

# Water Resource in Kenya: Impact of Climate Change/Urbanization

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**Abstract-** Climate change is a major concern worldwide. The combination of climate change, rapid urbanization, industrialization, population growth, and low environmental awareness poses a major threat to Kenya's valuable water resources, which are important to the country's ecosystem. There is an urgent need to monitor and assess these resources, as this information is indispensable for sustainable decision-making and water resources management. The paper seeks to highlight the impacts of climate change and urbanization in Kenya and the strategies being implemented by the Government to mitigate or reduce these impacts as well as provide suggests for future solutions.

**Index Terms-** Climate Change, Water Resources, Urbanization, Catchment Area.

## I. INTRODUCTION

Kenya is a country located in East Africa and covers a total surface area of approximately 580,000 km<sup>2</sup> with an estimated population of 47.2 Million people. The climate in the country changes from tropical along the coast to arid in the interior. Kenya is classified as a water scarce country whose surface water resources cover only two percent of its total surface area Per capita available water is about 650 m<sup>3</sup>/year, future projections show that by 2025, per capita water availability will drop to 235 m<sup>3</sup> as a result of population growth. The bulk of Kenya's renewable water resources are derived from an average annual rainfall volume of 322.77 billion cubic meters. Nairobi is the capital city of Kenya and like many urban towns it is experiencing serious population growth straining the already scare natural resources. There is need to manage the current resources for a sustainable future.

## II. EFFECTS OF URBANIZATION ON WATER RESOURCE MANAGEMENT

### a. Population growth

Nairobi city is the capital of Kenya, the City has grown over the last 100 years from a settlement of 25km<sup>2</sup> to the current settlement of 684km<sup>2</sup> with an estimated population of 3.5 million Kenyans in 2012 this figure is projected to rise to 6.4 Million people by 2035. According to Athi Water services [1] investments in water supply infrastructure has lagged behind citing the third Nairobi water supply projection in 1994 as the most recent investment in water infrastructure. At the moment the demand for water in Nairobi city outstrip supply with a demand deficit of 170,000m<sup>3</sup> per day and the figure is expected to rise to 280,000m<sup>3</sup> per day by 2017 and 970,000m<sup>3</sup> per day in 2035. Currently 65% of the city population receives safe and adequate water while the remaining 35% are either underserved or receive no water supply at all[1].

The main source of water supply for Nairobi is the Eastern Aberdare Rivers within the protected Aberdare Conservation Area which includes the Aberdare National Park and the Forest Reserves that surround the National Park. The total water supplied to Nairobi City currently is 580,000m<sup>3</sup> per day against a demand of 750,00m<sup>3</sup> per day. In an effort to meet the current demand the Government has embarked on a project whose main objective is to increase water supply in Nairobi County by 121,000m<sup>3</sup> per day. The Northern Collector Tunnel is a project that seeks to improve water supply to Nairobi, Kiambu and Muranga Counties. The project will cost an estimated 6.8 billion Kenyan shillings. The Northern Collector Tunnel will divert defined flood flows from rivers

Maragua, Gikinge and Irati into Thika dam where both raw and filtered water will be transmitted into pipelines up to Kabete Treatment plant. The 11.8km that is 3m diameter pipeline will pass through critical natural habitats, protected areas, natural forests and densely populated areas; This has raised concerns from residents of Muranga county and politicians across board with the team highlighting that there is a possibility of the rivers running dry and they serve the main economic activity of the residents of Muranga county i.e. Farming. The project is part of Government's Water Master Plan of 2012-2035 to be implemented by the Board in five phases[2].

### b. Development of Informal Settlements

Another major impact of urbanization is the growth of informal settlements in the country and especially in the city. An example is Kibera, an informal settlement in Nairobi City which is home to 170,070 people according to a census held in 2009 by the Government.

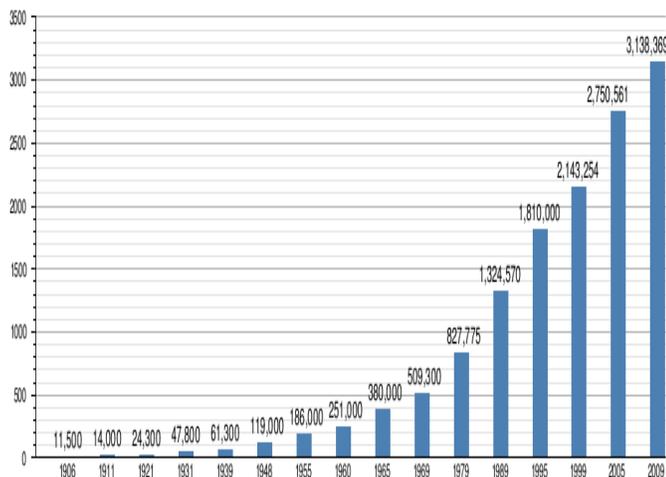


Figure 1: Population in Nairobi (in thousands)

Most of the residents in these informal settlements live in extreme poverty earning less than \$1.00 per day and unemployment rate is high. One of the challenges of managing water resource in informal settlements is the illegal connection to main supply lines often leading to contamination of treated water and disruption of supply in some areas within the city.

The water service provider has partnered with other organizations such as the World Bank to aid water connection in informal settlements through giving

affordable and subsidized loans for informal settlement residents. The residents also receive water at subsidized rates and are provided with water kiosks and water automatic teller machines. Other than providing affordable water the Government initiated a clearance program to replace the informal settlements such as Kibera with residential districts of high rise apartments.

### c. Water Pollution

Industrialization of the city of Nairobi has brought with it certain challenges to water resource management one of the major challenges is water pollution. Athi Water services Board highlighted the major water pollution challenges in the city of Nairobi as pollution from raw sewage which is overflowing from blocked or collapsed sewers as well as from filled up septic tanks and pit latrines, continued contamination of the aquatic environment by discharge of untreated or inadequately treated effluent from Dandora wastewater treatment plant, restricted access to waterborne sanitation for the population in informal settlements within Nairobi, continued menace of raw sewage flowing in open drains and continued accumulation of persistent contaminants in the environment[1].

Kenyan in the rural areas use wells for domestic water and pit latrines that are usually near the wells. This poses a threat because there is the likelihood of microorganisms traveling from the nearby pit latrines to the wells. The wells should be placed in elevated areas that is at least 2 meters above the water table and at least 15 meters from pit latrines, which is not the case in most overcrowded urban informal settlements [3]. A case study undertaken [4] provided an explanation for the severe contamination of drinking water in Kenya. The results indicated that contamination is largely as a result of the close distance between pit latrines and wells.

This cross-sectional study involved 192 respondents from Langas slum, Kenya. The Research made use of forty water samples that were checked for coliforms, thirty-one of the samples were from shallow wells while four were from deep wells and the remaining five were collected from taps. The study indicated that about 91% of informal settlements used wells as the

main source of water for domestic use while the rest use tap water. It was also noted that majority of informal settlers used pit latrines while thirty percent of children emit in open fields.

As indicated in the table below, the problem is that many wells were very close to the pit latrines. Out of 175 wells, about 39 percent of the wells were less than 15 meters from the latrines, about 59 percent were located within 15 and 30 meters and only about 3 percent were located 30 meters or more to pit latrines. All the samples taken from shallow wells were positive for total coliforms, which is fecal contamination. Three out of four samples taken from the deep wells were contaminated and none of the tap water samples were contaminated. From the extract below [4][3] it is clear that the growth of urban informal settlements have contributed to contamination of water.

Distance	Number	Perce
1-15 m	67	38.3
15-30 m	103	58.9
30 m and above	5	2.9
Total	175*	100

Source: [4]

Other reasons that were cited [4] as causes of water pollution in informal settlement include; children dipping dirty objects into water sources 34%, drawing water from the source using dirty containers 27%, domestic animals excreting around water sources 19% and people washing clothes at the water source 5%. The study concluded that water in langas slum / informal settlement was unsafe for human consumption. Langas informal settlement is a replica of water contamination in the various informal settlements in Nairobi which have grown as a result of urbanization.

#### d. Water Rationing

Currently the city of Nairobi is among the towns in Kenya that are under a water rationing program. The total water supplied to Nairobi City at the moment is 580,000m<sup>3</sup> per day against a demand of 750,00m<sup>3</sup> per day this has led to introduction of water rationing programs. The rationing program is also taking place in other towns in Kenya such as Nakuru and Meru

who recently announced that they were engaging in a water rationing program because of low water levels in their reservoirs and the need to ensure distribution of water is done equitably. Other than reduction in the amount of water in catchment areas increasing population has also led to rationing as a temporary water management strategy but this will not be sustainable there is need to manage both population growth and at the same time source more water for the urban areas.

#### e. Solid Waste

Another major challenge in the city in relation to water resource management has been pollution by solid waste disposal into water bodies; Industrialization has led to increase in population which has increased consumption leading to an increase of waste in the city. Garbage dumping in Nairobi's surface waters is common especially where it passes through informal settlements, case in point is the Nairobi River which not only navigates through informal settlements but also through the infamous Dandora dumpsite where all waste from the city of Nairobi is dumped. This has posed a great challenge when it comes to water resource management in the city of Nairobi. During rainy season manmade floods occur as a result of blockage of storm water drainage systems by solid waste materials such as plastic bags, this leads to pollution of surface waters as the storm water carries all solid waste matter along its course into receiving waters.

#### f. Destruction of Catchment Areas

Rampant urbanization and pressure for land and resources are pushing up against the forest boundaries. Encroachment and land grabbing is affecting water resource management in Kenya. A good example is the encroachment of Mau forest which is a Major water catchment area. The forest has witnessed serious deforestation over the years leading to reduction in precipitation which results to reduced water supply. Poor land-use activities; characterized by deforestation and clearance of bushes and other vegetation is the major cause of catchment degradation. Cultivation on steep slopes without applying soil conservation measures promotes soil erosion and rapid generation of surface runoff [11]. Vegetation cover is essential since it retards the flow of surface run-offs, thus encouraging more water to infiltrate into the soil and replenish soil moisture. The

recharge of ground-water aquifers also takes place through infiltration and deep percolation of rainwater. Other causes of the degradation of catchment areas include poor construction of roads and footpaths, which are sources of sediments carried by the surface run-off to river channels. Lack of effective urban planning mechanisms promotes development of informal settlements and other residential structures, which discharge Sewage and domestic wastewater into river channels and all this is escalated by occurrence of floods creating more challenges for water resource management[12].

#### g. Non- Revenue Water

As at 2014 Non-revenue water in Kenya was estimated to be at 42%. This indicates that nearly half of water treated after production is unaccounted for. Illegal connections to the distribution system have been a major challenge for water service providers in the country, the illegal connections have also been attributed to increasing urban population and decreasing water supply. Athi water services Board is in the process of facilitating rehabilitation of the water distribution system to be able to mitigate such connections and account for any technical losses incurred during distribution.

### III. EFFECTS OF CLIMATE CHANGE ON WATER RESOURCES

#### a. Drought

Over the past decade Kenya has experienced severe drought. Global warming is one critical factor that has prolonged the drought and as a result, millions of Kenyans are unable to grow their crops and keep their livestock alive[3]. The drought has affected water resources in Kenya and this was experienced and declared national disasters in the years January 1997, December 2000, March to June 2004 and December 2005. This indicates that in the last decade alone there have been four cases of major food crisis all as a result of drought. This is as a result of climate change and has posed a challenge by reducing the amount of water resources that are already scarce.

In 2009 the dry season was longer than usual and the Thika Dam reservoir which is the main source of water for Nairobi residents with a storage capacity of 70m cubic meters, held only 26m cubic meters of

water at the height of the drought. Environmentalists attributed the low water levels not only to the failed rains that is climate change, but also to the destruction of forests in the Aberdare range leading to erosion which reduced the storage capacity of the reservoir. The Nairobi water utility drilled emergency wells during the drought and connected them to the piped network, this meant that the company reverted to relying on ground water after phasing it out a decade ago.

According to the Food and Agriculture Organization, Kenya is set to experience more dry weather in the first quarter of 2017 [5]. An estimated 1.3 million people are likely to go hungry as a result of crop failure, loss of livestock and lack of fresh water. This has been attributed to total failure of short rains which normally occur between November and December. This has led to the decision by the government to agree to the first of many desalination projects along the Kenyan coast to provide water for the coastal communities.[6] The desalination project will produce 10,000 litres of drinking water a day to serve about 3,500 people in Lamu County. Climate change in Kenya has led to droughts, case in point is in Lamu County which solely relies on rain water harvesting because it's residence lack local freshwater sources such as rivers or natural wells. Water that had been stored during past rainy seasons is quickly running out of stock hence the need to source for water from the ocean.

#### b. Floods

Floods and droughts are associated with extreme climate events. In contradiction, the country has also suffered from floods and droughts. Most parts of Kenya have two rainy seasons, March to May (long rains) and October to November (short rains) with the intensity of these rains having increased recently due to increased climate variability. In addition to annual local floods, the country experienced major floods in 1961 and in 1997/1998[7]. Floods can occur at any time, but weather/climate patterns have a strong influence on when and where floods occur[8]. The land management practices in the upper catchments may also contribute to the enhancement of surface water run-off and flooding and an unplanned human occupation in the lowland can also enhance the damages due to flooding.

During April and May 2003, Budalangi in Western Kenya experienced flooding at the lower Nyando River basin[9]. The heavy rains led to water supply disruption in urban and rural centers and washing away of river gauging facilities constructed along the rivers. After the April / May 2003 flooding it was evident that the Nyando River flooded downstream breaching the dykes of both Nzoia and Nyando river. Washing away of data loggers, water-level recorders, river gauging structures and bridges, affecting communication and flow monitoring activities in the field[10].

#### IV. CONCLUSION

Climate Change and urbanization are major considerations for water resource management in Kenya. The change in climate could lead to floods or even drought depending on the area in the country. Recently, the country has experienced floods which affected distribution of water supply within the city of Nairobi due to interference and even destruction of certain parts of the distribution system; on the other hand, droughts have led to reduction of water levels in the various water reservoirs resulting to a reduction in water supply straining the current water rationing program in place. Urbanization is also stretching water resource management by increasing water demand. The growth of informal settlements has led to an increase in water pollution through various human activities as a result of poor sanitation and discharge of raw waste into water bodies from various non-point sources in the informal settlements. The Kenyan Government has initiated several projects to mitigate these impacts or reduce their effects such as the northern collector to provide more water for Nairobi residents, implementation of county government to develop each county and devolution of resources to mitigate rural urban migration controlling population growth in Nairobi city and clearance of informal settlements by building affordable residential apartments for people living in the informal settlements. It is time Kenya viewed waste as a resource thus recycling, re-using and recovering solid waste promoting a circular economy. There is need to mitigate climate change through conservation and preservation of the environment and managing the rate of urbanization through proper policies that will safeguard the ecosystem.

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