act that that does not allow farming within a wetland. However, Taskforce initiative reclaimed a section of the dam built green houses and shops to provide farmers within the dam with an alternative economic activity for ease of their removal from the dam. This initiative was opposed by NEMA and WRA who stated that they are illegal and unsustainable proposals hence the need for a viable eco-friendly and sustainable economic activities integration that do not alter the conditions and health of the dam. NEMA official stated that they will only support activities that allow for sustainable utilization and conservation of the dam. Majority of the respondents claimed youth groups and women groups in the area were not involved in the past efforts, rather youths and friends aligned to various leaders within the society were brought from areas far

away from the dam to earn money from the activities but not to restore the dam, a claim that the local NGO green card mtaani supports.

On community mobilization, 75% of the respondents state that community mobilization programs were unsuccessful in fulfilling restoration objectives of the dam.

4.3.3 Respondents perception on Effectiveness of Strategies Applied restoration and management of the Nairobi Dam

The study sought to find the perception of the respondents on whether the previous restoration strategies were effective or not. 84% of the respondents stated that they were ineffective while 16% stated that they were effective.

NEMA and WRA for instance claimed that the past strategies were ineffective because they failed to incorporate the interests of the surrounding communities.

4.3.4 Respondents perception on Possible Reasons of Failure

Table 4.10 Showing the tabulation of the respondent's the possible reasons for the failure of the ineffectiveness of these approaches applied by these agencies in restoration and management of Nairobi dam been so far

Reasons	Prime Reason	Average Reason	Least Reason
Inadequate funding	10	2	2
Lack of good- will and support from local residents	7	2	0
Lack of harmonized approach to forge common conservation strategies	12	6	0
Ineffective conservation monitoring and enforcement programs	8	2	0
Corruption	4	1	3
Inadequate sensitization and conservation education	8	2	4
Total	49	15	9

Source: Field Survey, February 2019

It can be deduced that to own the process, there must be an integrated and harmonized effort of bringing all the stakeholders on board. Interviews gathered from NEMA, WRA and Nairobi City County officials preferred an integrated and harmonized approach in operation and law application and enforcement for better coordination and mobilization of resources and the community at large towards sustainable management of the dam

Official from NEMA noted that there was conflict in legal and institutional framework governing constructed wetlands management in Kenya, and the law was silent on buffer distance pertaining dam reserves, but noted there was a lot of disparities pertaining the legal requirements of riparian reserve. All respondents agreed there's need for a single co-coordinating institution to facilitate all the efforts geared towards the restoration of the dam.

Lack of harmonized approach was singled out as the prime factor that resulted to failure of the restoration efforts. Ineffective conservation monitoring and enforcement programs, inadequate funding, inadequate sensitization, Lack of good will and corruption were also other hindrance to successful restoration efforts.

Green card mtaani a local NGO that took part in Taskforce initiative notes that corruption and weak institutional framework were major reasons why previous efforts failed. He notes that corruption and misappropriation of funds meant for Nairobi dam restoration, made project funding institutions such as UN Habitat and UNEP to withdraw from the first and second restoration attempts. Green card officials further noted with concerns that institutions established for conserving the dam were individualized for either being used for making money or were under the mercy of the appointing authority, where he notes that the taskforce initiative propagated by Evans Kidero in 2014 collapsed in mandate and operation with the removal of the proponent in office in 2017. In addition Rugo 2015, also notes those officials appointed to the Taskforce by Kidero were civil servants with full time jobs, hence had no time and interests towards the restoration efforts of the dam.

From the findings and that of Murithi 2004 and Rugo 2015, it has emerged that because of lack of sensitization, awareness and community involvement; residents are not able to comprehend the operations of past restoration efforts for the Nairobi dam. In conclusion, respondents were of

the view that there is need of a bottom up approach that is community driven plus an harmonized approach in operation and restoration activities into one single and common front so as to stop ad hoc conflicting policies and institutions, that previously were used as loopholes for funds misappropriation without achieving results.

Sanyal & Mukhija (2001), notes that tension and conflict is due to arise as a result of distinct interests and priorities from involvement of many actors in a project. The study's conceptual Framework established a need to have a suitable institutional arrangement framework that is inclusive, can deliver and is widely acceptable to guide the process. From experience, it reveals that political will and firm commitment of institutions that can sustain long-term programming and implementation will ultimately enhance effective wetland restoration strategy. In operational terms, an effective wetland restoration strategy will require creation of an institutional and organizational setting through which: target groups participation can be facilitated, public, private and community stakeholders partnerships can be realized, financial resources mobilization and allocation on sustained basis, strengthening and coordination local implementation capacities, and organization of planning and management programs and projects.

Other Lessons Learnt from the causes of failure in Past Restoration Attempts includes:

Top-down implementation approaches- whereby the study noted that all the past restoration projects adopted a top-down approach where the decisions and planning were made by government officials and professionals without the input of the target beneficiaries. As a result, it leads to creation of disconnect between the project objectives and the needs of the people; disagreements and conflicts arise thereby hindering the implementation process. This approach

also limits community participation resulting in the project not benefiting the target population fully. The beneficiaries are subjected to predetermined plans and standards.

Political interference-in this case the study notes that all the past efforts were affected by political priorities that change with regimes, as the case of Taskforce restoration initiative effort by Kidero, that collapsed with the coming of a new regime. Political priorities also change with regimes, and this affects the funding, commitment to the projects and implementation. When governments change before a project is completed, there will be always be a disconnect with the new regime having their own prioritized projects. This loss in momentum causes delays and/or eventual failures in the upgrading process.

4.4 Alternative Measures

The continuing degradation of Nairobi dam due to an adjacent slum with expanding human population and growing development pressures plus failed past restoration attempts makes restoration of Nairobi dam high priority. However, urban constructed wetland restorations are particularly challenging due to varying interests and approaches from various stakeholders. Therefore Nairobi dam restoration projects must consider community-desired interests and socio-economic benefits. The study argues that gaps and weakness in previous restoration approaches and existing regulatory and institutional framework resulted to failure in the survival and recovery of the dam. Therefore the study agrees with Rugo (2015) that new efforts and programmes have to involve both cooperation and collaboration of stakeholders, including County Government, NEMA, and WRA, private landowners, scientists and the local community.

The study sought to find the residents perception of the possibilities of reclaiming the encroached riparian reserve

Table 4.11 Possibility of reclaiming the riparian reserve

Respondents	Yes	Not Sure	No	Total
whether it is possible to reclaim the riparian zone	62	20	13	95

Source: Field Survey, February

It can be deduced that majority of the respondents at 65 % (62) believe that it is possible to reclaim the riparian zone of Nairobi dam. These sentiments were echoed by interviewed officials from NEMA and WRA who stated that if the existing laws and regulations are enforced the riparian that have been encroached by illegal developments could be reclaimed by removal and demolition of those buildings. Water Act 2016 and EMCA 1999 empower these various institutions to preserve and protect the riparian reserve.

The practicality of reclaiming the entire Nairobi dam riparian reserve amidst current situation of encroachment of both formal and informal developments is a question of varied responses from both the surrounding dam community and other stakeholders who have been involved restoration efforts. For instance, the Kidero task force initiative believed that it was not practicable to reclaim the riparian area hence their objective for restoration, was on how to restore the dam area minus the encroached area. Some reasons cited included: sociopolitical reasons and fear of resistance from already overpopulated community residing around Nairobi dam, Difficulties in finding land for relocating this big population from the slum, who are poor hence meeting their livelihood requirements will be a another challenge.

In contrast however, NEMA ,WRA and NCC officials believe through Slum gentrification, enforcement of existing laws and presence of political will and environment it was possible to

reclaim the Dam reserve with a win-win outcome, that will see the interests of impoverished in the society are well taken care of and that of this vital wetland

Table 4.12: Residents support of viable mitigation Measures

Mitigation measures	Support for Alternative Measures and programmes		
	Respondents		
	Yes	Not sure	No
Alternative solid and liquid waste management infrastructure provision	64%	14%	22%
Reclamation of the riparian reserve and provision of Supportive Infrastructure to act as buffer for sustainable utilization of the dam	22%	54%	24%
Incorporation of community driven restoration initiatives	74%	18%	8%
Provision of Alternative eco-friendly economic activities for sustainable Dam utilization	12%	62%	26%
Education and sensitization on conservation of wetlands	56%	34%	10%
slum upgrading	44%	38%	18%
Conversion of the dam into more better economic Activity/use (Decommissioning)	38%	0	62%

Source: Field Survey, February 2019

Majority of the respondents of 74% supports community driven initiatives as the key mitigation measures towards sustainable restoration of the dam. This is because for success in the restoration and management of Nairobi dam, community based initiatives are fundamental

because these initiative promotes accountability, transparency, build trust, partnerships and empowerment; all that have been a missing link in the previous restoration efforts. Scott (2007) agrees with the findings and notes that community driven strategies are crucial in tapping community organizations resources, knowledge and skills.

64% of the residents agreed that they will embrace the alternative facilities for solid waste management and sanitation facilities were to be provided in order to ensure the success of the program. The rest did not agree, only 14% were not sure. NCC, NEMA and WRA officials also noted that provision of solid and liquid waste management infrastructure was fundamental in Dam restoration and management. The results were also in agreement with Taylor (2009), who confirmed that integration of basic solid and liquid waste infrastructure development with ongoing environmental and socioeconomic strategies commitment are fundamental driving force to sustainability of successful restoration projects.

Creation of awareness through education and sensitization of the communities on conserving Nairobi dam was supported by 56% of the respondents, while 34% was not sure. NEMA cited that environmental sensitization is key in building environmental-conscious behavior by encouraging sustainable lifestyles and ethical responsibility. In addition, for a down-top approach in restoration and management of the dam; Raburu (2012) notes education is vital in capacity building for enhancing skills and knowledge in restoration and management of wetlands.

Other viable alternatives measures that were supported included slum upgrading and reclaiming and buffering the wetland with supportive infrastructure at 44% and 22% respectively. Even though all the respective institutions agree, need of a slum upgrading strategy for Kibera in order to achieve a sustainable restoration and conservation of the dam, they had reservations of the

budget requirements for this projects. 38% and 18% of those who were not sure and who don't support respectively were of the view that previous slum upgrading projects did not meet the needs of the community.

On Decommissioning of the dam as a measure by refilling the dam with soil and converting its use for a different economic Purpose, proposed by the Parliament's Environment and Natural Resources Committee report on Nairobi dam of 2018 got support from 38% of the respondents who felt that the dam is idle, smelly and a health hazard hence its conversion would be necessary. NEMA and WRA disagreed with this proposal, in that they noted that each and every wetland has values and functions that can never be avoided, but rather must be rehabilitated if degraded to achieve sustainable development. These views were also echoed with Planners from NCC who agreed demolition of buildings around Nairobi dam that called for parliamentary committee intervention, was a 'brutal response'. Though they disagreed with the conclusion of decommissioning the dam to save properties, the planners view Nairobi dam as an important asset in flood control and doing away with the dam invites more disasters from the floods especially in the areas of Madaraka, South C, Nairobi West and Mukuru slums located downstream of Nairobi dam. The Planners argued that the dam is a natural water shade and a floodplain for the various rivers and streams in Nairobi and a "sponge" for runoff water whenever it rains, hence any interference or alteration would cause a more damaging environmental problem. A view supported by recently completed Nairobi Integrated Urban Use Master Plan (NIUPLAN) prepared in collaboration with JICA. In addition, 62% of the residents support the views of planners and conservationists who still believe Nairobi dam is redeemable and should not be converted into something else, but rather be restored. The study also agrees with Rugo 2005, Muriithi 2009 and environmentalist such as NEMA and WRA officials that

demolition or total overhaul of the dam as propagated by politicians and few private investors who have grabbed and encroached on Nairobi dam, have failed to quantify the environmental, social and economic benefits Nairobi dam has to its ecosystem. The removal of the dam will set a bad precedence to future restoration efforts of other constructed wetland facing challenges of illegal encroachers and degradation. The study further argues that Land use decisions affecting Nairobi dam wetland have been based primarily on the direct benefits of housing supply and millions of investments by the few home owners. While economic worth is important by these few illegal developments, other costs or impacts of such activity are often not properly identified and propagators of total overhaul fail to understand currently three tributaries of the Nairobi River pass through the dam, a situation that stirs the question of how the dam will be filled with soil?. If the channels will be filled, then the obstruction of the water may be even more catastrophic to the surrounding community. Muriithi 2009 also notes that Nairobi dam's Hyacinth acts as a water treatment remedy for Nairobi River due to improved water quality on River Ngong that gets its water from dam's outlet. This is particularly important where the same or similar benefits could be obtained on other sites with less impact.

The findings agree with The Brundtland Commission's "Our Common Future" report promoting the concept of sustainable development. Developments should not waste and degrade environmental resources but should be built and founded upon environmental strengths and opportunities. Hence need to advocate for strategies that strengthens planning procedures to anticipate and prevent negative environmental impacts. Nairobi dam therefore, is a constructed wetland ecosystem of economic and environmental significance that requires careful evaluation for its biological, hydrological and socio-cultural values.

4.5 Strategies And Scenarios

From the findings the study notes there are three schools of thoughts regarding Nairobi dam rehabilitation strategies. Whereas from the findings, Decommissioning as a strategy was found not viable, the study therefore analyses two schools of thoughts from the judgment of the professionals that include planners and environmentalist on the best strategy to conserve the dam.

4.5.1 Ecological/Preservation strategy

This strategy predicates safeguarding of the dam wetland reserve as a green buffer through a blanket recovery of the 30-metre riparian reserve. It involves dam's restoration and management and its buffer zone as a protected green area. From the study findings, NEMA, WRA and Nairobi River Clean up initiative have attempted and propagated this strategy on the Nairobi River and dam regeneration plan, with little to be shown from the attempts. In the recent past, Nairobi City regeneration Project committee attempted this strategy through massive demolition of critical building along Nairobi River, but stopped after a backlash with investors, politicians and developers, who argued buildings, had legal documents.

a) Strengths of the strategy

Expansion of Urban green infrastructure: complete restoration of the 30-metre riparian buffer will add to the environmental quality and vitality of Kibera and Nairobi dam neighborhood, which in turn will contribute to the expansion of open space network and urban aesthetics expansion. Revitalization of biodiversity levels by green infrastructure enhancement.

Wetland ecological services and functions: a restored Nairobi dam and its riparian reserve will ensure pollution levels reduced in the environment; this is made possible as a result of wetland's

function and ability to serve as, natural filters, water purifiers and carbon sinks through biodegradation.

Land relief and environment: Nairobi dam is experiencing settlement-related pressures as a result of encroachment by developers and the slum that has triggered increased densities of people living around the dam. Demolition of hard landscape to pave way for green cover will see a regeneration of Nairobi dam and enhanced environmental quality.

b) Weakness of the strategy

Displacement: application of the strategy will lead to massive displacement of settlements falling within the thirty-meter riparian reserve and loss of properties worth billions.

Loss of livelihoods: The study observed the riparian corridor of Nairobi dam is a beehive of informal economic activities in form of micro-commercial enterprises such as small kiosks and vegetable vendors, agricultural activities like yam farming within the dam, and micro-industry. These economic activities provide sources of livelihood for a majority of residents and hence threatened by a blanket recovery of the dam reserve.

Disruption of community's Social fabric: in terms of separation of neighbors, relatives, friends, social groups, community-based organizations and also eliminating vital informal social facilities such as schools, churches, and communal places that are important to residents and the community and also an attachment to.

4.5.2 Integrated holistic Wetland use and Management strategy

Performance based model that produces a spatial negotiated wetland and land use patterns pegged across economic, environmental, physical, social, and cultural dimensions founded upon various optima, objectives, and constraints. From the findings this strategy is propagated by

planners and NCC who advocates for a range of strategies for allocation of land to alternate with competing uses by generating spatial scenarios of land use allocation. The model is based on varied width of the riparian reserve that depends on the interaction of site conditions and land uses. Exorable possible uses of the riparian area includes recreation, forestry, urban agriculture, nature trails, bee-keeping, and composting.

a) Strengths of the Model:

Responsive environmental governance: that appreciates the human-environment linkage and its implications on livelihoods and poverty levels in Kibera.

Sustainable and inclusive: it formulates scenarios for multiple land use through access, utilization, and management of resources.

Framework for engagement and consensus building: provides avenues for creation of a long-term strategy in form of a multiple usage master plan. It also provides a basis of framework where diverse stakeholder' information, aspirations, needs, and claims by different can interact and agree.

b) Weaknesses of Strategy

Prone to abuse: systemic malfunctions and ultimately tragedy of the commons are some of the possible challenges likely to emanate from the model; this is as result of the nature of the model to attract speculative users and investors bent on maximization rather than optimization in accessing and utilization of the riparian areas.

Time consuming: the strategy is characterized by a lengthy rigorous process of sensitization, consultations, and consensus building associated by frustrating signs of fatigue and apathy due to the negotiated style approach it operates on.

Resource intensive: This model is viewed as an expensive process that entails enormous technical and financial resources as a result detailed studies in a scientific and socio-spatial sense in model's construction and program.

4.5.3 Operationalization of Studies Alternative Strategy: Consensus building

The study notes that it would be appropriate that a wide range of stakeholders be involved for successful sustainable restoration and management of Nairobi dam and its riparian reserve. Failures and weaknesses attributed to lack of stakeholders consultation and involvement more so the local kibera community, has significantly drained momentum from various restoration initiative and even attracted sabotage and resistance at the worst. The study found that the surrounding community in Nairobi dam neighborhood is not involved or engaged in the dam's conservation with majority involved in polluting and degrading it. The study notes there is need to mobilize civil society organizations and research institutions in community engagement and sensitization exercises through awareness creation and environmental education programs where the community is sufficiently trained and educated on the Dam's riparian reserve, legal implications and influence, and the significance of the environment. In addition there is need to go a step further in assisting with the visualization of various desirable scenarios and outcomes for utilization of riparian areas by the local community, that will also include an alternative human settlement program and pattern. The prime objective is to empower the surrounding Kibera and dam community with the necessary skill through awareness creation that will efficiently enable them to engage effectively and actively mandated agencies and other concerned stakeholders in meaningful and properly designed negotiations regarding Nairobi dam restoration and the riparian zone that will minimize confrontation, forceful and inhumane evictions, and loss of businesses and livelihoods that has been a thorn of flesh on the various demolition attempts along the reserve of the dam. The study notes that the civil society organizations and research institutions can also act as intermediaries to promote and pull-off negotiations between the county government and the community via various urban planning and management forums. The vital steps in pushing this agenda forward include sensitization and

impact assessment, creation of an adaptive riparian buffer through proper survey and delineation of, alternative resettlement of the affected human activities, riparian rehabilitation and management of vacated area, and proper co-ordination and facilitation of the management of the riparian area. The study notes that this proposed model can be incorporated into the Nairobi county integrated Development Project 2018-2022 implementation strategies for national spatial plan that aims an integrated, sustainable and balanced development of the County under the key themes of diversifying tourism, managing human settlement, conserving natural environment and providing appropriate infrastructure.

4.6 HYPOTHESIS TESTING

Regression Analysis

The hypothesis that was tested mainly was to ascertain whether there was a correlation between land use and degradation of Nairobi dam. The nature of the data prompted the use of regression method to analyze data whereby the data analyzed showed a linear correlation.

To test the hypothesis the researcher considered the two main variables; urban built-up areas and Forest area cover. Samples were collected over a period of about 30 years and were tested against the area of the Dam through the same period of time. The output was as shown below.

Years	Area of Nairobi dam (km ²), Y	Urban Built-up areas (km ²), X ₁	Forest Area (km ²), X ₂
1988	0.25	27.09	9.53
1995	0.21	28.4	8.64
2004	0.09	33.08	7.73
2017	0	51.47	6.67

Table 4.13 Area of Nairobi Dam and Land uses

- a. Predictors (independent variables); urban development, Forest loss, land reclamation due to population pressure.
- b. Dependent variable; degradation of Nairobi dam.

The R value shows a relative strong correlation 0.99 between land use and degradation of Nairobi dam. The R squared shows the variations between land use and degradation of Nairobi dam.

<i>Regression Statistics</i>	
Multiple R Squared	0.9766
Adjusted R Squared	0.9298
Residual Standard Error	0.03024
Observations	4

Table 4.14: Summary of output

$R^2 = 0.97$, taken as a set, the predictors urban built-up and forest cover account for 97% of the degradation of the Nairobi dam.

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>
Intercept	-0.458438	0.427398	-1.073	0.478	5.88904974	4.97217328
Forests	-0.001462	0.003960	-0.369	0.775	0.05177991	0.04885647
Urban Built-up	0.079506	0.036283	2.191	0.273	0.38151848	0.54053012

Table 4.15 Correlation coefficient

ANOVA Table

	<i>Df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Forests	1	0.033769	0.033769	36.9223	0.15558152
Urban Built-up	1	0.004391	0.004391	4.8016	0.2726
Residuals	1	0.000915	0.000915		
Total	3	0.039075	0.03816		

Table.4.16

Table 4.16 Analysis of Variance

The overall regression model was significant, $F(2, 1) = 1213.716$, $p < .05$, $R^2 = .97$

The P value = .44 which is lower than the selected alpha level and therefore;

The tabulated results confirm a significant relationship between the degradation of the dam and land use around the dam. They also indicate that land use is major variable influencing the rehabilitation of the dam. We then reject the null hypothesis and conclude that land use significantly influence restoration and rehabilitation efforts of the dam.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

The first objective of the study aimed on undertaking a situation analysis of Nairobi Dam and its surroundings. The study findings quantified the nature, pattern and trends of land use and land cover dynamics of Nairobi Dam area and its watershed between the years 1988 to 2017. The study established marked decline in Nairobi dam, agricultural, grass, riparian, rangeland and shrubs as well as Ngong forest covers within the study period. The study established the decline and degradation of Nairobi dam is attributed to gradual encroachments by urban built-up, transitional and agricultural land uses and massive loss of the Ngong forest which have significant implications on quality of the dam as a result of anthropogenic activities that has led to massive pollution, siltation and eutrophication of the dam leading to degradation of the dam as revealed by the water quality analysis.

The study findings also reveals lack of awareness, ignorance to various laws and policies by the majority of the population has contributed to the unplanned and unsustainable development around the dam. In addition it reveals gaps exist in terms of enforcement legislations in the various Acts and policies, lack of compliance with environmental regulations and weak institutional frameworks in various institutions. The institutional structures that have been put in place to manage sustainable utilization of Nairobi dam that include NCC, WRA and NEMA have failed to ensure sustainability in management and use of the dam is achieved.

The findings also revealed lack of tenure especially from Kibera sides of Laini Saba and Lindi discourages residents in improving their shelter conditions as an activity of achieving wetland

conservation and management. Secondly, it hinders efforts of relevant institutions in supplying basic infrastructure to the slums. In addition the study also found, most of the new developments perceived to have grabbed and encroached into the riparian land on Dam estate side had legal documents to ownership of the land rendering previous restoration efforts futile and powerless against demolition of buildings for sustainable restoration of the dam. Other constraints to sustainable restoration of the dam as the findings of the study included, issues of solid and liquid waste as a great section of Kibera slums lacks facilities and infrastructure of solid and liquid waste hence as our findings, the dam has been turned into a dumping site for both liquid and solid liquid.

On objective two on past restoration strategies and efforts towards restoration, the study established that all the previous efforts failed in restoring Nairobi dam. The failures were in all aspects of sustainability that included social, economic and environmental aspects and also on the enabling aspects that included legal, institutional and infrastructural aspects. In addition, the study found there are varying institutional challenges at various past restoration efforts that include: - varying and multiple interests from various groups; divergent levels of power and influence; low and misguided budgetary allocations; politicization of the Nairobi dam restoration effort thus slowing down decision making; inadequate land for infrastructure upgrading; mistrust and absence of good will from the surrounding community as they feel jeopardized of uncertainties such as house demolitions to pave way for restoration of the dam ; and lack of a strong institutional framework to guide Nairobi dam restoration and management process.

The result of the above situation is manifested by the continuing degradation and pollution of Nairobi dam characterized by expansive permanent slums settlements and massive grabbing and

encroachments of adjacent land by developers amidst four previous attempts by various powerful government agencies and institutions to restore the dam. This coupled with negative perceptions towards dam restoration efforts due to the inability of such efforts to involve and integrate the surrounding communities in restoration plans and programmes and their failure to enhance the communities' socio-economic status. Overall, past restoration strategies have had minimum impact on betterment towards achieving sustainable management that seek to ameliorate the social, economic and environmental quality of Nairobi dam, surrounding human settlements plus the living environments of all people, particularly Kibera slums through adopting an enabling approach to slum upgrading strategy and solid and liquid waste infrastructure improvements which are environmentally sound. The findings also revealed that the restoration of the dam could not be singled out and must incorporate its watershed that includes Motoine, silanga and Ngong Rivers.

5.2 Conclusions

Nairobi dam like many other urban wetlands in developing countries have has been degraded as a result of anthropogenic activities as a result of ever-increasing urban population. Degradation is a serious issue that requires urgent attention especially due to threats of a growing population and poverty levels. Numerous past efforts to restore and conserve the Dam by the divergent players have not produced the desired results leading to failure in each and every attempt ascribed to lack of integration of the conservation activities into one common front which in effect has resulted loss and degradation of resources. The problems to this urban wetland have expanded towards larger complexity as every restoration attempt fails each passing by. It will therefore require collective harmonized community driven efforts to tackle these challenges. This calls for a strategy for sustainable management taking cognizance of the levels of degradation

and restoration challenges like cost and logistics, so that proper scoping is done. This strategy should integrate the technical, socio-economic, environmental and legal aspects of the wetland resources management and must involve the local community at all levels.

Sustainable wetland restoration and management can only be achieved through an integrated strategy that link or integrate the environment, the economy and the society. This therefore means in analyzing and assessing the restoration strategy, the long term impact should be viewed from all three spheres of sustainability; the environment, the society and the economy. Single sided dimensional approach on sustainability as many of the past efforts have tried may prove successful on the short term but expensive on the long run. Long-term sustainability of wetland utilization and use must be planned in a way that long-term sustainability of the natural basis of living is sustained and achieved, i.e. land consumption and usage should correspond to its natural potential. This should be determined by prior elaborate ecosystem services inventory. The measures applied should be desirable, supported and largely carried out by the community to ensure social compatibility and cultural suitability, inclusive of local knowledge and capacities. The planned measures should be designed in a manner that their contribution to the basis of living of people should offer a long-term economic security. Consequently, the measures should be both self-financing and economically justified. In this manner, overall economic development and improvement of the living conditions shall be sustained. To be viable, the measures planned should consider tolerance level of the local population with regards to technology, economy and organization. Therefore, this constructed urban wetland have to be in focus of urban managers and planners because if Nairobi dam is restored and managed appropriately, it will create colossal potential to supplement the water supply for non-potable water requirements, provision of alternative livelihoods and recreational services within the city.

5.3 Recommendations

The study has shown that Nairobi dam which once was a major fishing, sporting and recreational facility within the city precinct has undergone massive degradation and pollution as a result of continuous unplanned utilization of this vital constructed wetland by the surrounding communities. Efforts have been tried before to restore this wetland, yet they all have led into failures. The ever increasing population within Kibera and the demand for more space is a great threat to the existence this fragile wetland ecosystem. It is therefore important for new restoration efforts to embrace a balanced and integrated urban wetland management strategy that is community driven and will ensure the society, economy and the environment benefit .As aforementioned, this study proposes several measures that should be given priority. They include;

1. Development of land use plan

Nairobi dam having been surrounded by a kibera slum and lacks comprehensive land use plan. Nairobi County should develop comprehensive land use plan for Nairobi dam neighborhood. Due to the poverty characteristics especially in Kibera around the wetland, the proposed land use plan should consider elements of social justice to address distribution and kind of benefits, so that even the socially weak participate in the process.

The study recommends this land and water development plan should be pegged on the ecosystem based approach on water management, conforming to accepted environmental legislation and ensuring social wellbeing, economic prosperity, environmental sustainability and cultural sanctity of the place.

The study recommends a creative Land Readjustment (Consolidation) measures that include re-arrangement of current land ownership and land use patterns that ensures an adequate supply of land for development and the protection of Nairobi dam, that may include land sharing, land pooling, re-blocking and the transfer of development rights as the case study in India.

The land use plan should also include a detailed integrated infrastructure plan for Kibera with diverse standards and options to what the slum residents can afford, with an aim objective of curbing a pollution menace into Nairobi dam.

3. Survey and demarcation of Nairobi dam

Currently the physical boundaries of Nairobi dam are not defined due to the continuous encroachment of the wetland by both the surrounding communities and private developers. The National land commission and Multi Agency team of Nairobi County, NEMA and WRMA should identify and demarcate the legal boundaries of the dam with the involvement of the residents. Any land that is found to be illegally occupied should be recovered and protected.

Compulsory acquisition of land may however prove unpopular due to the residents especially in kibera who have overstayed in the grabbed land for over 20years and detaching the people from the land may meet resistance. In addition home owners who have invested in developments perceived to have encroached the dam will oppose any attempts to demolish their investments. It is therefore important to undertake in-depth consultations with the stakeholders before the process is undertaken.

Demolition of all the structures within the riparian reserve of the dam to and replace it with a green park which can be used as a buffer zone and for recreational facilities. The park shall enhance the aesthetics of the dam while ensuring compatibility of land-uses.

4. Alternative livelihood

The County Government in collaboration with other agencies should empower the local communities especially the farmers within the dam on alternative livelihood opportunities such as recreation, eco-tourism, and agro-forestry among others. It is hoped that this will help meet the needs of a proliferating population while reducing pressure on the already overburdened dam ecosystem. There should be well planned commercial activities within the proposed park on the

reclaimed land to promote well provided recreational services while gaining revenue to protect the dam.

The study recommends a Safilguda Lake development restoration experience model of India that incorporated measures such as creation of recreation activities such as Public Park, boating activities and provision of alternative livelihoods that made stakeholders around the lake to keep vigil on the wetland environment and conservation. With this experience, Safilguda wetland has redefined its responsibilities in wetland restoration and sustainable Management that is citizen based and sustainable, and this can be the same experience of Nairobi dam.

5. Harmonization of various laws and institutions into one single entity:

The greatest threat to wetland restoration and management is that there are too many laws and institutions addressing the riparian reserve and management. Hence need for Parliament to harmonize these laws into a single policy framework so as to have a single legislation regarding riparian land and a coordinated approach regarding wetland management to avoid duplication and conflict from various institutions.

6. Slum upgrading;

Mobilization of funds and investment on slum housing in kibera should be a priority of the National government and County government. This will be a remarkable effort in upgrading the adjacent slum and ensuring clean and sustainable dam and achievement of Agenda 4 on housing.

7. Water supply and sanitation infrastructure:

Slum upgrading should be followed by a network of sewer system to ensure that raw sewer does not flow into the dam. Provision of potable water supply around the dam will also imply less incidents of water borne diseases, thus improved health to the residents.

Nairobi county government should integrate both the Non-conventional approaches and conventional treatment process of sewer treatment with based upon local standards and requirements. Any plans for dam restoration and revival should integrate available local based methods of nonconventional treatment.

8. Solid waste management and collection:

The Nairobi county Government should initiate a community based system of solid waste management that will go a long way in reducing litter and waste pile up in Kibera slums. This coupled with environmental awareness through CBOs, will ensure that the residents handle the waste responsibly. To implement waste management and collection concerted efforts between the communities will need to put in place systems that will be sustainable in order to avoid accumulation of waste. The study further recommends emphasis on Recycle Re-use and Reduce to ensure that the waste does not accumulate and contaminate the dam. It is also envisaged to create employment and will lead to sustainable management of waste.

9. Governance and Management

Implementation agency should prepare a clear vision of the dam regarding the level of restoration of this wetland. Establishing acceptable level of restoration of the dam will ensure efficiency and productive use of available and limited resources.

A strategy that is time bound and integrative should be formulated as part of dam and watershed restoration and protection programmes, taking into account all the components integral and that have a footprint and effect on Nairobi dam; In addition, in order to effect and achieve better coordination stakeholders involvement should be included in every phase and process of management.

Stakeholder participation and capacity building must be used as an important instrument for better management of urban constructed wetland.

Adoption of appropriate Public, private partnership project in restoration mechanisms as an appropriate strategy in restoration and management of Nairobi dam that ensures the wetland is not handed over, forever, and into hands of private partners. To ensure transparency the study recommends a tripartite model formed between funding agencies, the government and implementing agency of an impeccable wetland conservation track record plus the community.

10. Hyacinth Removal

An integrated removal and control programme for water hyacinth should be structured within the dam. The study recommends a simplest method of management and research in harvest, utilization and value addition for cost effectiveness in production such as use of hyacinth for preparation of fish and livestock feeds, fertilizers, bio-gas production, making of charcoal briquetting and waste water treatment for domestic and industrial use.

Measures like cleaning of the rivers and dam encompassing de-silting, de-weeding, aeration, nutrient reduction, eradication of floating and other invasive aquatic plant-species or any suitable successful tested and technologically measures suitable to the local condition, should be taken up for river and dam restoration . NEMA and WRA should undertake a comprehensive restoration

of the Catchment area like afforestation, management of storm water drainage, silt traps along Motoine and Silanga rivers.

For the above mentioned strategies to yield fruits, it is essential to promote effective and efficient communication, encourage understanding and participation of the public, private sector, local authorities, NGOs and other interested persons through proper education and public awareness among stakeholders on urban constructed wetlands. Wider community, industry and government support of social, economic and ecological values through involvement of all related stakeholders, long term maintenance and sustainability of ecological functions and services through integration of community aspirations for biodiversity conservation with sustainable use of natural resources in the urban context.

5.4 Suggestion for further research

The researcher suggests that there is need to have further research on economic and social valuation of the Dam in Nairobi County. From the research it was noted that there is a lapse in the project initiation process right from conceptualization to implementation from one regime to the other. It is at this juncture that further research should be carried out on how the political forces and factors influence dam restoration and conservation.

REFERENCES

- Abebe, Y. D. (2003). Wetlands of Ethiopia: an introduction. In Wetlands of Ethiopia. Proceedings of a seminar on the resources and status of in Ethiopia's wetlands, IUCN Eastern Africa Regional Office, Nairobi, Kenya, IUCN—The World Conservation Union.
- Adhiambo S.C., 2009, an assessment of wetland influence on water quality of river Mereronyi, Kenya.
- Bäckstrand, K. (2003). Civic science for sustainability: reframing the role of experts, policy-makers and citizens in environmental governance. *Global Environmental Politics*, 3(4), 24-41
- Barbier, E. B., Acreman, M., & Knowler, D. (1997). Economic valuation of wetlands: a guide for policy makers and planners. Gland, Switzerland: Ramsar Convention Bureau.
- Barthélémy, C., & Armani, G. (2015). A comparison of social processes at three sites of the French Rhône River subjected to ecological restoration. *Freshwater Biology*, 60(6), 1208-1220.
- Basiago, A. D. (1998). Economic, social, and environmental sustainability in development theory and urban planning practice. *Environmentalist*, 19(2), 145-161.
- Basiago, A. D. 1995. Methods of defining 'sustainability'. *Sustainable Development*, 3 3 , 109-119.
- Basiago, A. D. 1996. The search for the sustainable city in 20th century urban planning. *The Environmentalist*, 16, 135-155.
- Borrini-Feyerband, G. 1996 Collaborative management of protected areas: Tailoring the approach to the context IUCN land, Switzerland
- Callicott, J. B., & Mumford, K. (1997). Ecological Sustainability as a Conservation Concept: Sustentabilidad Ecológica como Concepto de Conservación. *Conservation biology*, 11(1), 32-40.
- Chikomo, T. (2014). Community Perceptions of Environmental Indicators for Management of Wetland Important Bird Areas in Kenya (Doctoral dissertation, UNIVERSITY OF NAIROBI).
- Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in society*, 28(1-2), 63-80.
- Day Jr, J. W., Martin, J. F., Cardoch, L., & Templet, P. H. (1997). System functioning as a basis for sustainable management of deltaic ecosystems. *Coastal Management*, 25(2), 115-153.

- Desveaux, J.A., (1994). *Anticipating Uncertainty: The Strategy-Structure Problem in Public Bureaucracy Governance*, London Publishers.
- De Smedt, J. (2009). " Kill Me Quick": A History of Nubian Gin in Kibera. *The International journal of African historical studies*, 42(2), 201-220
- Dugan, P. (ed) (1993). *Wetlands in Danger – A World Conservation Atlas*. Oxford University Press, New York, United States of America.
- Dugan, P. J. (Ed.). (1990). *Wetland conservation: a review of current issues and required action*. IUCN.
- Dukhovny, V.A. (2000). *Water Governance and Management – Theory and Practice*.McMillan Publishers.
- Edward, M.(2009) *The challenges for application of the Ecosystem Approach in Wetlands* Institute for Sustainable Water, Integrated Management & Ecosystem Research (SWIMMER).University of Liverpool
- Ehrenfeld, J.G., 2000. Evaluating wetlands within an urban context. *Ecological Engineering*, 15, pp.253–265
- Evans, P. B. (Ed.). (2002). *Livable cities?: Urban struggles for livelihood and sustainability*. Univ of California Press.
- Ewers, H. and Nijkamp, P. (1990). Urban sustainability. In: Nijkamp, P. ed , *Urban Sustainability*. Avebury: Gower, 8-10.
- FAO Report (2012). *Managing Africa’s Water Resources: Integrating Sustainable use of Land, Forest and Fisheries*. ISSN-I: 2026-5611.
- Fielding, K. S., Russell, S., Spinks, A., & Mankad, A. (2012). Determinants of household water conservation: The role of demographic, infrastructure, behavior, and psychosocial variables. *Water Resources Research*, 48(10).
- FoE 1994. *Planning for the planet: sustainable development policies for local and strategic plans*. London: Friends of the Earth, 10.
- Foy, G. (1990). Economic sustainability and the preservation of environmental assets. *Environmental Management*, 14(6), 771-778.
- Geoghegan, J. (2002). *The value of open spaces in residential land use*. *Land use policy*, 19(1), 91-98.
- Ghabo, A. A. (2007) *Wetlands Characterization; Use by Local Communities and Role in Supporting Biodiversity in the Semiarid Ijara District, Kenya*. Keddy, P.A. 2010.68Wetland

Ecology: Principles and Conservation (2nd edition). Cambridge University Press, Cambridge, UK. 497 pp.

Gibbs, A., Willan, S., Misselhorn, A., & Mangoma, J. (2012). Combined structural interventions for gender equality and livelihood security: a critical review of the evidence from southern and eastern Africa and the implications for young people. *Journal of the International AIDS Society*, 15, 1-10.

Githiga, J. M., Reid, R. S., Muchiru, A., & Dijk, S. V. (2003). Survey of water quality changes with land use type, in the Loitokitok Area, Kajiado District, Kenya.

Gregory, S., Li, H., & Li, J. (2002). The conceptual basis for ecological responses to dam removal: resource managers face enormous challenges in assessing the consequences of removing large dams from rivers and evaluating management options. *AIBS Bulletin*, 52(8), 713-723.

Hart, D. D., Johnson, T. E., Bushaw-Newton, K. L., Horwitz, R. J., Bednarek, A. T., Charles, D. F., & Velinsky, D. J. (2002). Dam removal: challenges and opportunities for ecological research and river restoration: we develop a risk assessment framework for understanding how potential responses to dam removal vary with dam and watershed characteristics, which can lead to more effective use of this restoration method. *AIBS Bulletin*, 52(8), 669-682.

Jähnig, S. C., Lorenz, A. W., Hering, D., Antons, C., Sundermann, A., Jedicke, E., & Haase, P. (2011). River restoration success: a question of perception. *Ecological Applications*, 21(6), 2007-2015.

JULIUS, M. (2013). *Nairobi Integrated River Park: A Mediation Development Project for Ngara Riparian Zone* (Doctoral dissertation, University of Nairobi).

Kaggwa, R. S. (2006). Fingerponds: managing nutrients and primary productivity for enhanced fish production in Lake Victoria's wetlands, Uganda.

Kahn, M. (1995). Concepts, definitions, and key issues in sustainable development: the outlook for the future. *Proceedings of the 1995 International Sustainable Development Research Conference*, Manchester, England, Mar. 27]28, 1995, Keynote Paper, 2-13.

Kaika, M. (2003). The Water Framework Directive: a new directive for a changing social, political and economic European framework. *European Planning Studies*, 11(3), 299-316.

Kansiime, F., & Nalubega, M. (1999). Wastewater treatment by a natural wetland: the Nakivubo swamp. Uganda: processes and implications, AA Balkema Rotterdam, the Netherlands.

Keating, M. (1993). *The Earth Summit's agenda for change*. Geneva: Centre for Our Common Future, viii, x, 12-13, 63-67.

- KINYARIRO, M. S. (2016). *Challenges And Opportunities Of Participatory Management Of Upland Wetland In Kiambu County, Kenya* (Doctoral dissertation, Kenyatta University).
- Lambin, E. F., & Meyfroidt, P. (2011). Global land use change, economic globalization, and the looming land scarcity. *Proceedings of the National Academy of Sciences*, 108(9), 3465-3472.
- Lambin, E. F., Geist, H., & Rindfuss, R. R. (2006). Introduction: Local processes with global impacts. In E. Lambin F., & H. Geist (Eds.), *Land-use and land-cover change local processes and global impacts* (1st ed., pp. 1-8). Germany: Springer.
- Macharia Alice Ndunge (1999): Human impact on the biophysical characteristics of a tropical manmade wetland: A case study of Nairobi dam. Unpublished dissertation, department of Geography, University of Nairobi.
- McCully, P. (1996). *Silenced rivers: The ecology and politics of large dams*. Zed Books
- McDonough, W. (1992). *The Hannover Principles*. New York: Self-Published, 1-2.
- McKenzie, S. (2004). *Social sustainability: towards some definitions*.
- Mironga J.M.,(2005), *Effect of Farming Practices on Wetlands of Kisii District, Kenya*.
- Morelli, J. (2011). Environmental sustainability: A definition for environmental professionals. *Journal of environmental sustainability*, 1(1), 2
- Moser, M., Prentice, C., & Frazier, S. (1996). A global overview of wetland loss and degradation. In *Papers, Technical Session B, Vol 10/12B, Proceedings of the 6th Meeting of the Conference of Contracting Parties, Brisbane, Australia, 19–27 March 1996*, Ramsar Convention Bureau, Gland, Switzerland, 21–31.
- Muchiri, N. W,2012 ,*The impact of human activities on Wetlands: a case study of Ondiri Wetland in Kiambu County, Kenya*
- Mundia, C. N., & Aniya, M. (2006). Dynamics of landuse/cover changes and degradation of Nairobi City, Kenya. *Land Degradation & Development*, 17(1), 97-108.
- Mutisya, E., & Yarime, M. (2011). Understanding the grassroots dynamics of slums in Nairobi: the dilemma of Kibera informal settlements. *Int Trans J Eng Manag Appl Sci Technol*, 2(2), 197-213.
- Namale, B.D., (2013). *Nairobi Dam: Daunting Task to Rehabilitate Water Reservoir*, Jassem ISSN 1119-8574.

Nellemann, C., (2010). *Dead Planet – Biodiversity and Ecosystem Restoration for Sustainable Development: A Rapid Response Assessment*. UNEP and GRID-Arendal. Printed by Birkeland Trykkeri AS, Norway. ISBN: 978-82-7701-083-0.

County, N. C. (2017). *County Integrated Development Plan (CIDP) 2018-2022*.

Nilsson, C., Polvi, L. E., Gardeström, J., Hasselquist, E. M., Lind, L., & Sarneel, J. M. (2015). Riparian and in-stream restoration of boreal streams and rivers: success or failure?. *Ecohydrology*, 8(5), 753-764

Nilsson, C., Reidy, C. A., Dynesius, M., & Revenga, C. (2005). Fragmentation and flow regulation of the world's large river systems. *Science*, 308(5720), 405-408.

Nuruzzaman, M., Al-Mamun, A., & SALLEH, M. N. B. (2017). CHALLENGES IN THE REHABILITATION OF THE PUSU RIVER. *International Journal of Conservation Science*, 8(1).

Odongo, M. O., and UNEP Report (2013). *Restoration Plan on Restoration of the Nairobi Rivers and the Restoration of the Nairobi Dam*, ISBN 987-92-807-3289-6. Pinsonneault

OECD (1996). *Guidelines for aid agencies for improved conservation and sustainable use of tropical and subtropical wetlands*. Organisation for Economic Co-operation and Development, Paris, France.

OECD (1996). *Guidelines for aid agencies for improved conservation and sustainable use of tropical and subtropical wetlands*. Organisation for Economic Co-operation and Development, Paris, France.

Okoth, P. F., & Otieno, P. (2001). *Pollution assessment report of the Nairobi River Basin*. UNEP. AWN. Nairobi, 1.

Olima, W. H. (2001). *The dynamics and implications of sustaining urban spatial segregation in Kenya: Experiences from Nairobi metropolis*.

Opaa, B. O., Okotto-Okotto, J., Nyandiga, C. O., & Masese, F. O. (2012). *Nyando Wetland in the future. Community Based Approach to the Management of Nyando Wetland, Lake Victoria Basin, Kenya*, 132.

Pejchar, L., & Warner, K. (2001). A river might run through it again: criteria for consideration of dam removal and interim lessons from California. *Environmental management*, 28(5), 561-575.

Pezzoli, K. E. I. T. H. (2002). *Sustainability, Livelihood, and Community Mobilization in the Ajusco Ecological Reserve*. *Livable cities: The politics of urban livelihood and sustainability*, 195-222.

- Potts, D. (2012). What do we know about urbanisation in sub-Saharan Africa and does it matter?. *International Development Planning Review*, 34(1), v-xxii.
- Raburu, P. O., Wa'Munga, P. O., & Okeyo-Owuor, J. B. (2012). Experiences from Community Participation in Managing Nyando Wetland. *Community Based Approach to the Management of Nyando Wetland, Lake Victoria Basin, Kenya*, 81.
- Rakodi, C. (Ed.). (1997). *the urban challenge in Africa: Growth and management of its large cities* (pp. 111-149). Tokyo: United Nations University Press.
- Ramachandraiah, C. (2011). Coping with urban flooding: a study of the 2009 Kurnool floods, India. *Environment and Urbanization*, 23(2), 431-446.
- Ramsar, 1971. Ramsar international conference on the conservation of wetlands and waterfowl. In Ramsar: Ramsar Convention. Available at: http://www.ramsar.org/cda/en/ramsar_documents-texts-convention-on/main/ramsar/131-38^20671_4000_0__.
- Reiss, K. C., Hernandez, E., & Brown, M. T. (2009). Evaluation of permit success in wetland mitigation banking: a Florida case study. *Wetlands*, 29(3), 907.
- Republic of Kenya (1999): Environmental Management and Coordination Act 1999. Government Printer, Nairobi, Kenya
- Republic of Kenya (2007). Kenya Vision 2030. Government Printer, Nairobi, Kenya.
- Republic of Kenya (2010). The Kenyan Constitution 2010. Government Printer, Nairobi, Kenya.
- Republic of Kenya (2016), Water Act 2016. Government Printer, Nairobi, Kenya.
- Rhyner, Charles R., Leander J. Schwartz, Robert B. Wenger, and Mary G. Kohrell. Waste management and resource recovery. CRC Press, 2017.
- Robertson, M. (2017). *Sustainability principles and practice*. Routledge.
- Rugo, J. W. (2015). FACTORS INFLUENCING RESTORATION AND SUSTAINABILITY OF THE NAIROBI DAM IN NAIROBI COUNTY, KENYA.
- Schaich, H. (2009). Local residents' perceptions of floodplain restoration measures in Luxembourg's Syr Valley. *Landscape and Urban Planning*, 93(1), 20-30.
- Schiff, K., McLaughlin, K., Moore, S., & Cao, Y. (2019). Southern California Bight. In *World Seas: an Environmental Evaluation* (pp. 465-482). Academic Press.

Scott DA & Carbonell M (comp) (1986). A Directory of Neotropical Wetlands. IUCN Conservation Monitoring Centre, Cambridge, United Kingdom, and International Waterfowl Research Bureau, Slimbridge, United Kingdom.

United Nations (2018). World Urbanization Prospects: The 2018 Revision. New York, United Nations Publications.

Van Oel, P. R., Mulatu, D. W., Odongo, V. O., Meins, F. M., Hogeboom, R. J., Becht, R., ... & van der Veen, A. (2013). The effects of groundwater and surface water use on total water availability and implications for water management: the case of Lake Naivasha, Kenya. *Water resources management*, 27(9), 3477-3492.

Verhoeven, J. T., Arheimer, B., Yin, C., & Hefting, M. M. (2006). Regional and global concerns over wetlands and water quality. *Trends in ecology & evolution*, 21(2), 96-103.

Wangui J., (2014), Fourth attempt to clean up Nairobi Dam. Capital Press Article No.3

Woolsey, S., Capelli, F., Gonser, T. O. M., Hoehn, E., Hostmann, M., Junker, B. & Tockner, K. (2007). A strategy to assess river restoration success. *Freshwater Biology*, 52(4), 752-769.

World Commission on Dams. (2000). Dams and development: A new framework for decision-making: The report of the world commission on dams. Earthscan.

Zsuffa, I., Cools, J., Vlieghe, P., Debels, P., van Griensven, A., van Dam, A., & Kaggwa, R. (2016). The WETwin Project: Enhancing the Role of Wetlands in Integrated Water.

APPENDICES

University of Nairobi

School of the Built Environment

Department of Architecture and Building Sciences

This questionnaire is intended to gather data geared towards assisting Nelson Mandela Oude, a Masters Student in the School of the Built Environment, University of Nairobi for his Research Thesis titled: — Management Strategies for Restoration of Nairobi Dam”

NB: The information provided will be treated with confidentiality and only for the research purpose.

Section 1: General Information

Name.....Questionnaire number.....

Area of residenceContact no.....

Date..... Age.....

Please indicate the option correctly and diligently by putting a tick (√) against options provided in the boxes for each question. For the questions which require your suggestions/comments, use the space provided for each question. Kindly respond to all questionnaire items.

1. Probe and Fill the table below

a) Education Level	None { } Primary { } Secondary{ } Tertiary { } University { }
b) Occupation (main source of income)	Formal { } Informal{ } Other
c) Household size	1-3 [] 3-8 [] 8-10 [] Above 10 []
d) Duration of stay	0-10 Years [] 11-20 years [] 21-30 Years [] Above 30Yrs []
e) Reason of stay	Affordable cost of living [] Affordable cost of housing [] Proximity to CBD [] Proximity to work place [] If none, what other reasons.....

Section 2: Nairobi dam rehabilitation and use information (Situation Analysis)

4) Questions and perceptions towards Restoration and sustainable management of Nairobi dam

<p>a) I would like Nairobi dam to be restored for recreation?</p> <p><input type="checkbox"/> Strongly agree</p> <p><input type="checkbox"/> Agree</p> <p><input type="checkbox"/> Neutral/ doesn't matter</p> <p><input type="checkbox"/> Disagree</p> <p><input type="checkbox"/> Strongly disagree</p>	<p>f) I think Nairobi dam is essential to Nairobi city's recreational need?</p> <p><input type="checkbox"/> Strongly agree</p> <p><input type="checkbox"/> Agree</p> <p><input type="checkbox"/> Neutral/ doesn't matter</p> <p><input type="checkbox"/> Disagree</p> <p><input type="checkbox"/> Strongly disagree</p>
<p>b) I would visit more often if Nairobi dam area is restored and redeveloped as a park?</p> <p><input type="checkbox"/> Strongly agree</p> <p><input type="checkbox"/> Agree</p> <p><input type="checkbox"/> Neutral/ doesn't matter</p> <p><input type="checkbox"/> Disagree</p> <p><input type="checkbox"/> Strongly disagree</p>	<p>g) I think the Restoration of Nairobi dam will increase the price of nearby properties</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> Not sure</p> <p><input type="checkbox"/> No</p>
<p>c) I would support the following facilities to be introduced in the restoration plan of Nairobi dam area (you can choose more than one option)</p> <p><input type="checkbox"/> High-rise Housing Facilities</p> <p><input type="checkbox"/> Boating facilities</p> <p><input type="checkbox"/> Children's play area</p> <p><input type="checkbox"/> Sports facilities</p> <p><input type="checkbox"/> Meditation areas</p> <p><input type="checkbox"/> Fishing and Bird watching decks</p> <p><input type="checkbox"/> Area for strolling/ jogging</p> <p><input type="checkbox"/> Food kiosks</p> <p><input type="checkbox"/> Information center</p> <p><input type="checkbox"/> Others, please specify _____</p>	<p>f) I think the Restoration of Nairobi dam will reduce pollution</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> Not sure</p> <p><input type="checkbox"/> No</p>
<p>d) I would visit the park if there is an entry fee to the park</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> Doesn't matter</p> <p><input type="checkbox"/> No</p>	<p>g) I think the development of this park will reduce the risk of flooding</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> Not sure</p> <p><input type="checkbox"/> No</p>
<p>e) If no, I would be willing to pay or rent for the facilities and services when I use them</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> Doesn't matter</p> <p><input type="checkbox"/> No</p>	

5) Probe and Fill the table below on tenure

a) Do you own land in this area?	No() Yes()
b) If yes how big is it?	Acres (.....)
c) Does the piece of land that your house is erected have a title?	No() Not Sure () Yes()
d) If no, what documents prove ownership?	Allotment letter() Lease letter() Any other.....
e) If it is mandatory to vacate, to allow for restoration of the dam, will you vacate?	No() Not Sure () Yes()

6) Awareness of various policy/acts concerning urban wetland development and conservation and how they influence development around the dam? Fill the table with Yes or No

Act/Policy	Awareness	Influence on Development	Probe, if yes, on how it influence development around the dam?
Physical planning act			
EMCA(EIA)			
Water Act			
Agriculture Act			
Other.....			

7. Do the relevant institutions (NCC, NEMA, WRMA and other relevant institutions) approve and control development around the dam?

Yes No

If yes what measures and development tools do they employ?

8. Mechanism of Liquid and solid waste disposal

a) How do you dispose your solid waste?	b) How do you get rid of your liquid waste and fecal waste?
<input type="checkbox"/> In the river/dam	<input type="checkbox"/> in the river/dam
<input type="checkbox"/> In Garbage bags	<input type="checkbox"/> Established sewer lines
<input type="checkbox"/> In open garbage pits [<input type="checkbox"/> Pit latrines
<input type="checkbox"/> Other Specify	<input type="checkbox"/> Other Specify.....

Section 3: Past strategies and Feasible Alternatives

9. Are you aware of these previous attempt, if yes was there community involvement and at what stage?

Previous Attempts	Awareness (No or Yes)	Involvement (No or Yes)	Stage of involvement (Plans, Activities or Both)
Nairobi Dam Trust initiative by Moody Awori			
Nairobi River Clean up initiative by Mutula Kilonzo			
Kazi kwa Vijana initiative by Raila Odinga			
Dam Restoration Taskforce initiatives by Evans Kidero			

10. If involved above, Can you please probe on the activities and programs if either they were initiated or not by the previous restoration efforts in relation to their objectives? In your opinion, how would you rank the benefits or not of previous restoration efforts project in order of importance (1= Very poor,2 poor,3 Good, 4 Very Good , 5 Excellent)

Activities	Initiated (No /Yes)	Probe
Provision of alternative economic facilities/livelihoods(access to alternative opportunities)		
Slum upgrading(Houses built)		
Waste infrastructure provision(Access to basic services)		
Wetland Environmental Quality (Removal of hyacinth)		
Community mobilization(no of youths & women groups formed)		
Restoration of the riparian Reserve(Demolition of buildings on riparian reserve)		
Other..		

11. How effective do you think these approaches applied by these agencies in restoration and management of Nairobi dam been so far? Would you say they have been;

Effective Ineffective

12. If ineffective, which of the following are possible reasons for the failure? Rank them where 1 represent prime reason, 2 average reasons, 3 least reasons

- Inadequate funding
- Lack of good- will and support from local residents
- Lack of harmonized approach to forge common conservation strategies
- Ineffective conservation monitoring and enforcement programs
- Inadequate sensitization and conservation education
- Other possible reasons

13. Do you think it is possible to reclaim the riparian zone hence the successful restoration and management of Management of Nairobi dam and its rivers, given the presence of a section of slum in the riparian reserve?

1. Yes 2. Not sure 3. No

14. If Alternative restoration mitigation measures is initiated. Which of the following alternative measures will you support? Rank them where 1 represent most preferred, 2 average preferred, 3 least preferred

- Alternative solid and liquid waste management infrastructure provision
- Reclamation of the riparian reserve and provision of Supportive Infrastructure to act as buffer for sustainable utilization of the dam
- Incorporation of community driven restoration initiatives
- Provision of Alternative eco-friendly Livelihoods for sustainable Dam utilization
- Education and sensitization on conservation of wetlands
- slum upgrading
- Mandatory evacuation of household to allow for successful restoration of the dam
- Conversion of the dam into more better economic Activities (Decommissioning)

University of Nairobi
School of the Built Environment
Department of Architecture and Building Sciences

INTERVIEW GUIDE FOR Pro-restoration pressure groups,NEMA,WRA,NCC

This Interview guide is intended to gather data geared towards assisting Nelson Mandela Oude, a Masters Student in the School of the Built Environment, University of Nairobi for his Research Thesis titled: — Management Strategies for Restoration of Nairobi Dam”

1. What initiatives have been tried in the past and present to rehabilitate the dam?
.....
.....
.....
2. Why did the fail?
.....
.....
.....
3. What activities in your opinion should be stopped in order to preserve the Dam?
.....
.....
.....
4. What activities should continue in order to preserve the dam?
.....
.....
.....
5. What potential opportunities and benefits can the city derive from clean and healthy Nairobi dam?
.....
.....
.....
6. If you could propose new strategies that the government and other organizations could put in place to rehabilitate the dam, what would they be?
.....
.....
.....