# Emphasising Ecosystems Elevating People (3ep)

## Ngong River Basin

## Assessment Report

**Prepared by**

**Kounkuey Design Initiative and UN-Habitat**

# TABLE OF CONTENTS

**Glossary of Terms and Concepts**

***Adaptive Capacity*** The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (Millennium Ecosystem Assessment, 2005)

***Biochemical Oxygen Demand (BOD)*** The amount of oxygen demanded by microorganisms in wastewater for the decomposition of biodegradable matter under aerobic conditions

***Biodiversity*** The variability among living organisms from terrestrial, marine, and other ecosystems. Biodiversity includes variability at the genetic,species, and ecosystem levels[1]

***Chemical Oxygen Demand (COD)*** The amount of oxygen that is required for chemical oxidation of the organic and inorganic chemicals present in the wastewater

***Climate Change*** A long term shift in global or regional climate patterns[2]

***Climate Change Mitigation*** A human intervention to reduce emissions or enhance the sinks of greenhouse gases

***Climate Change Adaptation*** In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effect

***Ecosystem*** Total sum of all interactions/interconnections that occur among living organisms and their non-living environment in a given space at a given time[3]

***Ecosystem based Adaptation (EbA)*** The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change [4]

***Ecosystem Services*** The benefits people obtain from ecosystems. These can be grouped into provisioning, regulating, supporting and cultural services (Millennium Ecosystem Assessment, 2005)

***Eutrophication*** Over-enrichment of water by nutrients such as nitrogen and phosphorus. It is one of the leading causes of water quality impairment. The two most acute symptoms of eutrophication are hypoxia (or oxygen depletion) and harmful algal blooms[5]

***Hazard*** The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage

---

[1] Heywood, V. H. (Ed.). (1995). Global Biodiversity Assessment. Cambridge, UK: Cambridge University Press and Millennium Ecosystem Assessment (MEA). (2005). Ecosystems and human well-being: Synthesis. Washington, DC: Island Press.

[2] Intergovernmental Panel on Climate Change (IPCC). (2018). Annex I: Glossary [Matthews, J.B.R. (Ed.)]. In Global warming of 1.5°C: An IPCC special report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. https://doi.org/10.1017/9781009157940.008

3 Convention on Biological Diversity. (1992). Convention on Biological Diversity. Retrieved from https://www.cbd.int/doc/legal/cbd-en.pdf (Accessed: [03/06/23])

4 International Institute for Environment and Development (IIED). (n.d.). Ecosystem-based approaches to climate change adaptation. Retrieved from https://www.iied.org/ecosystem-based-approaches-climate-change-adaptation (Accessed: [03/06/23])

5 Intergovernmental Panel on Climate Change (IPCC). (2014). Annex II: Glossary. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Working Group II Contribution to the Fifth Assessment Report). Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf (Accessed: [03/06/23])

and loss to property, infrastructure, livelihoods,service provision, ecosystems, and environmental resources[6]

***Nature based Solutions (NbS)*** Actions to protect, sustainably manage and restore natural and modified ecosystems in ways that address societal challenges effectively and adaptively, to provide both human well-being and biodiversity benefits (IUCN, 2020). It is an umbrella term for a range of nature-based approaches, including Ecosystem-based Adaptation[7]

***River Recovery Capacity*** The trajectory of change a river takes towards an improved condition. In geomorphic terms this includes improvement in both the physical structure and function of a river[8]

***Risks*** The potential for adverse consequences of a climate-related hazard on lives, livelihoods, health and well-being, ecosystems and species, economic, social and cultural assets, services (including ecosystem services), and infrastructure

***Urban Heat Island (UHI)*** The relative warmth of a city compared with surrounding rural areas, associated with changes in runoff, effects on heat retention, and changes in surface albedo

***Turbidity*** A measure of relative clarity of a liquid. Turbidity makes water cloudy or opaque. Material that causes water to be turbid include clay, silt, very tiny inorganic and organic matter, algae, dissolved coloured organic compounds, and plankton and other microscopic organisms[9]

***Vulnerability*** The tendency of a socio-ecological system to be adversely affected[10]

---

[6] Ibid

[7] Intergovernmental Panel on Climate Change (IPCC). (2014). Annex II: Glossary. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Working Group II Contribution to the Fifth Assessment Report). Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf (Accessed: [03/06/24])

[8] Agnew, D., & Fryirs, K. (2022). Identifying corridors of river recovery in coastal NSW, Australia, for use in river management decision support and prioritisation systems. PLoS ONE, 17(6), e0270285. https://doi.org/10.1371/journal.pone.0270285

9 U.S. Geological Survey (USGS). (n.d.). Turbidity and water. Water Science School. Retrieved from https://www.usgs.gov/special-topics/water-science-school/science/turbidity-and-water (Accessed: [10/06/24]

[10] Intergovernmental Panel on Climate Change (IPCC). (2014). Annex II: Glossary. In Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects (Working Group II Contribution to the Fifth Assessment Report). Retrieved from https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-AnnexII_FINAL.pdf (Accessed: [03/06/24])

# Acronyms and Abbreviations

| | |
|---|---|
| 3EP | Emphasising Ecosystems Elevating People |
| AWWDA | Athi Water Works Development Agency |
| BOD | Biochemical Oxygen Demand |
| CAP | Climate Action Plan |
| CBD | Convention on Biological Diversity |
| CIDP | County Integrated Development Plans |
| COD | Chemical Oxygen Demand |
| EbA | Ecosystem based Adaptation |
| EMCA | Environmental Management and Coordination Act |
| GCMs | Global Climate Models |
| GHGs | Greenhouse Gases |
| GPRBA | Global Partnerships for Result-Based Aid |
| JKIA | Jomo Kenyatta International Airport |
| KDI | Kounkuey Design Initiative |
| KEEP | Kenya Electricity Expansion Project |
| KeTRACO | Kenya Electricity Transmission Company |
| MTP | Medium Term Plan |
| NAP | National Adaptation Plan |
| NARSIP | Nairobi River Basin Rehabilitation and Restoration Program: Sewerage Improvement Project |
| NAS | Nairobi Aquifer System |
| NbS | Nature based Solutions |
| NCCAP | National Climate Change Action Plan |
| NCCG | Nairobi City County Government |
| NCWSC | Nairobi City Water and Sewerage Company |
| NDC | Nationally Determined Contributions |
| NDVI | Normalised Difference Vegetation Index |
| NEMA | National Environmental Management Authority |
| NETWAS | Network for Water and Sanitation |
| NMS | Nairobi Metropolitan Services |
| NRBP | Nairobi Rivers Basin Rehabilitation and Restoration Programme |
| NRLP | Nairobi River Life Project |
| NUIPLAN | Nairobi Integrated Urban Development Master Plan |
| NWSEPIP | Nairobi Water and Sewerage Emergency Physical Investment Project |
| SDG | Sustainable Development Goals |
| SSS | Simplified Sewer System |
| UHI | Urban Heat Island |
| UNCED | United Nations Conference on Environment and Development |
| UNEP | United Nations Environment Programme |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNH | United Nations Habitat |
| URRP | Urban River Rehabilitation Programme |
| WRA | Water Resource Authority |
| WRI | World Resource Institute |

# List of figures



# List of maps

# List of tables

# Executive Summary

The Ngong River, one of Nairobi's primary urban waterways, flows through a dense and dynamic landscape shaped by rapid urbanisation, diverse land uses, and growing populations. Once a natural asset supporting ecosystems and communities, the river is now facing acute pressure from unchecked development, pollution, inadequate infrastructure, and the growing impacts of climate change. This assessment offers a comprehensive overview of the river's current condition, identifies the challenges and risks it faces, and outlines potential pathways for restoration, resilience, and more equitable urban development.

The findings reveal a deeply degraded river system, where pollution from industrial discharges, untreated wastewater, and solid waste dumping is commonplace. These pressures have severely compromised water quality and ecological integrity, posing serious risks to both human and environmental health. At the same time, Nairobi is experiencing increasing climate-related stresses. Rising temperatures, more erratic rainfall patterns, and a higher frequency of extreme weather events are already evident, with future projections suggesting these trends will intensify. Vulnerable populations, especially those living in informal settlements along the river, are disproportionately affected, facing recurrent flooding, water contamination, and limited access to essential services.

The governance landscape surrounding the Ngong River is complex and fragmented. Multiple institutions with overlapping mandates operate in parallel, often without coordination, which has made effective regulation and planning extremely difficult. Land use conflicts, weak enforcement, and siloed sectoral approaches further complicate the situation. In addition, the city's spatial and social inequalities are mirrored in the river basin, where low-income communities bear the brunt of environmental hazards while remaining largely excluded from decision-making and planning processes.

Despite these challenges, there are clear opportunities for change. The assessment identifies strong potential to regenerate the river through a combination of nature-based solutions, community-led action, and improved policy alignment. These insights support the goals of the Emphasising People, Elevating People (3EP) project, a collaborative initiative that promotes participatory, ecosystem-based approaches to urban river regeneration. By centring local knowledge and stewardship, enhancing inter-agency coordination, and prioritising interventions that deliver both ecological and social benefits, 3EP provides a viable framework for long-term, sustainable transformation.

To regenerate the Ngong River and reduce risks to both people and ecosystems, Nairobi must invest in integrated, inclusive strategies. This includes scaling green infrastructure, strengthening governance systems, empowering community participation, and aligning urban planning with national and county climate priorities. The regeneration of the Ngong River is not only an environmental necessity, it is also a critical step toward building a safer, healthier, and more resilient Nairobi for all.

# Chapter 1: Introduction

This chapter presents the purpose for this Ngong River assessment, including how the assessment supports work under the 3EP project, including providing a thorough understanding of basin-wide challenges and opportunities for ecosystem-based adaptation approach to river regeneration, and identifying context-specific issues across the 3 nexus neighbourhoods to support planning and catalytic projects implementation.

The sections as well as explains how the assessment informs ongoing city-level river basin regeneration debates, policies and ongoing and planned actions. The key objectives of the assessment, as well as the scope, particularly the spatial scope, are also outlined.

**Background of the assessment**

The Ngong River assessment seeks to inform the broader objectives of the "Emphasising Ecosystems, Elevating People" (3EP) project by providing key insights into the challenges and opportunities for ecosystem-based adaptation (EbA) approaches to river regeneration.

**E**mphasising **E**cosystems, **E**levating **P**eople (3EP) employs a bottom-up approach to the rediscovery, regeneration, and protection of Nairobi's natural assets throughout the river system. In turn 3EP will underpin and activate the Nairobi Rivers Basin Regeneration Programme, a multi-actor, interdisciplinary initiative which aims to reclaim and regenerate Nairobi's three main rivers through public, private and civil society partnerships.

Focused on Ngong River Basin, 3EP demonstrates how EbA principles incorporate scales from neighbourhood to city. Within the city-wide RLP context, 3EP catalyses and integrates basin scale visioning, co-produced settlement 'Rivers + People' plans, and builds tangible community-driven climate adaptations into the most challenging urban river corridors.

Therefore, to effectively achieve this, one needs to start from a point of knowledge, ensuring a comprehensive understanding of the specific environmental, social, and economic dynamics within the Ngong River Basin. This foundational knowledge will guide the identification of targeted interventions, facilitate stakeholder engagement, and support the development of sustainable and resilient adaptation strategies.

**Purpose, Objectives and Scope of the Assessment**

**a. Purpose**

The purpose of the Ngong River assessment is to support the "Emphasising Ecosystems, Elevating People" (3EP) project by providing a thorough understanding of the challenges and opportunities by identifying context-specific issues along the Ngong River to support planning and the implementation of catalytic projects.

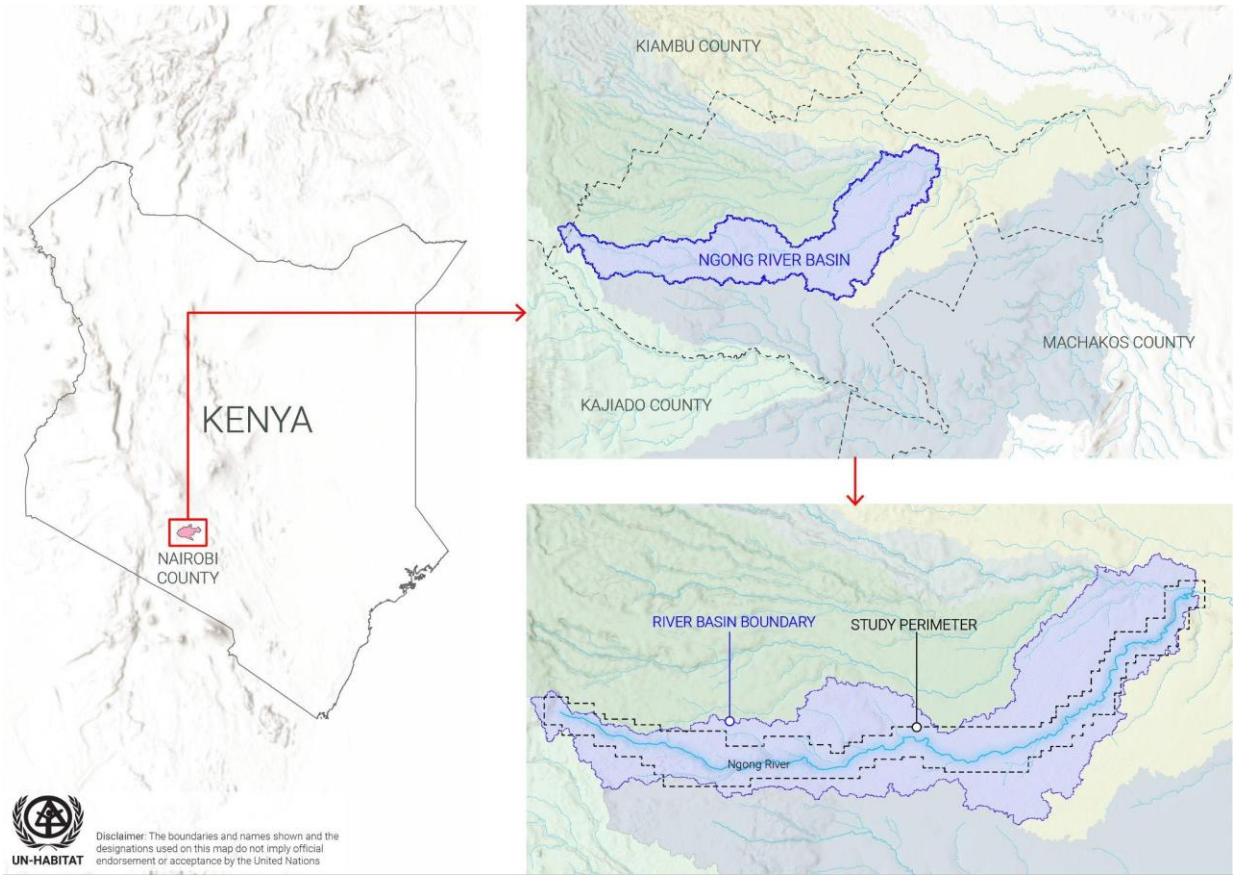
**b. Objectives**

The overall aim of the project is to rediscover and regenerate Nairobi's natural assets throughout Nairobi's river system with focus on the Ngong River Basin to reduce climate risks, increase

biodiversity, and enhance resident's climate change and socio- economic resilience.

### c. Scope

The assessment covers the Ngong River Basin, which is part of the larger Nairobi River Basin. The Ngong River Basin (Figure 1) is bounded by longitudes 36.65oE and 36.89oE and latitudes 1.27oS and 1.34oS




*Map 1: The Ngong River Basin (from Bernard, Olang, Bukachi, Mulligan et al, 2021)*

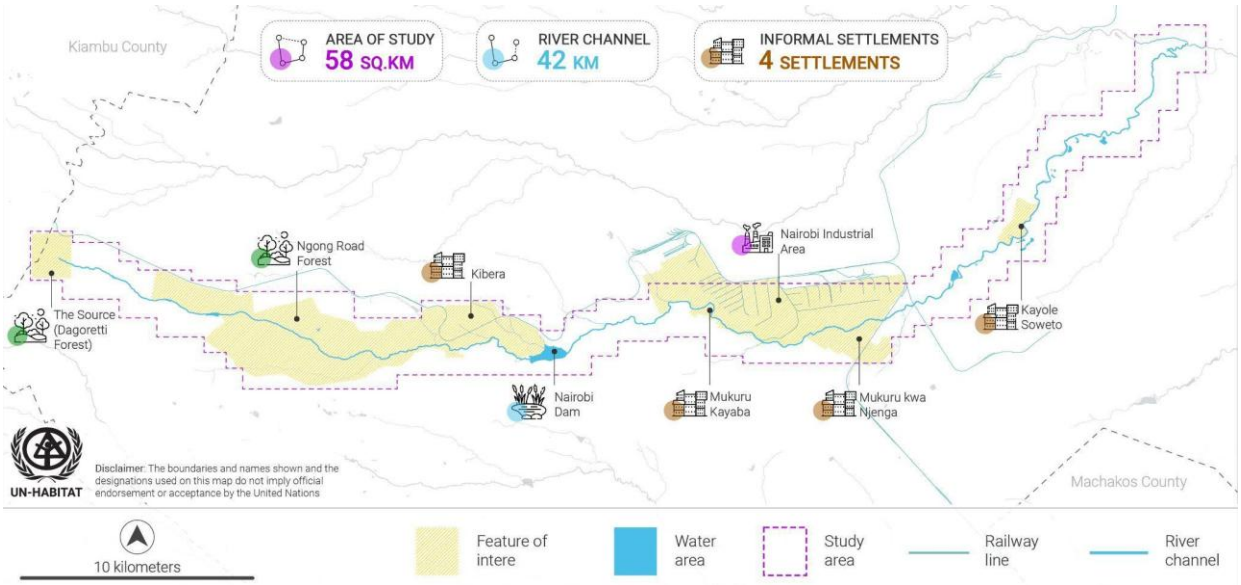
The downstream of the catchment is a floodplain and mostly occupied by the urban poor in the informal settlements. Ngong River is the main perennial river, originating from the Ngong forest and routing through the Kibera, Mukuru, and Kayole-Soweto informal neighbourhoods. These three "nexus neighbourhoods," which make up more than a third of Nairobi's population, are both hubs of innovation and sites of outsized climate risk and unmanaged urbanisation.

The settlements, within which 3EP interventions are planned, have been selected based on the following criteria:

- Position at the confluence of cross-cutting issues
- High impact potential from the intervention, with direct benefits to human safety, biodiversity increase, and natural assets restoration
- Location along the Ngong River, distributed across the transect of the Ngong river as it flows past Nairobi CBD
- Lack of documented efforts in both river ecosystem restoration and sustainable, human

rights-based urban development
- Experience and presence of KDI and the project team
- Alignment with the government's activities (2x SPA & 1 X KISIP)

This spatial assessment focuses on the Ngong River Basin from its source in the Kikuyu highlands and Dagoretti forest to the confluence of the Ngong River with the Nairobi River in the Chokaa neighbourhood in Njiru.




*Map 2: Ngong River characterization © UN Habitat*

An assessment area of 58 square kilometres of the basin has been defined as per the map above. For the purposes of this spatial assessment, a modified study perimeter of between 500 metres to a kilometre on either side of the Ngong River has been defined along its entire 42 kilometre stretch from source to mouth.

At the national and regional level, the spatial assessment in the previous section gives an overview of the major river basins in Kenya, and identifies and maps out the location of the Ngong River sub-basin within the larger Athi River Basin.

The following sections of the spatial assessment provide a detailed description and analysis of the Ngong River Basin, including defining and mapping its various sections, and conducting an analysis of environment conditions and land use activities within the assessment area of the basin, as well as the interactions of the river system, with other systems and human activities, and their outcome.

**Urban growth trajectory of Nairobi**

Africa is urbanising at an astonishing rate - growth that, when unmanaged, drives the loss of natural assets and damages ecosystems. Urban ecosystems are crucial in African cities, where relatively high levels of unemployment and poverty necessitate a reliance on urban natural assets

for the provision of basic services.[11]

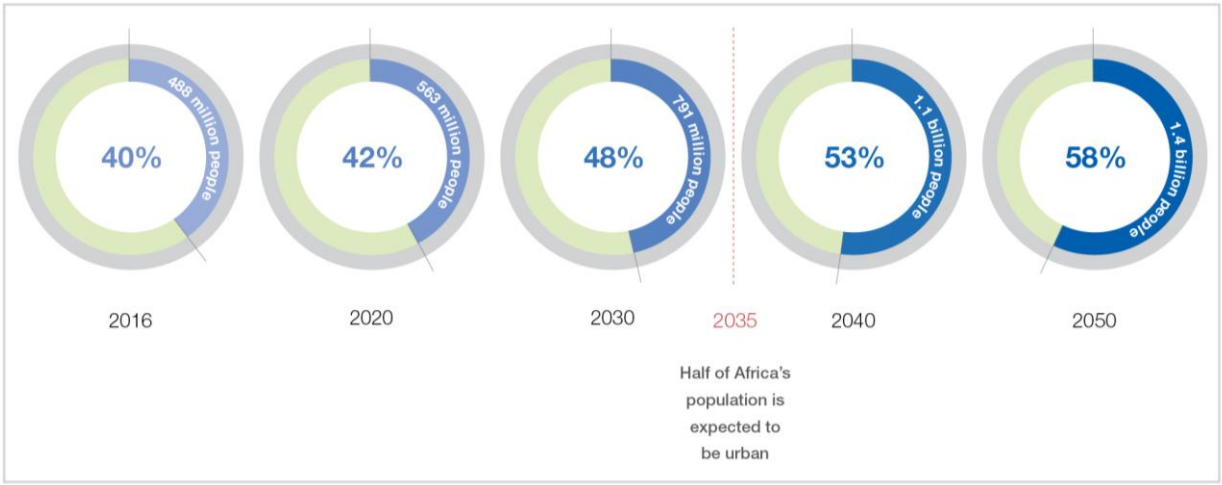



*Figure 1:Africa's urban population growth (2016 - 2050) © United Nations World Urbanization Prospects*

There is a limited window of opportunity to build awareness of the critical role of natural assets in underpinning resilience in African cities. Many advocates for working with residents to demonstrate how urban nature and people can flourish, and to build momentum for mainstreaming an ecosystems approach, thereby spurring innovation in municipal and national policy.

3EP will be delivered in Nairobi County, Kenya, and focuses on the Ngong River Basin, one of the three major river systems in the Nairobi River Basin. A particular challenge in Nairobi is that of river remediation. Flooding disproportionately affects children and the elderly, and women–residents who typically spend more time at home. Other hazards impacting Nairobi include strong winds, hail, landslides, earthquakes, and disease. For residents of informal settlements, these risks are heightened.

In recent years, there has been a dramatic decrease in natural assets across Nairobi and resulting decline in the larger river ecosystem. Studies estimate that the city has lost approximately 20% of its green coverage since 1986, while the rivers have become a noxious mixture of industrial, human, and even medical waste. This degradation, largely resulting from the effects of unplanned urbanisation and unregulated industrial activity, severely impacts the lives of the city's residents and is compounding the effects of climate change on the capital[12].

11 Du Toit, M.J., Cilliers, S.S., Dallimer, M., Goddard, M., Guenat, S. and Cornelius, S.F., 2018. Urban green infrastructure and ecosystem services in sub-Saharan Africa. Landscape and Urban Planning, 180, pp.249-261.
12 Aryampa, S.; Maheshwari, B.; Sabiiti, E.; Bateganya, N.L.; Bukenya, B. Status of Waste Management in the East African Cities: Understanding the Drivers of Waste Generation, Collection and Disposal and Their Impacts on Kampala City's Sustainability. Sustainability 2019, 11, 5523. https://doi.org/10.3390/su11195523

*Figure 2: Flooding in Mukuru settlements © The Star*

**Past and present natural assets**

Nairobi boasts strategic geographic advantages, characterized by a diverse landscape that combines forests and savanna grasslands sloping in the south east direction, with three rivers flowing through it: Ngong River, Mathare River, and Nairobi River. These rivers previously were vital sources of freshwater, sustaining both the natural ecosystem and the city's inhabitants.

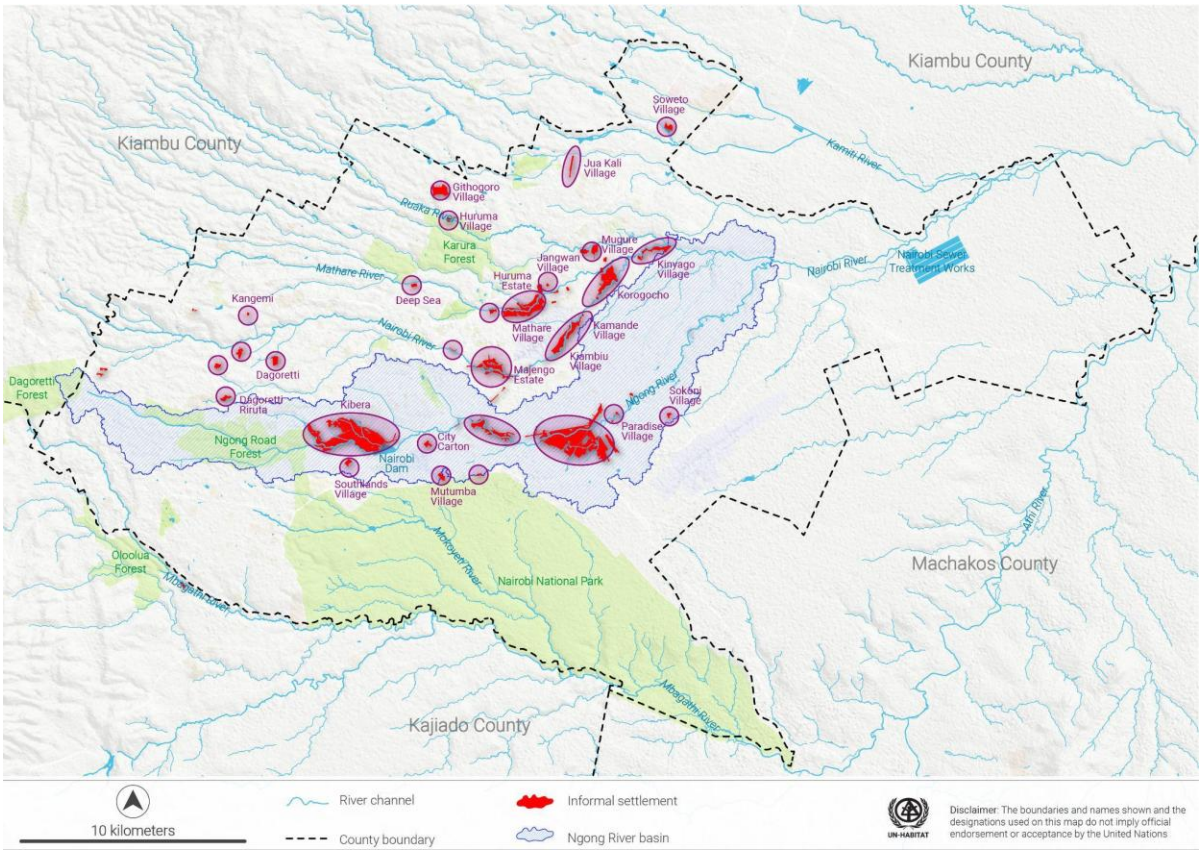
However, similar to the trajectory of many rapidly expanding cities, Nairobi presently neglects its rivers that are currently heavily polluted. The city's rapid growth has led to malevolent encroachment of its rivers by settlements, industries, and agriculture along their banks, resulting in pollution, deforestation, and increased erosion. These rivers have become dumping grounds for industrial and domestic waste, causing severe water quality deterioration. The rivers have turned into open sewers, posing a major health hazard to the city's residents.

However, in recent years, there has been a growing awareness of the importance of reviving Nairobi's rivers. Community-based initiatives, government projects, and environmental organizations have, so far, launched several initiatives, including clean-ups and regeneration efforts.

In 2019, UN Habitat, in collaboration with the Nairobi City County Government, conducted a City-wide public space inventory and assessment, identifying over 800 public spaces, among them green public spaces. However, the majority of the city's formal green public spaces, frequented by the city's residents, are concentrated either in the city centre or distant from residential neighbourhoods. Prominent examples of such spaces include Uhuru Park and Central Park,

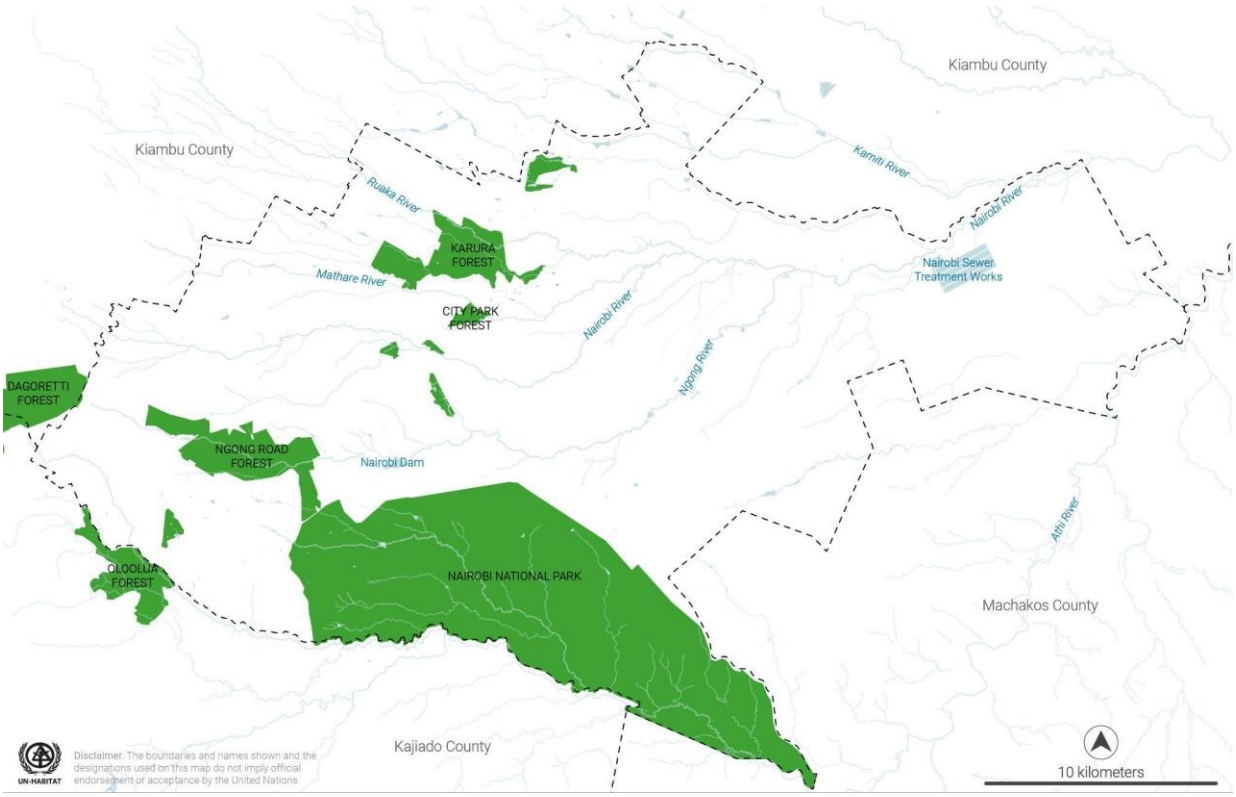
which attract a significant number of visitors, especially during weekends and peak hours.

However, other informal public spaces are quickly spurring along areas such as riverfronts and streets, particularly within the urban neighbourhoods, underscoring the need to rethink the distribution of public spaces in the city.




*Map 3: Location of Informal Settlements Vis a Vis Rivers in Nairobi County © UN Habitat*

The city boasts several natural forests, including the Karura Forest, Nairobi National Park, Ngong Road Forest, Nairobi Arboretum, and John Michuki Park which not only serve as recreational spaces, but also conserve biodiversity, act as the city's carbon sinks and serve as catchment areas for the city's main rivers and their tributaries. However, like the rivers, the city's forests and parks face increased threats from urbanization and deforestation. Land encroachments, illegal logging, and agricultural expansion have diminished the size and health of these green spaces. Pollution and climate change have also taken a toll on their ecosystems, affecting biodiversity and overall ecosystem health.




*Map 4: Nairobi City and the major public green open spaces*

*Figure 3: Uhuru Park, Nairobi (left)[13], Karura Forest, Nairobi (right)[14]*

## Climate Change Impact and Trajectories

Kenyan cities are already grappling with the adverse effects of climate change, including flooding, rising temperatures, the resulting urban heat island effect, and issues related to water availability and quality. Although slightly more than a quarter of the population resides in urban areas, urbanization is rapidly expanding due to a growth rate exceeding four percent. Consequently, cities in Kenya are confronted with substantial challenges, especially in terms of increased flood

13 Friends of Karura Forest. (n.d.). Friends of Karura Forest. Retrieved from https://www.friendsofkarura.org (Accessed: [03/05/24])
14 Wikipedia contributors. (2015). Karura Forest – Image: Karura Forest Nairobi 03.JPG. Wikipedia. Retrieved from https://en.wikipedia.org/wiki/Karura_Forest#/media/File:Karura_Forest_Nairobi_03.JPG (Accessed: [03/05/24])

risk, particularly in flood-prone and low-lying areas.

Nairobi, for instance, faces emerging climate change challenges, particularly in its densely urbanized river areas. In 2010, Nairobi had 2.78 ha of natural forest, extending over 6.8% of its land area. In 2022, it lost 3 ha of natural forest, equivalent to 1.45 kt of $CO_2$ emissions.[15]

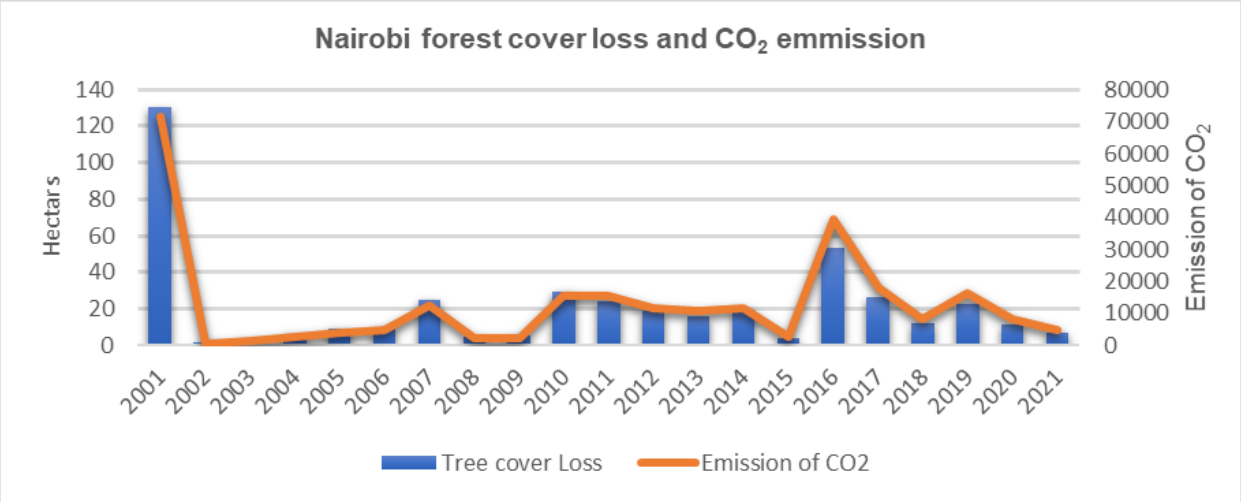



*Figure 4: Forest cover loss and carbon dioxide emission in Nairobi city © Global Forest Watch (2021)*

The current level of urbanization in the basin makes its residents susceptible to climate-related risks, while also projecting a scenario of high carbon emissions, significantly undermining the basin's ability to withstand climate impacts.

Climate models for Nairobi suggest temperature changes of between +0.5°C to +2°C in the next 20 years, and between +2°C to +5°C by 2100. Day heat spells are also projected to increase by +10 to 130 days by 2040 and by a minimum of +60 to 270 days by 2100 (UrbanARK, 2017). Urban heat is increasingly recognised as a major climate risk in Nairobi's dense urban areas, where structures often employ high albedo materials and have limited green space. Additionally, extreme rainfall events are expected to become more frequent, lasting longer and becoming more intense.

According to future climate projections, there is expected to be a 13% to 25% increase in annual precipitation by the end of the century, coupled with a 2 to 3-degree temperature rise. Already, the annual average rainfall has increased by 50%, and when combined with the prevalence of impervious surfaces, there is about a 43% chance of flooding occurring every two years between 1984 and 2016. This projected increase in precipitation will result in more frequent and severe urban flash floods and riverine flooding.


*Figure 5: Effects of increased rainfall in Nairobi, Kenya © Tony Karumba / AFP*

Warmer temperatures will also contribute to a higher occurrence and intensity of heatwaves. The urban heat island (UHI) effect has exacerbated as temperatures rise, primarily due to the use of new construction materials and the proliferation of impervious surfaces. Between 2016 and 2017, Nairobi witnessed a staggering 476.9% increase in areas affected by the UHI effect. The impacts of extreme heat are particularly pronounced in informal settlements in Nairobi, where temperatures regularly surpass those in non-informal areas by several degrees. This is mainly due to the high population density, tin housing, and limited vegetation in these settlements. Studies have further demonstrated a link between extreme heat and increased mortality and morbidity rates in Nairobi's informal settlements.

**Governance and Political Environment**

Over the years, efforts to regenerate the Nairobi rivers were largely decentralized, involving multiple stakeholders with varying degrees of influence and resources. Local governments, community-based organizations, non-governmental organizations (NGOs), and private sector actors all played roles in various initiatives aimed at improving water quality, reducing pollution, and restoring natural habitats. However, the fragmented nature of these efforts often led to overlapping responsibilities, inconsistent policies, and inefficiencies that hampered meaningful progress.

In 2022, recognizing the need for a more coordinated and comprehensive approach, the Kenyan government established the Nairobi Rivers Commission (NRC). The NRC was created to centralize the management and regeneration efforts under the national government's purview, aiming to streamline initiatives and ensure more effective implementation of policies and projects.

This move was intended to overcome the challenges posed by the previously decentralized approach, which often suffered from a lack of coherence and unified direction.

The creation of the NRC marked a significant shift in the governance of the Nairobi Rivers Basin. By bringing various stakeholders under a single regulatory and administrative framework, the NRC seeks to enhance accountability, improve resource allocation, and facilitate better coordination among different actors. This centralized approach is expected to lead to more strategic planning and execution of river rehabilitation projects, ensuring that efforts are not duplicated and that resources are used more efficiently.

*Figure 6: Community engagement during the launch of the Nairobi Rivers Commission in 2023 © The Star*

However, this has also brought to light diverse political interests. The river flows through various settlements, each with its own needs, priorities and political dynamics. These varying interests can sometimes lead to delayed progress and lack of commitment due to poor resource allocation and project prioritization, as well as lack of balance between environmental conservation and development, thus the centralized approach is a significant step towards streamlining the regeneration of the river.

Moreover, the Ngong River's context within Nairobi, a rapidly growing city, adds another layer of complexity. The river is not only a crucial natural resource but also a critical component of the urban ecosystem, influencing public health, sanitation, and urban planning. Political leaders, therefore, have to navigate the competing demands of urban development, environmental sustainability, and social equity. The NRC's mandate to bring these interests into alignment under the national government's umbrella is a challenging task, requiring careful negotiation and collaboration among all stakeholders.

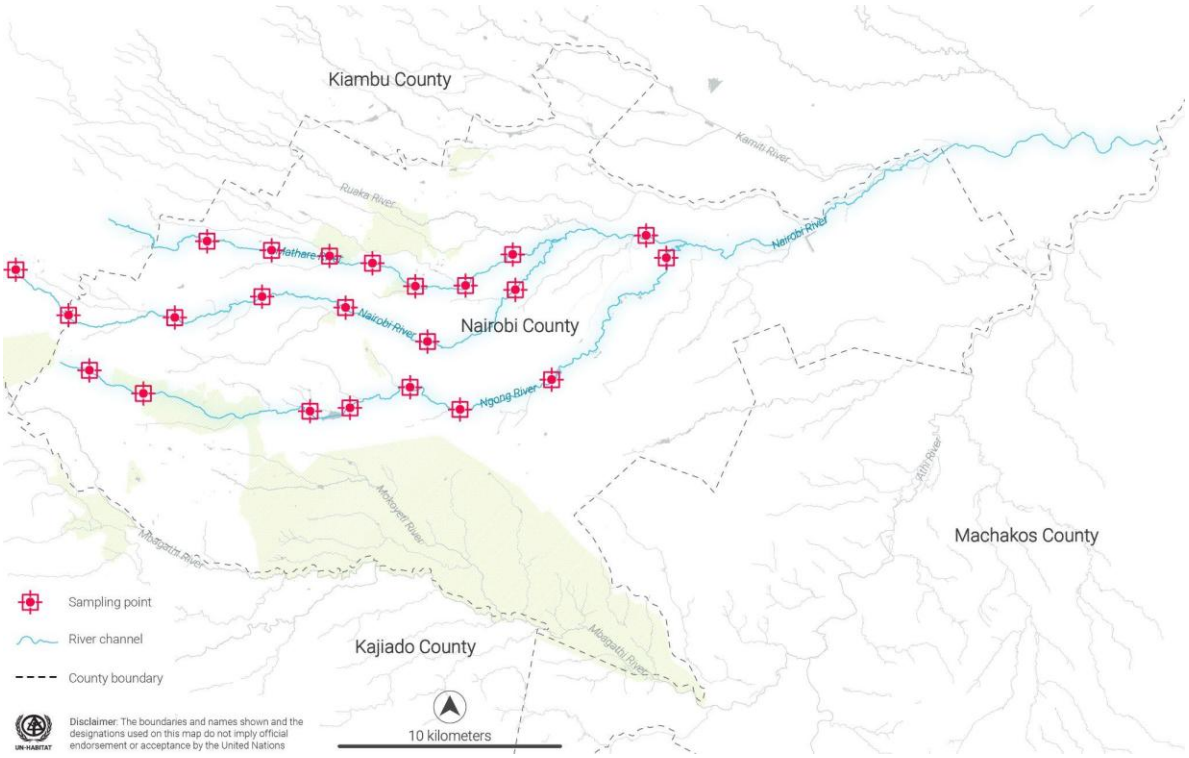
## Previous and on-going river regeneration initiatives

### i. Nairobi Rivers Basin Rehabilitation and Restoration Programme

This programme was initiated to reduce pollution in the Nairobi river basin, and improve the environmental health and quality for people living in the basin. It was implemented under the six sub-components[16] of Assessment and Monitoring, public awareness and education, waste recycling and community managed ablution blocks, micro-enterprise development and construction of wetlands.

Phase I (October 1999 - March 2000)

The initial phase focused on assessing water quality, raising public awareness, and engaging the community through pilot income-generating interventions. Sponsored by UNEP, this phase involved stakeholder capacity building and developing an environmental management information system. The Africa Water Network conducted chemical analyses of water samples from three rivers. Key findings revealed high pollution levels, primarily from raw sewage in informal settlements and industrial discharge. Other sources included burst or blocked sewers, direct industrial effluent release, and solid waste.




*Map 5: Map showing sampling stations of the Nairobi Rivers in Phase 1 © AWN NRBP Phase 1, 2002*

Phase II (June 2001 - December 2003)

The second phase included the Ngong River pilot initiative, which assessed and monitored pollution in the upstream, Nairobi Dam, and downstream sections. It emphasized community education, information sharing, and collaboration between local government, civil society, and

16 University of Nairobi, (). Survey and situational analysis of the biological characteristics of the main tributaries of the Nairobi rivers, reservoirs and wetlands.

the community to restore the Nairobi River Basin's ecological integrity. Baseline data collection was conducted by NETWAS and the Nairobi City Council. Key findings showed that self-purification mechanisms reduced turbidity and pollutants as water passed through dams. However, turbidity and heavy metal concentrations increased downstream of Nairobi Dam, and COD and BOD levels remained high despite some self-purification and dilution.

Phase III (October 2004 - September 2008)

The final phase aimed to achieve the vision of a restored riverine ecosystem with clean water for Nairobi and a healthier environment. It focused on developing environmental management and urban planning systems, restoring the Nairobi Dam, testing water quantity and quality protocols, enhancing public awareness, and improving service delivery and resource conservation. This phase involved UNEP, UNDP, UN-Habitat, five Kenyan government ministries, the private sector, and civil society.

**ii. Adopt a river (Phase I and II)**

The "Adopt a River" initiative, spearheaded by NEMA (National Environmental Management Authority), aims to oversee the preservation and revival of wetlands. This initiative is currently in the pilot phase within the Nairobi River Basin and hinges on active community engagement, particularly involving students from various educational institutions, including high schools, universities, as well as community youth groups and other interested organizations.

Under this program, these participating groups are expected to select a nearby river and take part in its conservation efforts, employing suitable approaches such as monitoring pollution levels. The ultimate goal is to progressively rejuvenate the river and its associated ecosystems.

The primary focus of this initiative currently centres on the upper course of the river. Nevertheless, the intention is to employ the outcomes and experiences gained as a blueprint for expanding this initiative to other geographical regions.

*Figure 7: Community members conducting a river clean up exercise © Gavin Reynolds*

### iii. Nairobi River Basin Rehabilitation and Restoration Program: Sewerage Improvement Project (NARSIP) - Phase 1 and 2

In 2011, the Nairobi County Government, in partnership with the National Government, initiated the Sewerage Improvement Project as a part of the larger Nairobi River Basin Rehabilitation and Restoration Project (NaRSIP). The primary objective of NaRSIP was to address pollution control and waste management, a pivotal strategy within the broader rehabilitation and restoration effort of the Nairobi Rivers Basin. The responsibility for implementing this initiative was entrusted to the Athi Water Services Board.

The project encompassed the riparian zones along the Nairobi River, Mathare River, and Ngong River, and it consisted of three main components: i) Development of wastewater infrastructure, ii) Enhancing sanitation, promoting hygiene, and providing social and environmental support and iii) Strengthening institutional support and project management.

The successful implementation of this project relied on ongoing engagement with stakeholders to revitalize treatment plants, expand infrastructure to support these services, and confront the significant issue of encroachment within the riparian zones. The achievements attained by revitalizing and extending sewerage services in different areas of the city played a vital role in improving the water quality of Nairobi Rivers. This improvement stemmed from the reduction in the discharge of wastewater effluent into the rivers, resulting in a significant decrease in river pollution at the time.


*Figure 8: Construction of sanitation infrastructure along the Eastern Bypass in Nairobi, Kenya © Skyscraper City*

**iv. Urban Rivers Regeneration Programme**

The Urban River Rehabilitation Programme (URRP) was a five-year initiative involving multiple stakeholders, and led by NEMA, focused on rejuvenating urban rivers. Key objectives of this include sustainable solid waste management by establishing waste cycles, promoting waste utilization for income generation, enhancing resource recovery, and reducing landfill waste, including public accessibility to landfill sites. Another priority is safeguarding riparian zones against informal settlement encroachment through clear demarcation and policy enforcement.

Addressing river pollution due to wastewater effluents is crucial. The URRP focuses on maintaining and upgrading sanitation infrastructure, relocating water treatment to industrial parks away from riverbanks, and adhering to Physical Development Plans and Policies, designating zones for informal industries away from rivers.

Enhancing security and accessibility in informal settlements is a significant component, with environmental police involvement to ensure safer living conditions. Public awareness and partnerships are fostered by engaging community groups, schools, and institutions in river restoration, promoting collaboration.

Additionally, the URRP aims to collect research data through automated water monitoring and beautify riverbanks through clean-up and re-vegetation, improving both visual appeal and ecological health of urban waterways in the city.

*Figure 9: River clean-up activities along the Nairobi Rivers Basin © The Star*

**v. Nairobi Rivers Basin Regeneration Programme**

The program, under the leadership of the Nairobi Rivers Commission, has a comprehensive goal of rejuvenating, restoring, and improving the Nairobi Rivers Basin and its associated infrastructure in a unified and all-encompassing manner. This approach is designed to meet the necessary standards for ensuring that everyone can enjoy a safe, inclusive, and healthy environment while unlocking the socio-economic potential of the rivers basin.

The government, through the Nairobi Rivers Basin Commission, is capitalizing on the revitalization of the Nairobi Rivers basin to enhance environmental quality, particularly in congested inner-city neighbourhoods.

Centred on the three primary rivers in the city, namely the Mathare, Ngong, and Nairobi Rivers, this program is envisioned to serve as a model for inclusive regeneration, acting as a catalyst for social, economic, and environmental transformation within the city. Moreover, the program intends to illustrate the value of partnerships involving the public, private sector, and the community, integrated planning and design, the creation of social benefits for residents, innovative approaches, and placemaking in the revitalization of the river, its associated public spaces, and the city as a whole. It also aims to create opportunities for local economic development and an alternative mobility and development corridor, along with a research-driven approach to water quality management.

To achieve these objectives, the Nairobi River Commission, in collaboration with UN-Habitat, UNEP, and WRI, is eager to engage and integrate local and international technical expertise,

collaborate with other agencies and organizations for comprehensive technical and financial support, and involve the community and tap into the city's creative potential to establish a shared vision and awareness regarding the interventions.

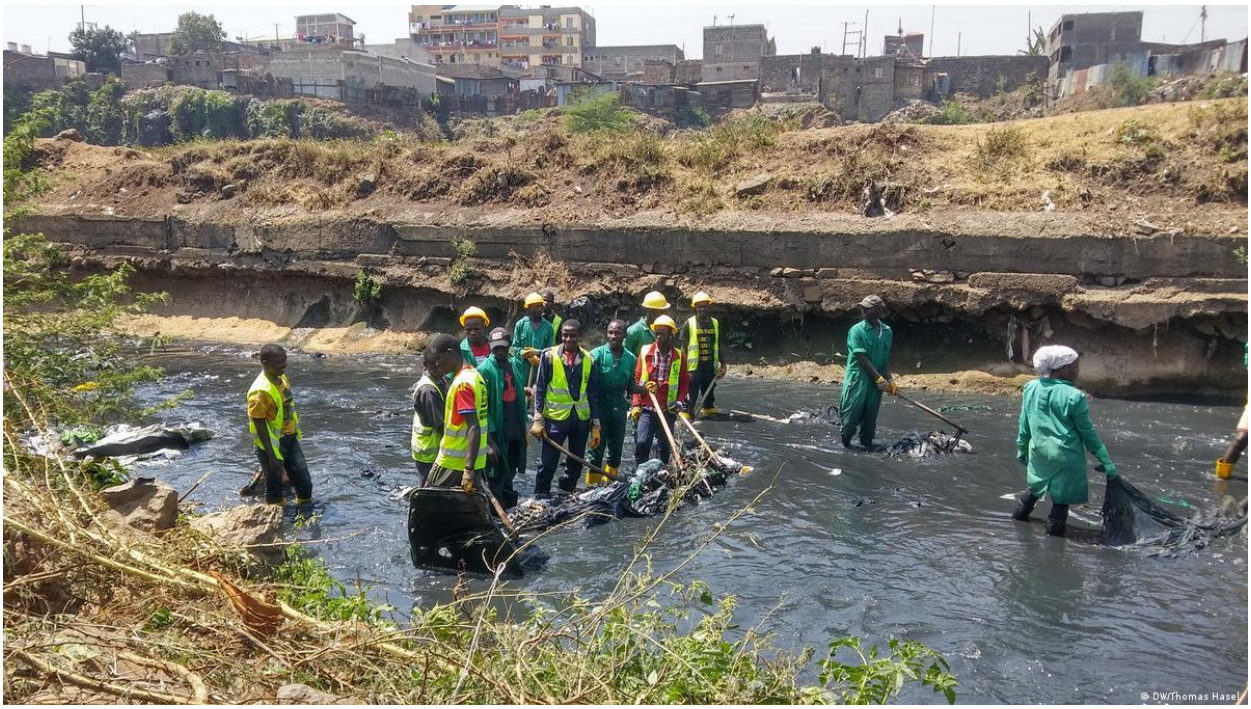



*Figure 10: Community-led River clean up in Korogocho, Nairobi, Kenya © DW*

# Chapter 2: Policy and Institutional Landscape for River Management in Kenya

This chapter provides an outline of the policies that guide, inform and govern river management and concomitant natural assets in urban areas at both global, national, county and local levels. The chapter focuses on particular aspects of the policies of relevance to river regeneration in Kenya and Nairobi, as well as to the 3EP project.

A summary of the institutional framework for river management at both national and subnational scales is also presented in this chapter. The chapter also identifies actions under the 3EP project that align and support achievement of some of the goals and priorities espoused in the presented policies at both global, national and sub-national levels.

## I. Global Policy Agreements and Commitments

Healthy and thriving river ecosystems in cities and urban areas support the achievement of Sustainable Development Goals (SDGs), including SDG 3 on Good Health and Wellbeing, SDG 11 on Sustainable Cities and Communities, SDG 13 on Climate Action and SDG 15 on Life on Land.

Kenya has a commitment and obligation to undertake development in a manner that contributes to achievement of the SDGs, and is also a signatory to various multilateral agreements whose commitments are achieved through national, subnational and local level policy, legal and development actions.

Some of the multilateral agreements that Kenya is party to include the United Nations Framework Convention on Climate Change (UNFCCC), Convention on Biological Diversity (CBD), the Sendai Framework, the Kyoto Protocol and the Paris Agreement.

The UNFCCC aims to prevent dangerous human interference with the climate system.[17] It emphasises the importance of adapting to the impacts of climate change, particularly for vulnerable countries and communities. It promotes strategies and actions to enhance resilience and reduce vulnerability to climate change effects, and brings together governments, stakeholders, and organisations to collaborate on addressing climate challenges, sharing knowledge, and fostering partnerships.

The Kyoto Protocol is an international treaty adopted in 1997 under the UNFCCC. This Protocol recognized the importance of adaptation to the impacts of climate change, particularly in vulnerable developing countries. It established a framework for international climate negotiations and set the stage for the development of the Paris Agreement in 2015, which aimed to enhance and strengthen global climate efforts beyond the Kyoto Protocol.

The Paris Agreement is a landmark international treaty adopted in 2015 under the UNFCCC[18]. It aims to combat climate change and strengthen global responses to its impacts. The Agreement recognizes the importance of adaptation to the impacts of climate change, particularly for vulnerable countries and communities. It encourages countries to develop and implement adaptation plans, strategies, and actions to enhance resilience and reduce vulnerability to climate change effects.

The CBD has three main objectives: conservation of biodiversity, sustainable use of biodiversity and access and benefits sharing[19]. The CBD puts emphasis on the importance of biodiversity for sustaining ecosystems, human well-being, and future generations. It encourages the sustainable use of biodiversity to meet the needs of present and future generations, as well as the integration of biodiversity considerations into broader policies and sectors.

The Sendai Framework aims to reduce the human and economic impacts of disasters and build more resilient societies. It provides a framework for countries to strengthen their disaster risk reduction efforts, enhance preparedness, and work towards sustainable development in the face of growing disaster risks. [20] It promotes risk assessments, data collection, and analysis to identify hazards, vulnerabilities, and exposure, enabling better planning and decision-making to reduce disaster risk.

17 United Nations Framework Convention on Climate Change (UNFCCC). (1992). United Nations Framework Convention on Climate Change. Retrieved from: https://unfccc.int/resource/docs/convkp/conveng.pdf
18 United Nations. (2015). Paris Agreement. Retrieved from: https://unfccc.int/sites/default/files/english_paris_agreement.pdf
19 Convention on Biological Diversity. (1992). Convention on Biological Diversity. Retrieved from: https://www.cbd.int/doc/legal/cbd-en.pdf
20 United Nations International Strategy for Disaster Reduction. (2015). Sendai Framework for Disaster Risk Reduction 2015-2030. Retrieved from https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

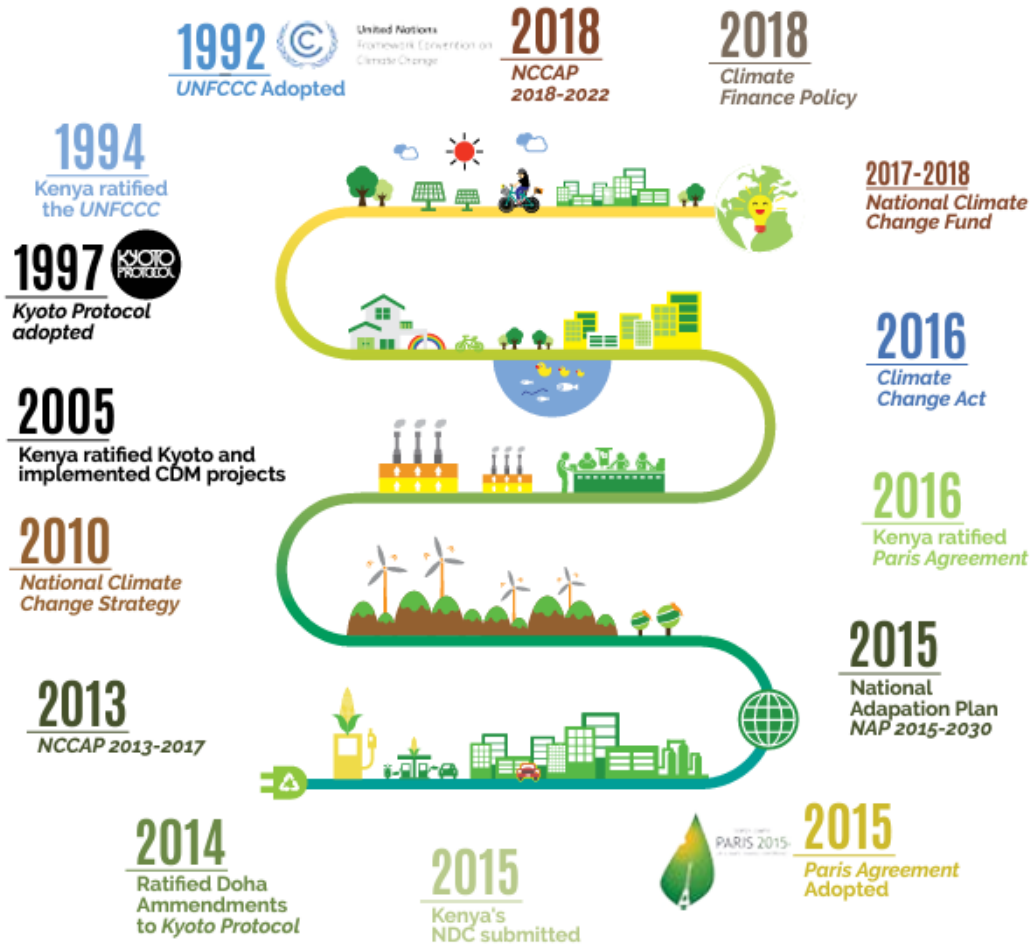



*Figure 11: National Climate Change Action Plan 2018-2022*

## II. National Policy, Action Plans and Legislation

As part of its commitment and contribution to the targets set under the Paris Agreement, Kenya has prioritised mitigation and adaptation actions to be achieved by 2030 under its **Nationally Determined Contributions.** Prioritised mitigation actions include limiting the country's GHG emissions by 32% by 2030, and bearing 21% of the cost of mitigation using local resources. Prioritised mitigation actions also include achieving a tree cover of at least 10% of the total land area of Kenya, scaling up nature-based solutions, and implementation of sustainable waste management systems.

Prioritised adaptation and loss and damage actions include mainstreaming climate change adaptation into the Vision 2030 Medium Term Plans and County Integrated Development Plans, as well as enhancing the adaptive capacity and resilience across economic sectors and uptake of adaptation technology by women, youth and vulnerable groups, including scientific and indigenous knowledge.

Under its Social Pillar, the **Kenya Vision 2030** intends to improve and increase access to safe water and sanitation services through investments in adequate sanitation, hygiene and wastewater management infrastructure, as well as in improving water quality, water availability and protection of water related ecosystems.

The **Medium Term Plan (MTP) IV** prioritises rehabilitation and protection of the water towers, expansion of drainage infrastructure and waste management and pollution control under its social pillar. Conservation and management of forests, as well as harvesting and storage of water through construction of dams, are prioritised under the pillar as well.

The **National Climate Change Action Plan (NCCAP) 2018 - 2022** prioritised management of climate-related disasters, particularly flooding and drought to reduce associated risks to communities and infrastructure. It also prioritised sanitation, health and human settlements to reduce malaria and other disease incidences set to rise due to climate change, encourage climate-resilient buildings, settlements and solid waste management in urban areas.

The Kenya **National Adaptation Plan (NAP) 2015-2030** is the basis of the adaptation component of Kenya's Nationally Determined Contribution, and aims to support attainment of Vision 2030 by enhancing the long term resilience and adaptive capacity of key sectors in Kenya. The National Adaptation Plan identifies and prioritises various adaptation sections across 20 planning and economic sectors. To operationalise each sectoral priority actions, short, medium and long term sub-actions are identified under each.

Mainstreaming climate change adaptation into county integrated development plans and other county plans is a priority action under the NAP. Short term sub-actions under this action include increasing awareness of climate change impacts to communities and counties and building the capacity of county governments on climate change adaptation. The medium term sub-actions include developing county adaptation plans and developing county climate financing mechanisms and tracking systems. The long term sub-actions focus on implementing the county adaptation plans and scaling up successful adaptation actions.

The NAP also has mainstreaming of climate change adaptation in the environment sector as another priority action. Some of the short term sub-actions under this action include enhancing the participatory scenario planning with communities, undertaking climate vulnerability and risk assessment on ecosystems and recommending effective adaptation actions and strengthening tree planning and conservation efforts. The medium term sub-actions include strengthening the capacity of national and county institutions involved in climate change adaptation coordination, while the long term sub-actions focus on integration of ecosystem and community based approaches in sector strategies to support adaptation, and continued rehabilitation of water catchment areas to provide sustainable ecosystem services.

Regarding the use and sustainable management of river ecosystems in Kenya, including their biodiversity and the ecosystem services they provide, the Kenyan Constitution 2010 recognises the right of everyone in Kenya to a clean and healthy environment, and the right to have this right protected for present and future generations.

The Constitution sets out various actions through which the state shall protect this right, including achieving a minimum of 10 percent tree cover of the land area of Kenya, encouraging public participation in environmental management, protection and conservation, as well as eliminating processes and activities endangering the environment.

The Environmental Management and Coordination Act (EMCA) affirms the right of every person in Kenya to a clean and healthy environment, and their duty to safeguard this right. The act recognises rivers, lakes and wetlands as protected areas and prohibits unauthorised activities in

these areas, including excavating or disturbing the river, erecting, extending or placing any structure in the river, and draining the river without an approved EIA licence.

Various regulations exist under the EMCA. The Water Quality Regulation 2006 prohibits anyone from depositing any liquid, solid or gaseous substance in or near a water resource so as to directly or indirectly lead to water pollution.

Sewage treatment and industrial effluent should only be discharged into the aquatic environment where a discharge licence has been issued, and any activities near lakes, rivers and wetlands with an impact on the quantity and quality of water should be preceded with an Environmental Impact Assessment.

EMCA, through the regulations, also prohibits anyone from cultivating or developing within a minimum of 6 metres and maximum of 30 metres of the highest ever recorded flood level on either side of a river or stream.

The now repealed Physical Planning Act of Kenya (Cap 286) required that in subdivision schemes abutting a river, a minimum width of 10 metres of wayleave or reserve be provided on each bank along the river.

The Agriculture Act of Kenya (Cap 318) under its basic land usage rules also provided that no unauthorised activity should occur within 2 metres of a watercourse, or within a distance equal to the width of the watercourse up to a maximum of 30 metres if it is more than 2 metres wide.

## III. National Institutions and Mandates

The Constitution of Kenya 2010 creates various institutions and offices which hold responsibility at the national and county level to protect and promote this right.

These include the offices of the Cabinet Secretary, Secretary to the Cabinet and the Principal Secretary. The Constitution also classifies all rivers, lakes and other water bodies as public land, and creates the National Land Commission, which is the body with the responsibility to manage public land on behalf of national and county governments.

The National Land Commission also holds the responsibility to monitor and conduct oversight over land use planning, as well as conduct research on the use of land and natural resources and develop recommendations on their use and sustainable management.

EMCA gives powers to the Cabinet Secretary under the Ministry of Environment, Climate Change and Forestry to declare a river bank a protected area to protect it from environmental degradation, as well as issue orders, regulations and standards for its management and conservation.

The Cabinet Secretary has power to declare the interests of local communities' residents within a river bank as protected interests. The EMCAalso creates various institutions involved in the governance of the environment, including rivers. These included the National Environment Council and the National Environment Management Authority (NEMA), as well as various committees.

The National Environment Council, provides policy direction, sets national priorities and promotes

cooperation for environmental protection. NEMA coordinates environmental management actions by lead agencies in Kenya. NEMA also publishes guidelines, manuals and codes for the management of the environment, including that of rivers and lakes, conducts inventory of natural resources in Kenya, including on biological diversity, and the threats it faces.

The authority also promotes integration of environmental considerations into policies, plans, programmes and projects. Provincial and district environment committees established under the EMCA enable community participation by decentralising environmental management actions.

Various committees are also established under EMCA, including the National Action Plan Committee which prepares national environmental action plan every five years for national assembly approval, as well as the National Environment Complaints Committee and the Public Complaints Committee involved in receiving and investigating, as well as reporting on environmental degradation issues.

The Water Act 2016 is the principal law for regulation, management and development of water resources, water and sewerage services in Kenya. The Act gives powers to the Cabinet Secretary under the Ministry of Water, Sanitation and Irrigation to formulate a national water resources strategy, as well as establish various institutions, including appointing the chief executive office of the Water Resources Authority (WRA), and establishing a basin water resource committee and water works development agencies, including the Athi Water Works Development Agency, which is one of nine water works development agencies responsible for the development, maintenance and management of water and sewerage infrastructure in the counties of Nairobi, Kiambu and Muranga.

WRA advises the Cabinet Secretary on policy on management and storage of national water resources, as well as flood control. It also develops and enforces standards and regulations for the management and use of water resources and flood mitigation, as well as coordinates with regional, national and international actors for improved regulation of management and use of water resources. The Basin water resources committee manages water resources in their respective basin area.

The Climate Change Act 2016 requires government agencies to include the public by undertaking public awareness when making laws, policies and strategies on climate change, and ensuring their input is part of decisions made.

The Climate Change Act 2016 establishes the National Climate Change Council and the Climate Change Directorate. The National Climate Change Council, which is chaired by the President, sets GHGs emissions regulation targets, gives advice to national and county governments on legislation and policy, approves and oversees implementation of the national climate change action plan, as well as promotes mainstreaming of climate change at national and county government levels.

The Climate Change Directorate is the lead agency in the operationalisation of government national climate change plans and actions. It acts on behalf of the National Climate Change Council and reports to the Cabinet Secretary, Ministry of Environment, Climate Change and Forestry.

The figure below shows the institutional structure for climate change in Kenya as per the Climate

Change Act 2016.

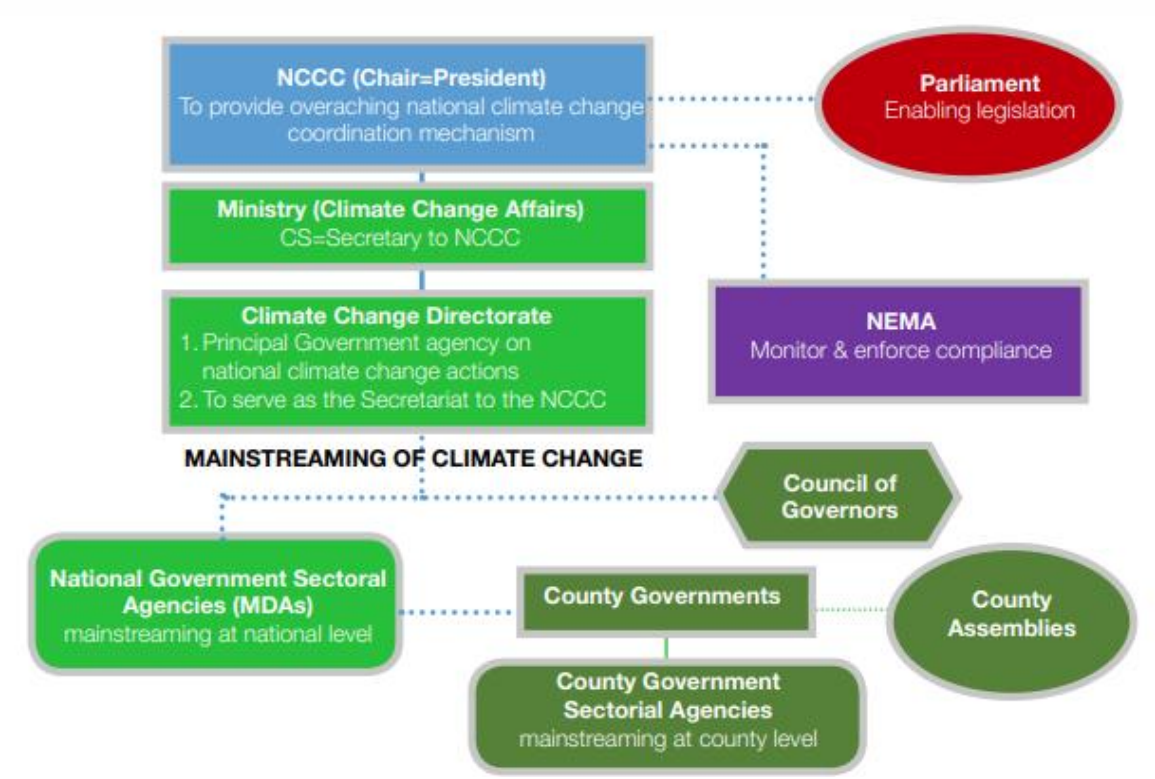



*Figure 12: Kenya National Adaptation Plan 2015 - 2030*

## IV. County Plans and Development Priorities

The Nairobi City County Integrated Development Plan (CIDP) 2023 - 2027 under its environment, water and sanitation sub-sector programmes prioritises improved access to water and sanitation services, including through sewer extension and non sewered sanitation works, catchment protection to ensure increased water resource management, and exploring of rainwater harvesting. The CIDP 2023 - 2027 also prioritises protection of residents of Nairobi from environmental pollution, specifically air pollution.

In the Nairobi Integrated Urban Development Master Plan (NIUPLAN) 16 high priority multi-sector projects to be actualised by 2030 were proposed. Under the environment sector, a river improvement project and sewerage improvement project were identified as among the 16 priority projects. However, both were not prioritised as programmes for implementation. Instead, under the environment sector, NIUPLAN prioritised capacity development for storm water drainage system and capacity development for sewerage system, as well as solid waste management in Nairobi were prioritised.

The Nairobi City County Climate Action Plan (CAP) 2020 - 2050 is the county's strategy to achieve GHG emission reduction targets of the city, and reduce the city residents' vulnerability to climate change. The CAP has identified 11 climate actions cutting across mitigation and adaptation, with supporting actions under each.

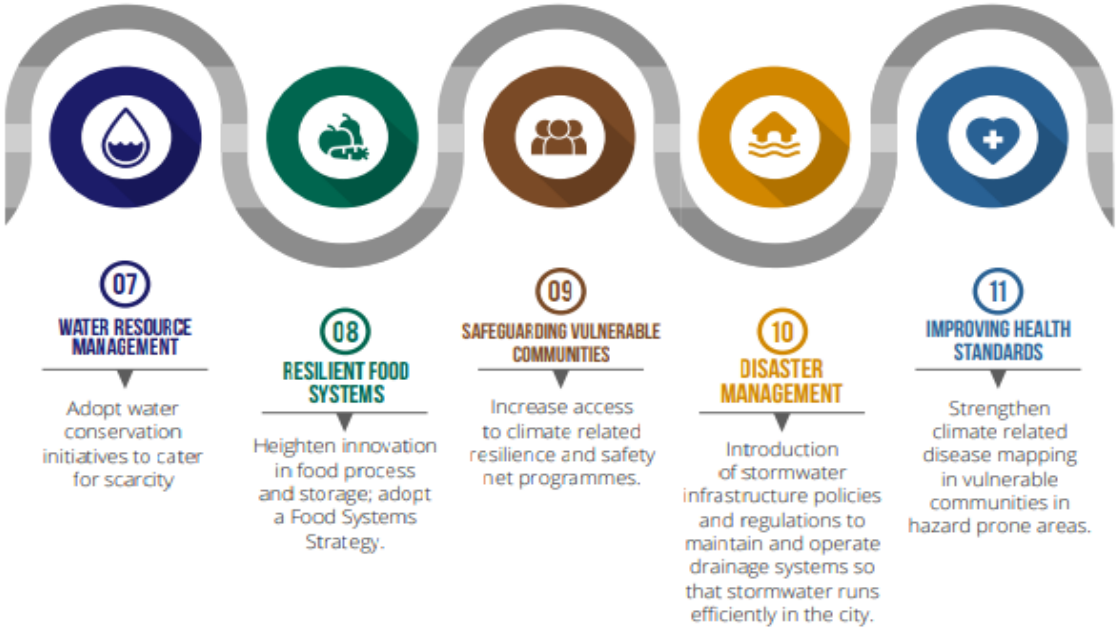



*Figure 13: Nairobi City County Action Plan 2020 - 2050*

These actions include Action 7 on water resource management with supporting actions of adopting water conservation initiatives to cater for scarcity; Action 9 on safeguarding vulnerable communities with the supporting action to increase access to climate related resilience and safety net programmes; Action 10 on disaster management with supporting actions of introducing stormwater infrastructure policies and regulations to maintain and operate drainage systems for efficient stormwater flow in the city; and Action 11 on improving health standards with supporting actions to strengthen climate related disease mapping in vulnerable communities in hazard prone areas.

## V. 3EP in the Global and Local Policy and Legal Context of Climate and River Regeneration

In the context of regeneration, conservation and protection of river ecosystems in Kenya, including the Ngong River Basin, the figure below represents the interplay between the SDGs, other global instruments, and national, county and local level legal and policy actions and priorities for Kenya.

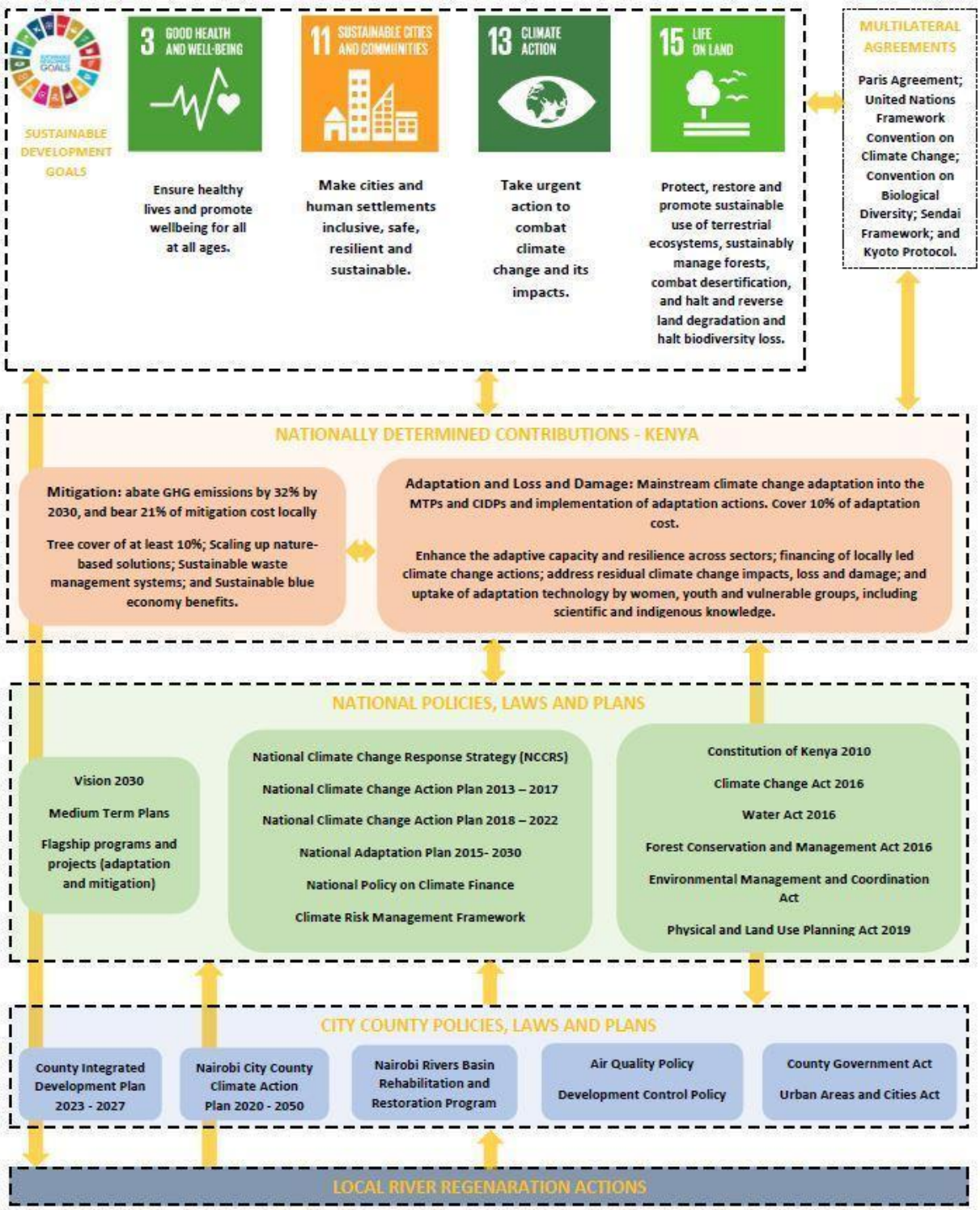



*Figure 14: Policy and Legal Framework by Pascal Mukanga KDI, 2023*

This interrelation underscores the significance and need for local, county and national level actions and efforts to regenerate river ecosystems in Kenya, as one piece of the puzzle towards attainment of the SDGs and fulfilling other global commitments, as well as creating sustainable and quality environments for people in cities and urban areas to thrive in.

The Emphasising Ecosystems Elevating People (3EP) project, as an example of local river

regeneration actions, with a particular focus on low income communities and informal urban neighbourhoods, which are most at risk of climate change impacts, presents significant relevance to achievement of global actions and priorities espoused through the SDGs and multilateral agreements, as well as regional, national and city level climate and environmental priorities for Kenya, towards building of sustainable cities and urban areas, including resilient natural ecosystems and communities.

# Chapter 3: Approach to the Ngong River Profile Assessment - Methodology

## a) Study Extent and Sectioning

The assessment of the Ngong River was conducted over a stretch of more than fifty kilometres. For effective management and thorough assessment, the river was divided into ten sections, numbered from 1 to 10. This sectioning facilitated a structured approach to the reconnaissance and data collection processes.

## b) Team Organization and Reconnaissance Visits

The team comprised members from four partnering organizations, Akiba Mashinani Trust (AMT), GoDown Arts Center, Kenya Space Agency (KSA), and Kounkuey Design Initiative (KDI), who further subdivided the ten sections into three broader groups. Reconnaissance visits were conducted over three separate days, each focusing on one of these broader groups. During these visits, the team performed guided walks along the river sections. Randomly selected individuals, who had relevant information about the river, were interviewed. Additionally, key informants from the local community were identified in each section. These individuals provided valuable insights and accompanied the team during the walks.

## c) Data Collection Techniques

During the Ngong River reconnaissance walks, the team employed various data collection techniques:

- Map Reading and annotation: Utilizing maps for navigation and ensuring comprehensive coverage of the river sections.
- Note Taking: Detailed notes were taken in notebooks to document observations and information obtained from interviews.
- GPS Tracking and Mobile Applications: A mobile-based GPS tracking application was used to track the path followed during the reconnaissance. Geo-tagged images were captured along these paths.
- Photography and Videography: Visual documentation through photos and videos provided a rich dataset for subsequent analysis.

## d) Data Integration and Analysis

The collected data, including geo-tagged images and GPS tracks, were later uploaded to ArcGIS, a geographic information system platform. This data integration enabled the creation of detailed maps and a Storymap. The Storymap, created on the ESRI StoryMap platform, served as a comprehensive, stand-alone resource. It combined online maps, legends, text, photos, and videos to provide an interactive exploration of the Ngong River Watershed. Features such as swipe, pop-ups, and time sliders were incorporated to enhance user interaction and understanding.

### e) Secondary Data Collection

To supplement the primary data collected during field visits, a thorough desk study was conducted. Secondary sources, including publications, reports, and papers, were examined. This secondary data provided additional context and insights that enriched the primary observations and findings.

### f) Mapping and Visualization

The mapping was conducted using ESRI ArcGIS, leveraging Google satellite imagery and open online data. The mapping covered the entire stretch of the Ngong River, from its source in Kibiku/Ngong Forest to its confluence with the Nairobi River. The resulting maps provided a detailed visual representation of the river and its surrounding watershed, enhancing the overall understanding of the area.

### g) Presentation of Findings

The final data presentation was achieved through a Storymap on the ESRI StoryMap platform. This web-based map integrated various elements such as text, photos, and videos, creating an interactive and engaging resource. The Storymap allowed users to explore the Ngong River Watershed interactively, offering functionalities like swipes, pop-ups, and time sliders, which provided a dynamic and informative experience.

In summary, this the Ngong River Assessment methodology combined structured field visits, primary and secondary data collection, advanced GIS mapping, and interactive digital storytelling (StoryMap) to assess and present the state of the Ngong River comprehensively. This approach ensured a thorough, multifaceted understanding of the Ngong River watershed.

# Chapter 4: 'The Ngong Riverscape'

In this chapter, the Ngong River basin is looked at within the context of the five major water towers in Kenya, and an environmental, socio-spatial and infrastructure assessment of the basin is done to understand the diverse character of the Ngong River ecosystem, and differentiation along the river basin, and across various land use, environmental and socio-economic characterisation with the basin.

The following sections of the spatial assessment provide a detailed description and analysis of the Ngong River Basin, including defining and mapping its various sections, and conducting an analysis of environment conditions and land use activities within the assessment area of the basin, as well as the interactions of the river system, with other systems and human activities, and their outcome.

## Nairobi River System

Kenya has five main river basins, with the Lake Victoria basin being the largest, accounting for 59 percent of the total surface water and 54 percent of renewable freshwater resources. The Tana River Basin accounts for 19 percent of the total freshwater resources, covering an area of about 28500 square kilometres. This basin includes the Thika River, a major water source for

Nairobi. The Tana River is the longest in Kenya flowing over a distance of 1050 kilometres[21] before draining into the Indian Ocean. The Rift Valley Basin accounts for 14 percent of Kenya's total surface water resources, including Lake Turkana, Naivasha and Magadi.


*Map 6: Map of Kenya showing the different river basins that include the Indian Ocean (and the Nairobi River Basin)*[22]

The Ewaso Ng'iro Basin is the biggest in terms of spatial coverage, but the smallest, only accounting for 2 percent of Kenya's surface water resources. The Athi River Basin extends from Nairobi to the Athi River until it drains into the Indian Ocean. This basin accounts for less than 6 percent of Kenya's surface water resources.

21 USAID & Sustainable Water Partnership. (2021). Kenya country profile: Water security, sanitation, and hygiene. Retrieved from https://winrock.org/wp-content/uploads/2021/08/Kenya_Country_Profile-Final.pdf (Accessed: [01/07/23])
22 ibid

The Athi River is the second largest[23] and longest river in Kenya, with a length of approximately 390 kilometres[24]. The Athi River Basin is 540 kilometres long and drains the Kenya highlands[25] of the Aberdares starting from the Kikuyu and Ondiri springs and flowing to the southeast to be a main source of water for the counties of Kitui, Makueni and Kilifi, before draining into the Indian Ocean north of Malindi and Mombasa. The Athi River through its Nairobi tributary drains the city of Nairobi in its upper catchment, and Malindi in its lower catchment area[26].

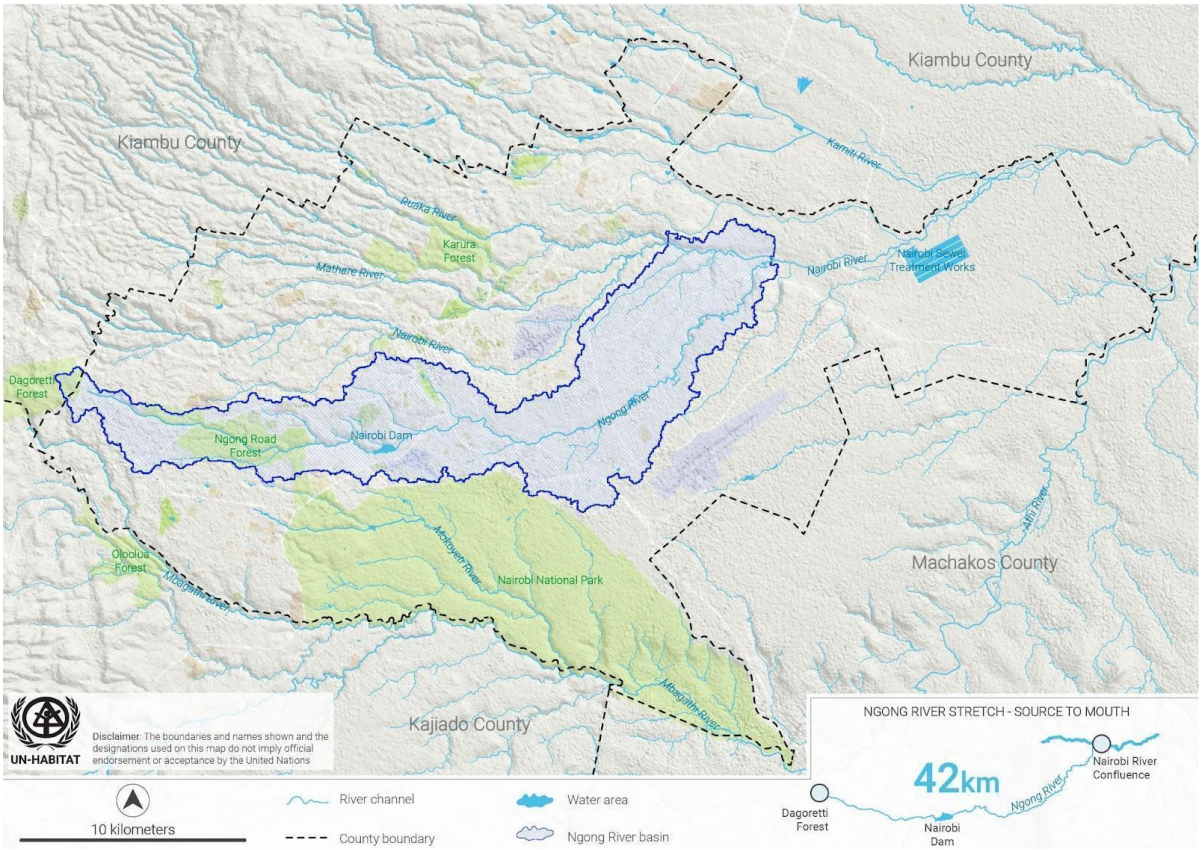
The upper zone of the Athi River Basin has an altitude of 2600 to 1500 metres above sea level, the middle zone is at 1500 to 500 metres above sea level, while the coastal lower zone is at 500 to 0 (sea level) metres above sea level[27].

The Athi River Basin is facing a number of challenges, including declining water quality, water scarcity, groundwater depletion, and declining river base flow. These challenges are being exacerbated by land use changes, increasing population, and climate change. There are a number of opportunities to address these challenges, such as improved water management practices, groundwater recharge, and climate change adaptation measures.

It is important to note that these challenges and opportunities are interconnected. For example, water pollution can lead to water scarcity, and groundwater depletion can lead to declining river baseflow. Therefore, it is essential to take a holistic approach to addressing the challenges facing the Athi River Basin.

The Nairobi Rivers sub-basin forms part of the upper catchment of the Athi River Basin, and mainly drains the Kikuyu escarpment. This sub-basin has Ngong, Mathare,Nairobi, Mbagathi and Ruaka as its main streams. These streams flow parallel[28] to each other in an eastward direction and join just before Ol Donyo Sabuk/Kilimambogo hill to form the main Athi-Sabaki/Galana River[29].

23 Ngatia, M., Kithiia, S. M., & Voda, M. (2023). Effects of anthropogenic activities on water quality within the Ngong River sub-catchment, Nairobi, Kenya. Water, 15(4), 660. https://doi.org/10.3390/w15040660
24 Water Resources Authority
25 A critical analysis of the water quality impacts on water resources in the Athi River Drainage Basin, Kenya, Kithiia, M., 2021
26 Kithiia, S. M. (2007). An assessment of water quality changes within the Athi and Nairobi River basins during the last decade. Journal of Environmental Science and Engineering
27 Kithiia, S. M. (2021). A critical analysis of the water quality impacts on water resources in the Athi River Drainage Basin, Kenya. Water Resources Authority Report.
28 Makathimo, M., & Guthiga, P. (2010). Land use policies and natural resource management in Kenya: The case of Nairobi River Basin. Nairobi: Kenya Institute for Public Policy Research and Analysis (KIPPRA).
29 Kithiia, S. M. (2021). A critical analysis of the water quality impacts on water resources in the Athi River Drainage Basin, Kenya. Water Resources Authority Report.




*Map 7: Ngong River Basin (source: UNH)*

The name 'Nairobi' means a place of cool and clean waters, and it is a testament to the fact that the city of Nairobi at its establishment in the 1900s indeed had clean water in its rivers suitable for drinking and domestic use.

However, rapid population growth and urbanisation resulting in increased and unsustainable settlement, industrial, commercial and transportation activities within the Nairobi River Basin catchment area have greatly impacted the water quality and quantity of the sub-basin, as well as its biodiversity.

The main causes of degradation and pollution of the Nairobi River Basin have been identified as informal settlements[30], industrial land uses and the city's sewage treatment plant, as well as various agricultural farms[31] along the river banks, with informal areas singled as the most complex[32] to deal with.

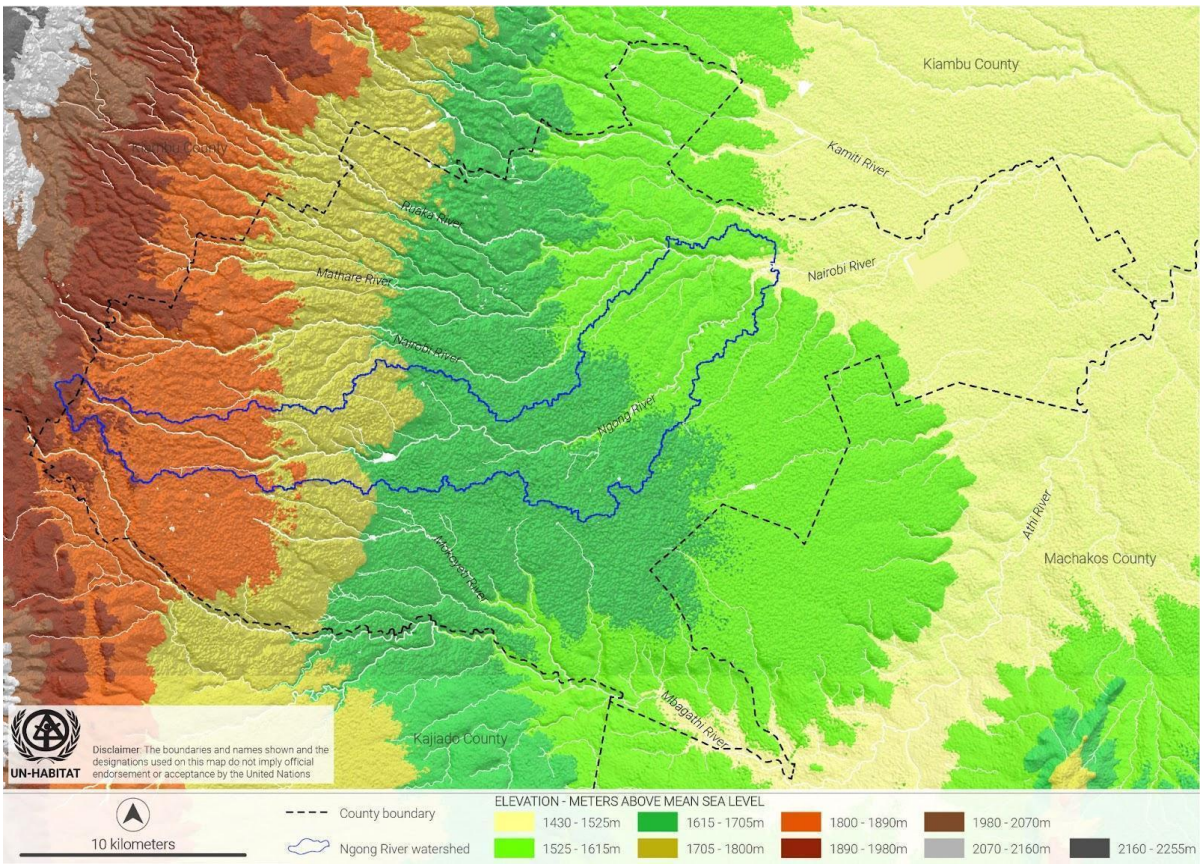
## Ngong River Basin

The sub-catchment (Ngong River Basin) has a maximum elevation of 2040 metres above sea level, and minimum elevation of 1560 metres above mean sea level. It starts at an altitude of

30 Kienja, K. (2017). Pollution of urban waterways in Nairobi: A case study of Mathare 4B Village, Nairobi, Kenya [Master's thesis, University of Nairobi].
31 Sobowale, R. (2019). River restoration in Nairobi, Kenya: Exploring public participation and learning outcomes [Master's thesis, University of Wageningen].
32 Kienja, K. (2017). Pollution of urban waterways in Nairobi: A case study of Mathare 4B Village, Nairobi, Kenya [Master's thesis, University of Nairobi].

about 2000 metres above sea level and drains into the Nairobi river at an elevation of about 1525 metres above mean sea level. The Ngong River catchment generally has a gentle slope of 1.01%, however, in some sections, this ranges between 7 and 19 % rise or fall.

The river is known as Motoine River in its upper catchment with its source being the Motoine Swamp to Dagoretti Forest[33] supplied by three permanent springs at the edges of the Thogoto forest[34]. From the swamp, Motoine river flows across the Karen-Dagoretti market road through a culvert, then vanishes into the adjacent farmlands that initially formed part of the Dagoretti forest. The Motoine River has a subsurface flow through the Dagoretti forest up to the Ngong Road Forest[35]. From here the Motoine River flows through Jamhuri Park[36] then into the Nairobi Dam in Kibera informal settlements where it becomes the Ngong River.



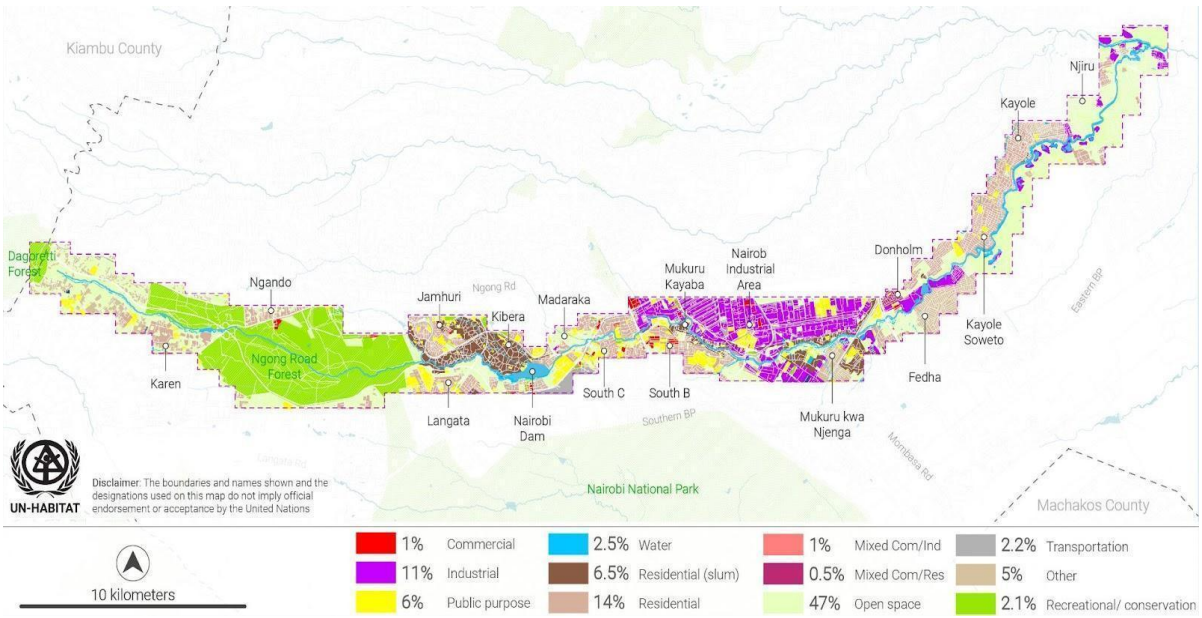

*Map 8: Ngong River Basin – Elevation – meters above mean sea level (source: UNH)*

33 Ngatia, M. 2023. Effects of anthropogenic activities on water quality within Ngong river sub catchment, Nairobi, kenya.
34 Monene, A. (2014) Effects of Land Use Change on StreamFlow, Channel Erosion and River Geomorphology: A Case Study of Motoine/Ngong River Sub-Catchment, Nairobi River Basin, Kenya.
35 ibid
36 ibid

After Nairobi Dam, the Ngong River flows through Nairobi West and the city's industrial area before its confluence with the Nairobi river below the Njiru shopping centre.
The Motoine/Ngong River flows through various dams[37] constructed along its path, including the Motoine Dam, Jamhuri Dam and the Nairobi Dam[38]. Farming activities and the agrochemicals used pollute the Motoine River in the upper catchment area of Dagoretti. Before entering the Nairobi dam, the Motoine River also collects untreated sewage and uncollected waste from the Kibera informal settlement[39].

A large section of the downstream waters of the Motoine/Ngong River is a floodplain[40] proliferated by the urban poor living in the various informal settlements along its banks. Between 2002 and 2010, the Ngong River's riparian zone changed from largely undeveloped to fully developed with informal settlements[41].

As the tributary flows from the Nairobi Dam as the Ngong River, it flows through a stretch of approximately 12 kilometres[42] of the city's industrial corridor where untreated industrial liquid waste and wastewater, as well as industrial solid waste are channelled into the river. This stretch also hosts various informal settlements including Kibera, Kayole, Soweto, Kibarage, Embakasi, Tassia, Mukuru Kayaba, Fuata Nyayo, Mukuru kwa Rueben, Mukuru Viwandani and Mariguini[43] where it picks up raw sewage and uncollected solid waste.




*Map 9: Land use distribution within the Ngong River Basin (source: UNH)*

37 Makathimo, M. and Guthiga, P. (2010) Land use policies and natural resource management in Kenya: The case of Nairobi river basin
38 University of Nairobi, (). Survey and Situation Analysis of the Biological Characteristics of the Main Tributaries of the Nairobi Rivers, Reservoirs and Wetlands.
39 Preparatory Survey for Integrated Solid Waste Management in Nairobi City, JICA
40 Juma, B. et al. (2020) Analysis of rainfall patterns in the Ngong River Basin of Kenya: Towards integrated urban flood risk management
41 Andersen, J. et al. (2021). Perspectives of Local Community Leaders, Health Care Workers, Volunteers, Policy Makers and Academia on Climate Change Related Health Risks in Mukuru Informal Settlement in Nairobi, Kenya—A Qualitative Study.
42 Muungano wa Wanavijiji/Akiba Mashinani Trust and SDI-Kenya, (2020). Unpacking Ngong River Challenges, Threats and Sustainable Solutions draft report.
43 Preparatory Survey for Integrated Solid Waste Management in Nairobi City, JICA

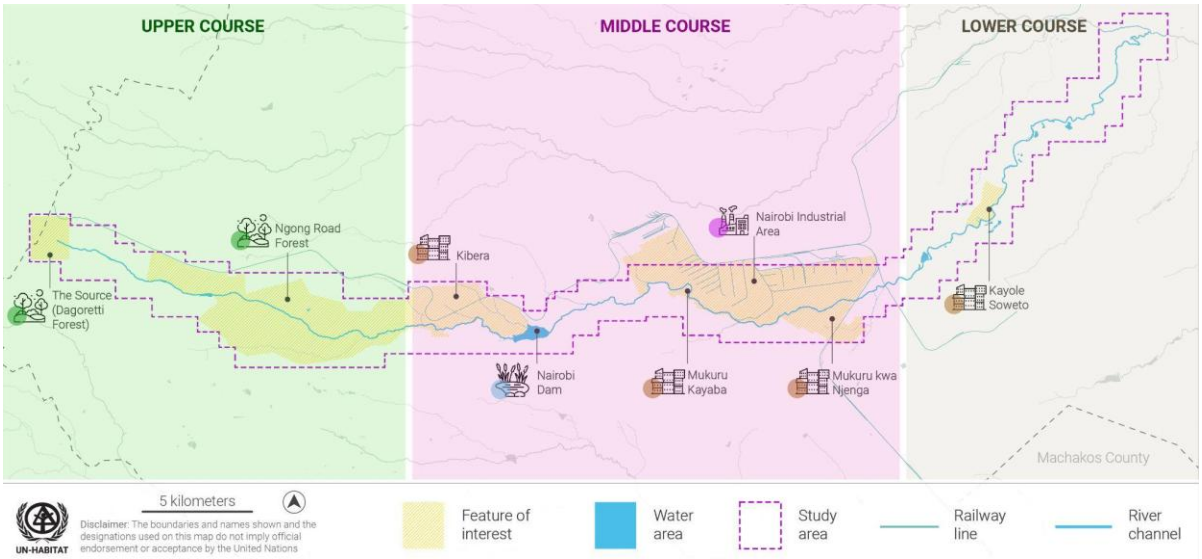
## Ngong River Basin and its sections

The Motoine/ Ngong River sub-catchment is approximately 42.3 kilometres in length, with a catchment area of 127 square kilometres[44] between its source in Dagoretti Forest and its confluence with the Nairobi River in Njiru. The assessment found it necessary to divide the river corridor. It is divided into three distinct sections[45]

1. **The upper course** – Dagoretti Forest to Jamhuri Dam at the top of Kibera, informal settlement.

2. **The middle course** – Kibera informal settlement to Kayole Soweto informal settlement.

3. **The lower course** - From Kayole Soweto downstream to the confluence with the Nairobi River.

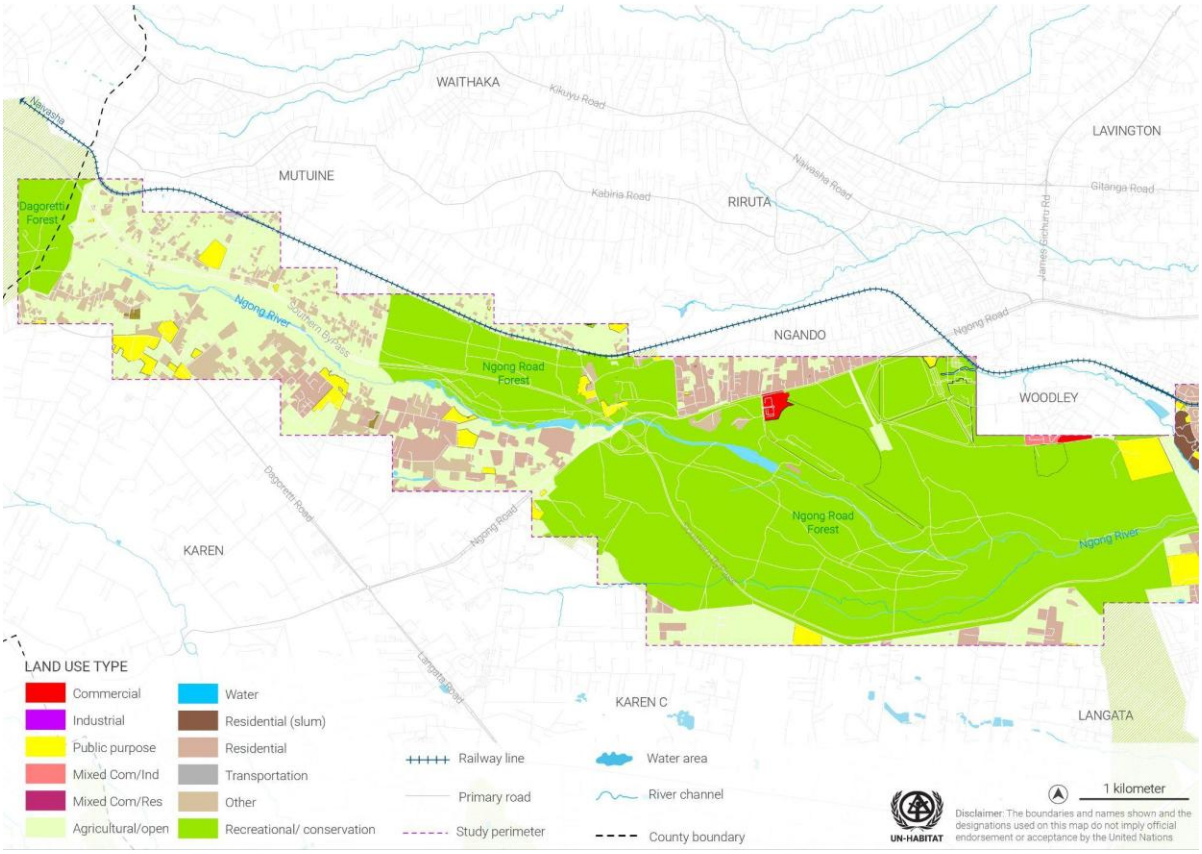



*Map 10: The three sections of Ngong River (Source: UNH)*

44 Okoye, G. and Monene, A. (2015) Impact of Urbanisation on the Morphology of Motoine/Ngong River Channel, Nairobi
45 ibid

## The Upper Course

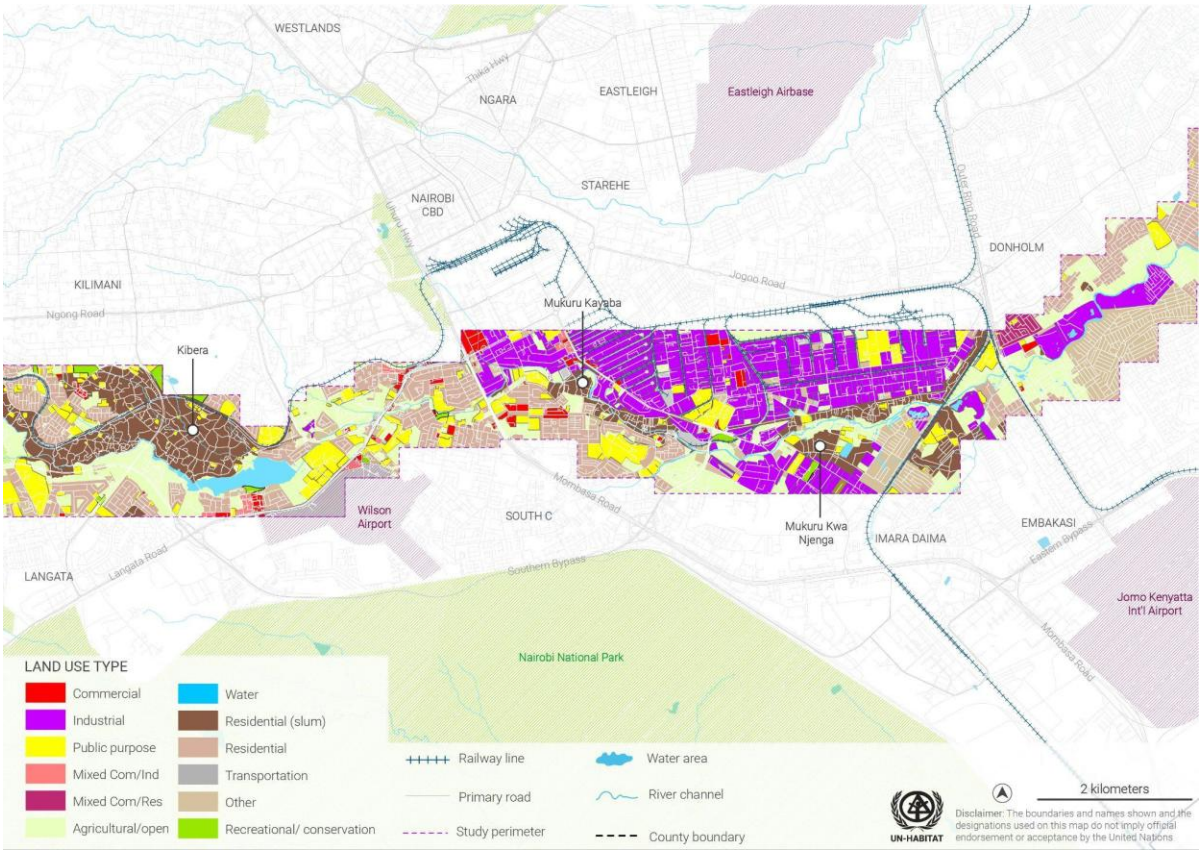
The upper reaches of the Ngong River extend approximately 10 kilometres, beginning in Dagoretti Forest and flowing through to Kibera. This section is characterised by low-density peri-urban residential areas interspersed with both large-scale commercial farms and smallholder agricultural plots. These farms rely heavily on inorganic fertilisers and organic manure, contributing to nutrient runoff. Soil erosion is a persistent issue in this area, leading to significant sedimentation and siltation within the river channel. Consequently, water turbidity is high, which reduces light penetration and adversely affects aquatic ecosystems.




*Map 11: The upper course of the Ngong River (UNH)*

## The Middle Course

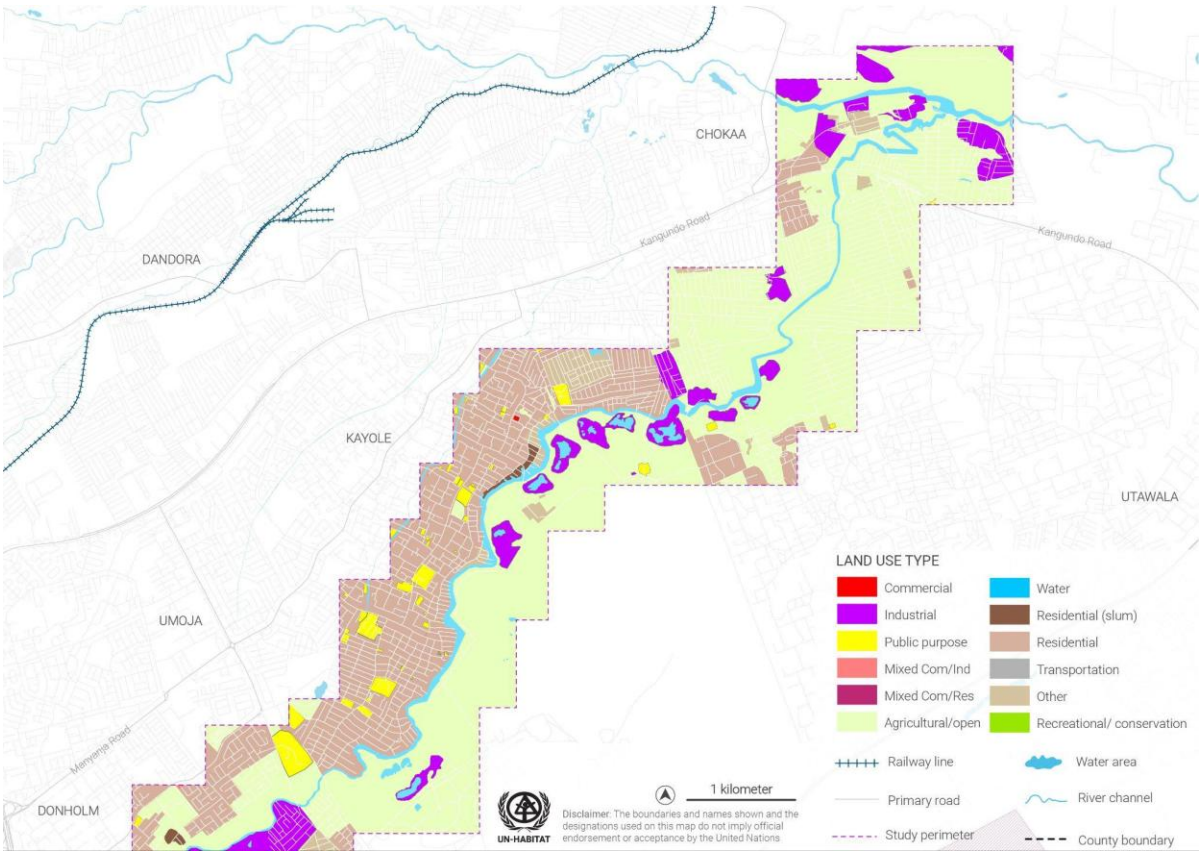
The middle stretch of the river runs through a densely populated urban corridor for roughly 20 kilometres. This section is dominated by high-density residential neighbourhoods and a mix of light and heavy industrial zones. It faces severe pollution challenges due to inadequate sewerage infrastructure, resulting in frequent discharge of raw sewage directly into the river. Additionally, unregulated industrial effluents and indiscriminate dumping of solid waste further degrade water quality. This has led to deteriorating ecological health and poses serious risks to communities living along the riverbanks.




*Map 12: The middle course of the Ngong River (Source: UNH)*

**The Lower Course**

The lower course of the Ngong River flows from Kayole Soweto to its confluence with the Nairobi River and continues downstream for about 10 kilometres. This segment features fewer residential developments and is primarily used for irrigation agriculture, with farms depending heavily on the river for water. The main environmental concern here is the discharge—both treated and untreated—from the Dandora Wastewater Treatment Plant. This contributes to nutrient loading and possible contamination of the water, raising concerns for both human health and downstream ecosystems.




*Map 13: The lower course of the Ngong River (Source: UNH)*

## II. Environmental Analysis

This section explores the environmental analysis of the Ngong Watershed, providing a comprehensive overview of its various environmental facets. It covers topography and climatic conditions, examining the physical landscape and prevailing weather patterns. The chapter delves into existing and future climate change scenarios, assessing potential impacts on the watershed. Hydrology and geology are thoroughly analyzed, alongside soil classification to understand the foundational characteristics of the area. The chapter also investigates biodiversity, including land cover analysis and city-wide biodiversity network mapping, with a focus on the catchment area and ecosystem services in the Motoine/Ngong River basin. Additionally, water quality and pollution are examined to identify current environmental stressors, and a multi-hazards assessment is conducted to evaluate potential risks within the watershed.

### a. Topography + Climatic Conditions

The city of Nairobi is located close to the eastern edge of the east african rift valley, bordering counties of Kiambu, Kajiado, and Machakos. The city has an elevation ranging from 1,460m to 1,920m above sea level.[46] It is in the subtropical highland, influencing the climatic conditions. This, however, can vary slightly depending on specific locations within the city and its surroundings, creating distinct climatic zones.

Nairobi can be divided into the Nairobi upper highland zone including the higher elevated areas surrounding Nairobi, such as Kitusuru, Runda, Kiambu road, Lavington, Nyari, Ngong hills. These locales have a cooler climate, with temperatures generally lower than in the city centre and the lower parts of the city. These microclimate differences could be attributed to their proximity to forests like Ngong Road, Karura and Olulua forests and the forests in Kiambu, as well as the natural vegetation in these regions. These areas are also wetter than the other parts of the city. The temperatures in the city centre are slightly higher from the higher elevated areas. The Central Business Dictrict's urban environment may contribute to localised variations in temperature due to factors such as heat by concrete and asphalt surfaces, reduced vegetation cover, and limited air circulation contributing to the urban heat island effect, where urban areas experience slightly higher temperatures than surrounding areas.[47] Lower highland zone encompasses the lower elevated areas around Nairobi, including the eastern and the southern outskirts of the city - Embakasi, Athi River, Kitengela. The lower highland zone experiences slightly higher temperatures compared to the upper highland zone and the city centre.

The average annual temperature ranges from around 14°C to 24°C with the hottest months being January and February. Nairobi receives just over 610 mm of rainfall a year occurring primarily in two rainy seasons: the long rainy season from March to May and records about 310mm of rainfall, the short rainy season from October to December and records about 200mm. The drier months are January, February, June, July, August, and September and record less than 80 mm of rainfall.[48] The seasons can be characterised by increased precipitation, and showers can be frequent during these months. The rainfall is generally moderate, with some variations in intensity

46 Athi Water Services Board. (2016). Consultancy services for preliminary and detailed design and tender documentation for the Nairobi Rivers Sewerage Improvement Project (NARSIP) Phase II. Retrieved June 20, 2024, from https://www.awwda.go.ke/wp-content/uploads/2022/07/Responses-to-Clarifications-No-2_-Dandora-Inlet-Works_full.pdf
47 Scott, A., Beckham, K., Mberu, B., Ezeh, A., & Monteiro, C. (2017). Temperature and heat in informal settlements in Nairobi. PLoS ONE, 12(11), e0187300. https://doi.org/10.1371/journal.pone.0187300
48 Ibid

from year to year.

Nairobi has experienced variations in its rainfall patterns in the recent past. In 2020, the city experienced its highest rainfall at 1002mm, while the lowest was recorded in 2022 at 337mm.[49] In 2023, Kenya and several other regions in Africa face a looming threat as the spectre of El Nino-induced floods intensifies due to the impacts of climate change. Despite January traditionally being a hot month in Nairobi, there has been a recent shift with increased occurrences of heavy rain and overcast conditions.

### b. Existing and future climate change scenarios

Nairobi's climate is projected to become significantly warmer in the coming decades. According to a study utilising 15 Global Climate Models (GCMs), daily maximum temperatures are expected to rise by 0.5°C to 2°C by the 2040s, and by 2°C to 5°C by the end of the century. Similarly, daily minimum temperatures are projected to increase by 1°C to 1.5°C by the 2040s, and by 3°C to 5°C by century's end. This warming trend is likely to intensify both the frequency and severity of heatwaves in the future.

In terms of precipitation, ensemble projections from GCMs generally indicate no significant change or a slight increase in rainfall by the end of the century. An ensemble of 11 statistically downscaled GCMs presents similar results for both temperature and rainfall projections. These findings are summarised in the table below.

| **Statistic** | **Annual** |
|---|---|
| Average Tmax [°C] | **Increasing** +1 to +1.5 °C by 2040, and between +2.5 to +4.5 °C by the end of the century. Warming trends may already be discernible from that of natural variability. |
| Average Tmin [°C] | **Increasing** +1 °C to +1.5 °C by 2040s, and between +3 and +5 °C by the end of the century. Warming trends may already be discernible from that of natural variability. |
| Daytime extreme heat events [days] | **Increasing,** +20 to 50 extra days by 2040, and between +75 to +180 extra days by the end of the century. Warming trend may already be discernible from that of natural variability in this decade |
| Nighttime extreme heat events [days] | **Increasing,** +70 to 110 extra nights by 2040, and between +210 to +310 extra days by the end of the century. |
| Total rainfall (mm/year) | **Normal to increasing rainfall**, ranging from slight drying to significant wetting from 2070 onwards. |
| Rainfall intensity (mm/day) | **No change** in daily intensity. |
| Rainy day frequency (days) | **No change to increasing** rain day frequency, ranging from no change to significant increase from 2070 onwards. |
| heavy rain frequency (days) | **No change to increasing** rain day frequency, ranging from no change to significant increase from 2070 onwards. |

49 Kenya Meteorological Department. (2021, June). State of the climate in Kenya 2020. Retrieved from https://meteo.go.ke/sites/default/files/downloads/STATE%20OF%20THE%20%20CLIMATE%202020_14042021.pdf

*Table 1: Adopted and modified from University of Cape Town (2017) Nairobi Climate Profile: Full Technical Version*

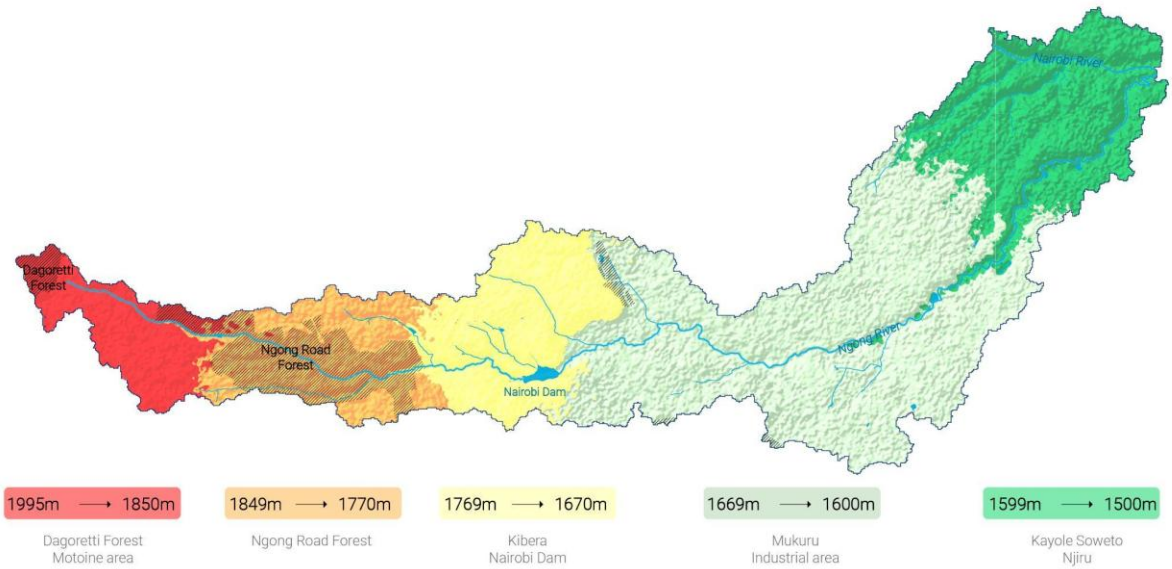
Over recent decades, Nairobi has experienced rising temperatures, shifting rainfall patterns, and increasing microclimatic variability, including the development of urban heat islands, more intense rainfall events, and a rise in surface runoff due to rapid urbanisation. These trends are expected to worsen, increasing the frequency and severity of climate-related hazards, particularly flooding.

Changes in land use and land cover, driven by rapid population growth and urban expansion, have contributed significantly to rainfall-runoff processes, increasing the risk of flooding in the city's river basins[50]. The continued spread of human settlements into flood-prone areas, particularly in developing countries like Kenya, amplifies the impacts of flash floods. These challenges are expected to intensify under future climate change scenarios[51].

Over the next two decades, Nairobi is projected to experience temperature increases of 1°C to 1.5°C, with a decline in thermal comfort, especially in densely built-up areas affected by the urban heat island effect[523]. The city currently has limited infrastructure and risk reduction measures to manage the escalating risks associated with climate change[4].

As a result, many residents—especially those living in informal settlements—are highly vulnerable to the impacts of climate change[5]. These communities are disproportionately affected due to inadequate access to basic services, including clean water, sanitation, waste management, and decent housing[536].

### c. Hydrology




*Map 14: The Ngong River Basin (adopted and modified from Bernard, Olang, Bukachi, Mulligan et al, 2021)*

The Motoine River originates from Motoine swamp at the boundary of Nairobi and Kiambu

[50] Ndolo, I. J. (2018). Effects of urbanisation on rainfall and temperature over the city of Nairobi, Kenya [Master's thesis], University of Nairobi

[51] Juma, B., Onyando, J., Obiero, J., & Kipkemboi, J. (2021). Analysis of rainfall extremes in the Ngong River Basin of Kenya: Towards integrated urban flood risk management. Environmental Development, 37, 100569. https://doi.org/10.1016/j.envdev.2020.100569

[52] Satterthwaite et al. (2018). Responding to climate change in cities and in their informal settlements and economies.

[53] Abuje, S. J., Otoki, B. M., Njuguna, B. M., & Munala, G. (2020). The vulnerability of Nairobi to the effects of climate change between 1984 and 2016. Landscape Architecture and Regional Planning, 5(2), 38–45. https://doi.org/10.11648/j.larp.20200502.14

Counties, where water emerges from three permanent springs located at the edge of Dagoretti Forest. Upon leaving the swamp, the river passes under the Karen-Dagoretti market road via a culvert and then disappears into nearby farms, previously part of Dagoretti forest. The river maintains a subsurface flow through the Motoine area until it reaches the Ngong Road Forest. The river's discharge varies along its course due to the undulating terrain of its water source, resulting in a slow runoff[54]. Additionally, the Ngong stream begins slightly above the Jamhuri Trade Fair grounds, at an elevation of approximately 1,850 metres above sea level, and eventually drains into the Jamhuri Dam. Furthermore, five additional streams, namely Gatwereka, Olympic, Banker, Golf Course, and Undugu, flow through the Kibera slums and into the Nairobi Dam[55].

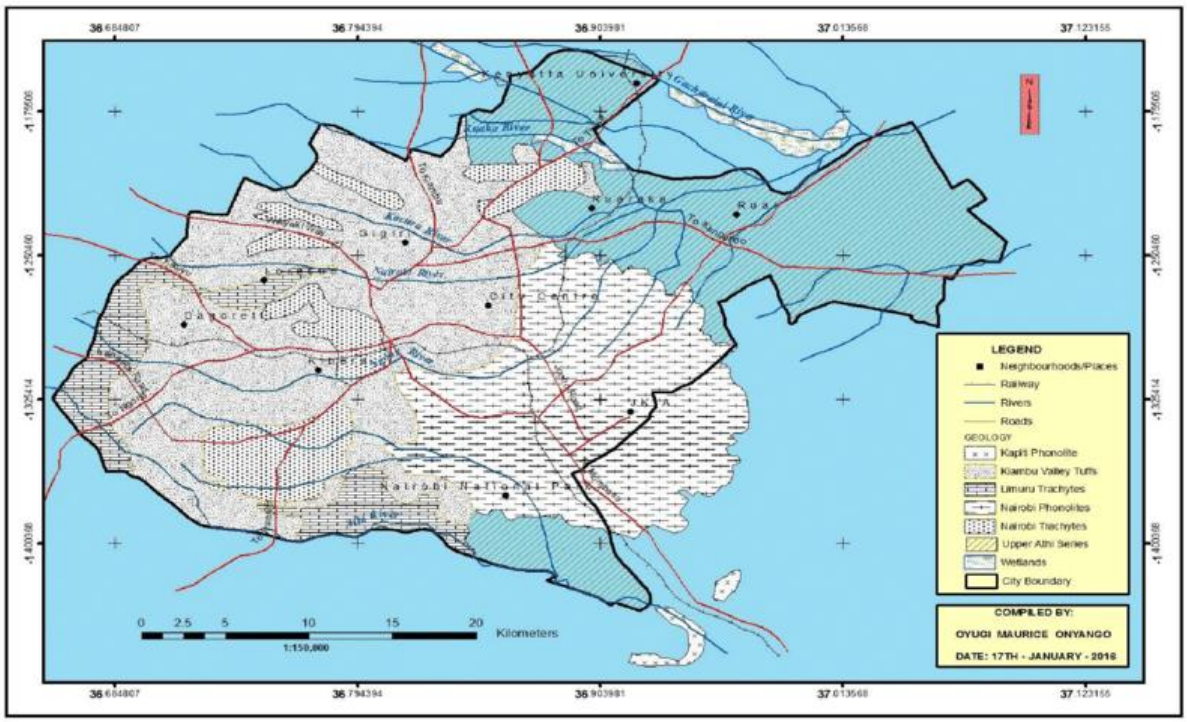
Land use changes within the sub-catchment increased impervious surface cover, which in turn has reduced infiltration capacity, while increasing surface run-off and streamflow. Reduction in infiltration capacity has subsequently led to reduced groundwater recharge resulting in a reduction in baseflow, a high seasonal flow variability, increasing overland flow (flooding) and river discharge, erosion as observed in the Motoine/Ngong river basin. Athi River base flow rates have declined by 9% since 1950 due to interconnectivity of surface and groundwater systems. A study[56] analysing the streamflow of the Motoine/Ngong river in relation to land use changes showed that the most significant land use change was clearing of forest cover and vegetation cover to built up areas. Clearing of vegetation has altered hydrological and geomorphologic states of streams by decreasing evapotranspiration and increasing overland flow (flooding) and river discharge, erosion and sediment fluxes[57]. Tall forests, due to their greater canopy roughness and more extensive root systems tapping into soil moisture, exhibit heightened rates of evapotranspiration compared to other vegetation types or land use categories. The removal of these forests consequently restricts water pathways within the watershed, resulting in an overall escalation in streamflow originating from the catchment[58]. The reduction in forest cover and grasslands, particularly in Ngong road forest where the area decreased from 2929.6 ha to 1224.4 ha, due to demand for land for road construction, schools, and other social facilities has seen expansion of impermeable surfaces in the sub-catchment, which has led to reduced infiltration capacity and increase in streamflow[59].

Insufficient and unreliable water supply in Kenya has forced the population to turn to private underground water sources in both urban and rural areas. The region underlain by the Nairobi Aquifer System (NAS) represents the largest area of demand with over 6 million people, most of which are already reliant on groundwater, and many industries and institutions. The Nairobi Aquifer is the most abstracted groundwater reservoir, surpassing sustainable extraction levels. As a result, the water table has dropped by 6m per decade, leading to the need for boreholes

54 Monene, A. K. (2017). Effects of Land Use Change on Streamflow, Channel Erosion and River Geomorphology: A Case Study of Motoine/Ngong River Sub Catchment.International Journal of Mathematics and Physical Sciences Research ISSN 2348-5736 (Online) Vol. 5, Issue 1, pp: (113-120), Month: April - September 2017, Available at: www.researchpublish.com Unpublished M.A. thesis, Department of Geography and Environmental Studies, University of Nairobi
55 Primoz, K. (2010). Mapping Flood Damage in Kibera.
56 Monene, A. K. (2017). Effects of Land Use Change on Streamflow, Channel Erosion and River Geomorphology: A Case Study of Motoine/Ngong River Sub Catchment.International Journal of Mathematics and Physical Sciences Research ISSN 2348-5736 (Online) Vol. 5, Issue 1, pp: (113-120), Month: April - September 2017, Available at: www.researchpublish.com Unpublished M.A. thesis, Department of Geography and Environmental Studies, University of Nairobi
57 Tibaijuka, A. (2007). Cities can achieve more sustainable land use if Municipalities combine Urban Planning and Development with Environmental Management. Nairobi and its Environs.
58 Miller, J. R. & Miller, M. O. (2007). Contaminated Rivers, a Geomorphological-Geochemical Approach to Site Assessment and Remediation, Springer Publishers
59 Mundia, C. N. & Aniya, M. (2006). Dynamics of Land Use/Cover Changes and Degradation of Nairobi City, Kenya. Land Degradation & Development, Volume 17, Issue 1, pp. 97-108, Wiley Online Library.

that are on average 150m deep, reflecting the decline in aquifer level[60].

### d. Geology and Soil classification




*Map 15: The Geology and Drainage of Nairobi Source: Adopted from Tibaijuka (2007)*

Pyroclastic volcanic rocks deposited during the formation of the East African Rift Valley characterise Nairobi's soil profile. During the process, some of these rocks were deposited in aqueous state for an extended duration and hence intercalated with lacustrine sediments. The nature of soil conditions gradually varied across the city as one moves from the water courses to raised grounds. During the soil's formation process, river valleys as well as other low-lying areas including depressions that existed at the time were covered with clays and alluvium[61].

Nairobi has a varied composition of three basic geological structures namely, the Mbagathi phonolitic trachyte which contains numerous closely spaced feldspar phenocrysts which are rather coarse groundmass containing little nepheline. This type of rock occurs across the Nairobi National Park and part of Athi plains. The second geological structure is the Nairobi trachyte (Pliocene), which dominates the northern and western part of the city. The Nairobi trachyte (pliocene) originates from pale grey moulted lava having a glistening appearance due to numerous tiny feldspar crystals. Finally, there is the Kirichwa valley tuff, which is an agglomeration of different rock types with the most important being devitrified welded tuffs (the Nairobi stone) used extensively for building purposes.

The Ngong/Motoine catchment occurs in an area of three geological formations: the upper catchment overlies the Upper Athi volcanics which are porous and permeable, the Lower Athi volcanics that are weathered down to clayey materials and the Kirichwa valley tuffs. At the lower

60 Oiro, S. et. al. (2020). Depletion of groundwater resources under rapid urbanisation in Africa: recent and future trends in the Nairobi Aquifer System, Kenya. VoL – 28
61 Onyancha C., Mathu E., & Mwea M., & Ngecu, W. (2011). Dealing with sensitive ana variable soils in Nairobi City. International Journal of Research and Reviews in Applied Sciences

catchment, the main top formation are the deeply weathered Nairobi phonolites (Rhoda and Kwamboka, 2016). The catchment is generally gently sloping at 1.01% except along river valleys where slopes range from about 7% to 19%[62].

The geological structure of Nairobi significantly influences land use and land cover, evident from the fact that the majority of the city is characterised by basement rocks covered by a thin layer of soil. As a result, the process of laying foundations for development does not require extensive excavation, leading to reduced development costs throughout the city. In turn, favouring the growth of real estate projects, as there are no significant physical barriers hindering such developments. Additionally, the geological structure provides readily available construction materials such as stones for walls and sand for building purposes. These stones are particularly abundant in the eastern part of the city[63].

Diverse human activities driven by population pressure in Nairobi have significantly modified the city's natural landscape. One notable consequence is the placement of buildings in areas characterised by poor subsoil conditions. This issue is particularly common in informal settlements, such as Mukuru, which are often situated in proximity to watercourses. The pressure from various competing demands has resulted in heavy manipulation of the river basin. This includes activities like soil dumping and backfilling to create space for housing, which, in turn, disrupts the natural course of the river channel. As a result of poor housing conditions and limited adaptive capacity, the use of unsuitable soils has significantly increased vulnerability to risks and hazards.

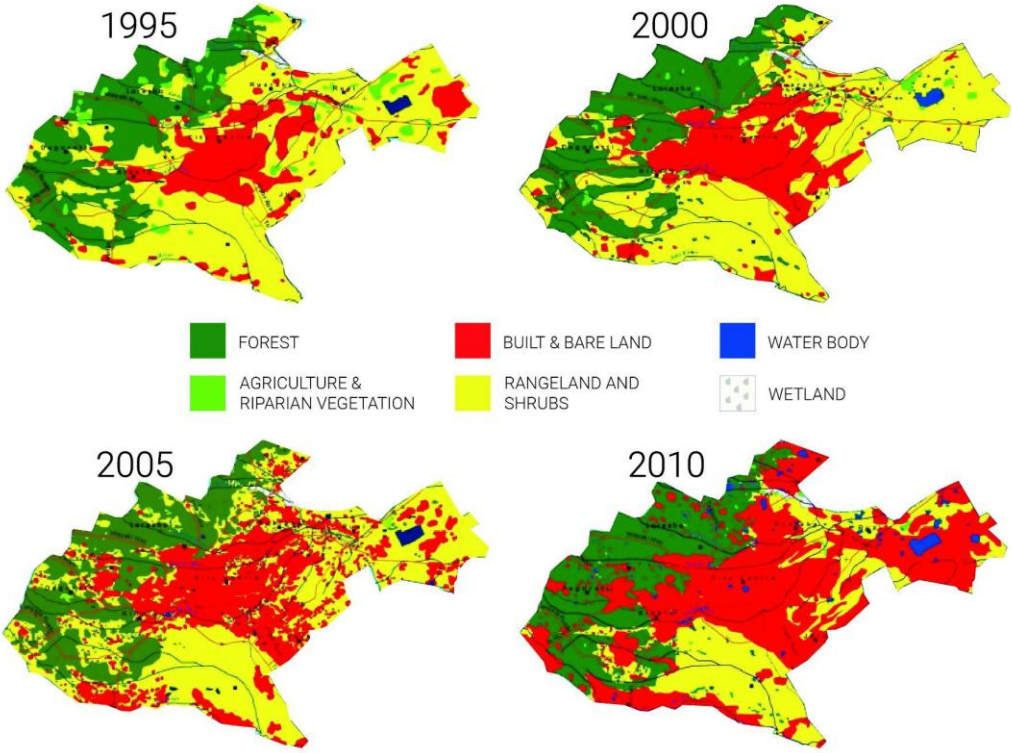
### e. Biodiversity

This section provides an in-depth analysis of the land cover within the Ngong Watershed, highlighting the complicated network of natural and urban landscapes. Key areas within the watershed, including Ngong Road Forest, Nairobi National Park, Oloolua Forest, Uhuru Park, and Hon. John N. Michuki Memorial Conservation Park, are focal points of the biodiversity network mapping. This city-wide mapping effort integrates these critical green spaces, emphasizing their role in maintaining ecological balance and supporting diverse flora and fauna. The analysis underscores the importance of these conservation areas within the broader catchment, illustrating how they collectively contribute to the ecological resilience and biodiversity of the region.

62 Monene, A. K. (2017). Effects of Land Use Change on Streamflow, Channel Erosion and River Geomorphology: A Case Study of Motoine/Ngong River Sub Catchment. International Journal of Mathematics and Physical Sciences Research ISSN 2348-5736 (Online) Vol. 5, Issue 1, pp: (113-120), Month: April - September 2017, Available at: www.researchpublish.com

63 Mwathi, P. (2016) Effects Of Land Use And Land Cover Dynamics On Environmental Quality Of Nairobi City And Its EnvironsStudies, University of Nairobi

## i) Land cover Analysis




*Map 16: Classified Land Use and Land Cover Map Of Nairobi 1995-2010 Source: adopted and modified images from Regional Centre, Nairobi.*

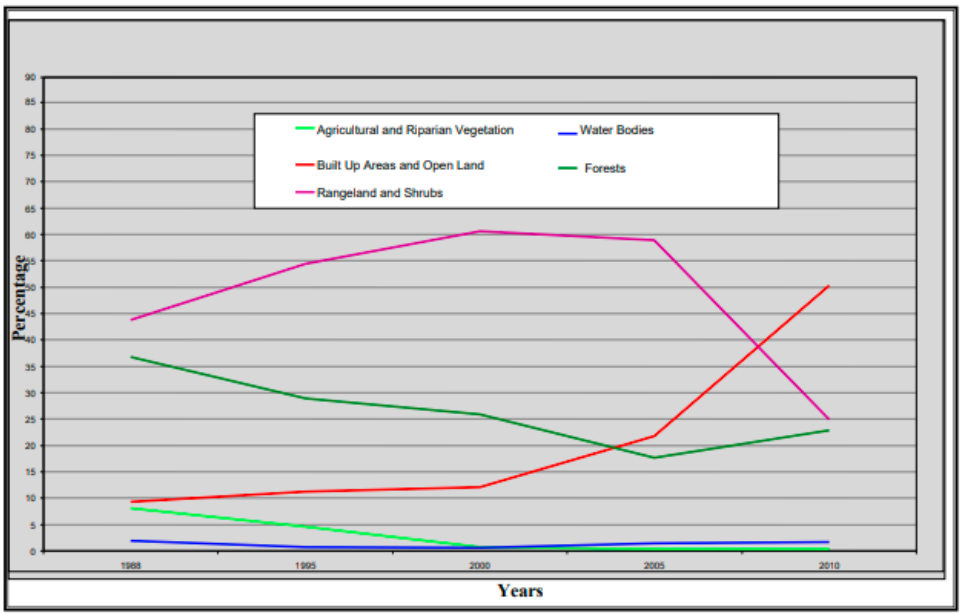



*Figure 15: Land Use and Land Cover Change Trends for Nairobi City between 1988 To 2010 Source: Years 1988 to 2010 images from Regional Centre, Nairobi.*

Urban expansion in Nairobi has led to land cover changes and development sprawl. The city has, in a period of 12 years (1988-2010), experienced an increase of 438.29% in urban built-up areas and open lands, forest cover decreased by 38% while agricultural and riparian vegetation decreased by 98%. The agricultural and riparian vegetation, rangeland and shrubs and forests

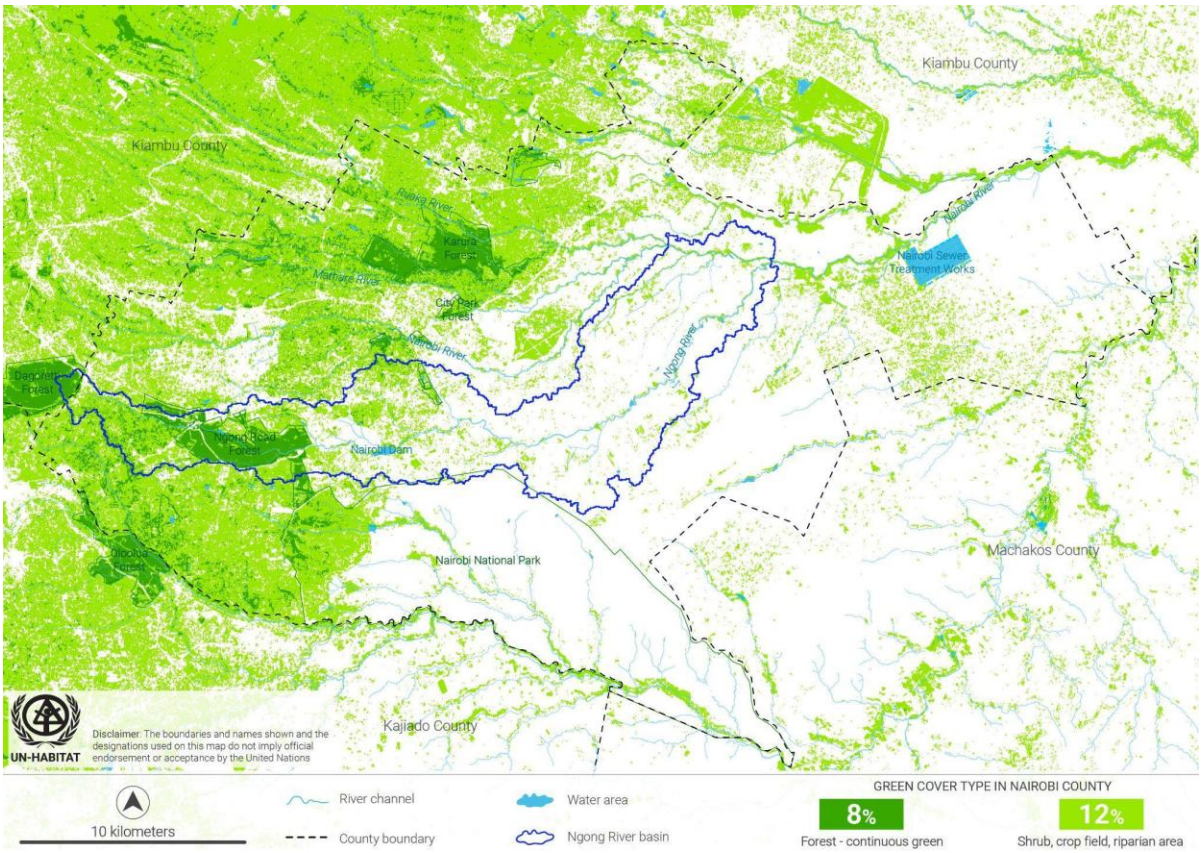
have mainly given way to expansion in built up areas and open lands[64]. There is growing and widespread concern over the shrinking size of green spaces in Nairobi. An example of this concern is the recent public uproar over the routing of the Nairobi Expressway to pass through Central and Uhuru Parks, key green and open spaces in Nairobi. The uproar resulted in the route for the highway being slightly diverted, and prevented the two green and open spaces from being encroached into. Still, many other spaces in the city face similar threats from mega infrastructure developments, land grabbing and human activities due to population pressure. Land cover categories of riverine vegetation and forest land showed the most marked decrease in real coverage by about 67 and 60%, respectively, while barren surfaces and urban areas increased by more than 100 and 98%, respectively, between 1976 and 2000.[65]

An assessment of land cover trends across various classifications such as forests, shrublands, woody savannahs, grasslands, croplands, urban areas, and wetlands revealed findings consistent with a comparable study focused on changes in land cover within similar usage categories from 1995 to 2010. The results indicated a rapid expansion of urban areas, leading to a reduction in other land cover types. Particularly, forests and woody savannahs experienced the most substantial losses due to this urban expansion[66].

**ii) Biodiversity Network Mapping - city wide including the catchment**

Urban forests contribute significantly to the ecological integrity of urban areas and the quality of life of urban dwellers through air quality control, energy conservation, improving urban hydrology, and regulation of land surface temperatures.

64 Mwathi, P. (2016) Effects Of Land Use And Land Cover Dynamics On Environmental Quality Of Nairobi City And Its Environs
65 Njoroge, et. al, (2011) "Change in landscape cover types and pattern within Nairobi city and its environs'
66 Oloo F, Murithi G, Jepkosgei C. Quantifying Tree Cover Loss in Urban Forests within Nairobi City Metropolitan Area from Earth Observation Data. Environmental Sciences Proceedings. 2021; 3(1):78. https://doi.org/10.3390/IECF2020-07952




*Map 17: Green cover - forested areas and vegetated areas in Nairobi Metropolitan area (Source: UNH)*

The main forest cover in the sub-catchment is the **Ngong Road forest** which was gazetted in 1932, and covered an area of 2929.6 ha at that time. Excisions have been made over the years to provide land for road construction, development of schools, churches, public cemeteries and other social facilities. The current cover of 1224.4 ha is only 41.8% of the original cover. The latest excision was made in the year 2013 for 56 ha for construction of the southern by-pass interchange road. Over the years, Ngong road forest has been excised, leaving it highly fragmented. The forest supports planted trees, indigenous trees and grasslands. The plantation area consists of exotic trees, with eucalyptus species occupying 148 ha, pine species 2.7 ha and cypress species 6.8 ha. Indigenous trees planted include Croton and Cordia species grown on 11.3 ha. The indigenous natural habitat and grassland occupy 504 ha of the sanctuary. The forest has had several excisions since being gazetted, most of these occurring between 1963 and 1994.

**Nairobi National Park** has vegetation cover that is predominantly dry savannah, open grass plains with scattered acacia bushes (KWS 2006). The park also has a permanent river with a riverine forest. It is located within the city of Nairobi – the only city in the world with a large assemblage of wildlife in its environs. The park is a major rhino sanctuary, supports the second-largest animal migration after theMaasaiMara, and is a dry season refuge for most wildlife. The benefits of the park include recreation, environment education, employment and income generation. The park is also an important carbon sink for Nairobi.

A quarter of **Oloolua Forest** is set aside as a nature reserve with nature trails on the forest for public education and awareness. The forest has been threatened by frequent mining activities, which have contributed to high biodiversity loss. In fact, in conjunction with stakeholders such as the Forest Working Group and East African Wildlife Society, the Government has banned any

further mining activity in the forest[67].

**Uhuru Park**

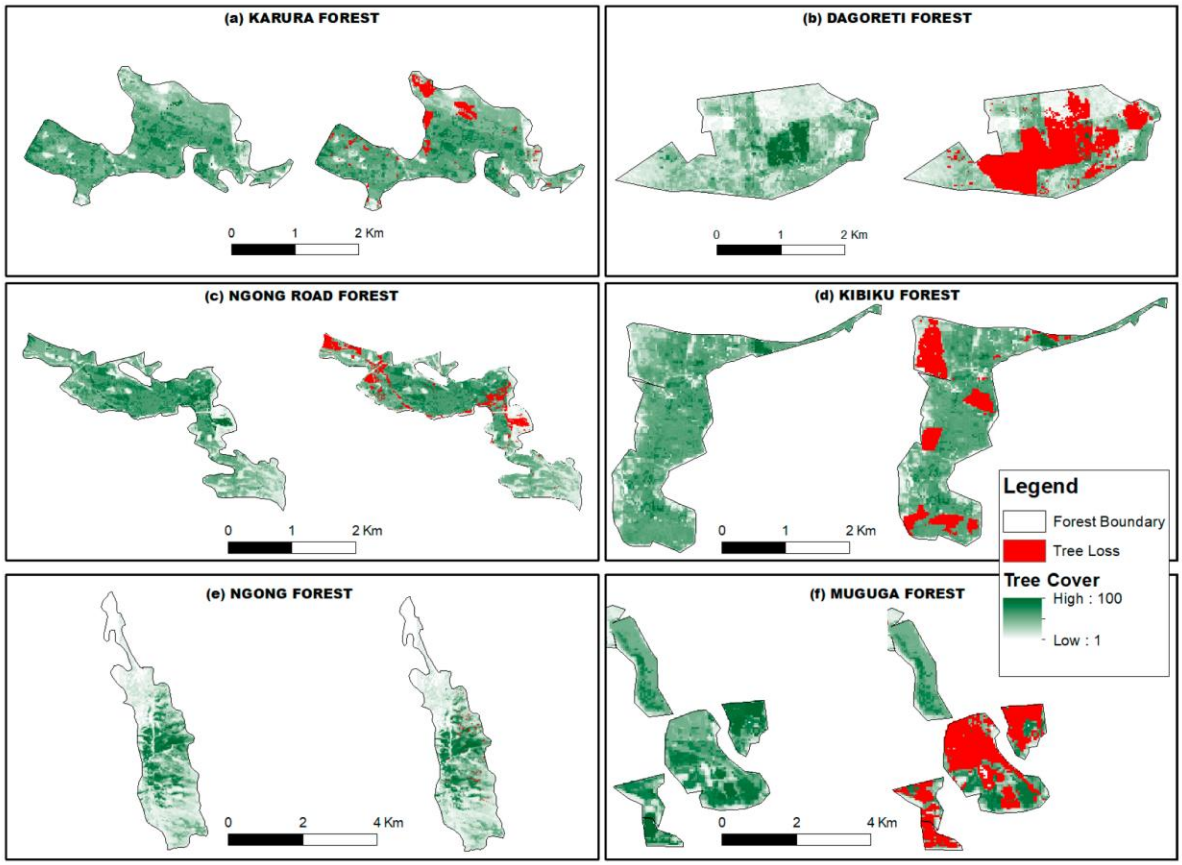
Uhuru Park spans 12.9 ha and is situated adjacent to Nairobi's central business district in Kenya. The park features an artificial lake, various national monuments, recreational activities, and grounds used for public gatherings. Notably, the park's artificial lake serves a purpose in stormwater management, storing runoff from nearby road infrastructure. Connecting to the Ngong River via a tributary, excess surface runoff from the park is directed into the river system[68].

**Hon. John N. Michuki Memorial Conservation Park** formerly known as Mazingira Park is located along the Nairobi River from the Globe Roundabout to Museum Bridge and covers an area of approximately 12.30 ha. The park was established in 2008 through concerted efforts geared towards creating a public recreation area at a site previously used as a dumpsite and a criminal hideout, which came about as a result of the rehabilitation and restoration of the Nairobi River park. The park forms part of the network of green open spaces within the city centre[69].

Tree cover data between 2001 and 2019 indicated that there was a significant tree cover loss of about 130 ha in 2001. In that year, major losses were recorded in the Ngong road forest with an approximate tree cover loss of 56.9 ha, the Dagoretti Forest with a loss of 34.8 ha, and the Muguga Forest at 27.7 ha. Other forests that also had significant losses in the same year were the Karura Forest with a loss of about 7 ha and the Ngong Forest with a loss of about 6.2 ha. After 2001, there were marginal losses between 2002 and 2010. Another significant period of loss was recorded between 2011 and 2019 with a peak in 2016 where an estimated 170 ha of tree cover was lost. In that year, major losses were recorded in Dagoretti, Ngong road, and Kibiku, respectively. Cumulatively, approximately 720.5 haof tree cover were lost in the urban forests around Nairobi between 2001 and 2019, approximately 11% of the baseline coverage of about 6620 ha in the year 2000. The annual rate of urban forest loss is at 0.58%, slightly higher than the overall forest cover loss reported for Kenya at 0.32%[70].

The main factors driving this loss are the conversion of forest lands for residential and agricultural purposes, the implementation of large infrastructure projects that cut through the forests, and the extraction of timber and other resources to support urban development. Illegal logging also contributes to the decline in forest tree cover, as high-value tree species, like the Muhugu tree (Brachylaena huillensis), are extensively harvested from Ngong forest for wood carving. Additionally, forests are being cleared for road development, human settlements, land speculation, and even for political reasons. The allocation of parts of Karura, Ngong Road forests, and City Park for residential and related developments has significantly reduced the city's forest cover and green spaces[71]. In six of the urban forests (in the figure below), the trend of loss was positive, indicating a continuing disturbance of urban forests around Nairobi[72]. Conversely, there was a negative trend in the annual mean Normalised difference vegetation index (NDVI) values for each of the forests, indicating a potential deterioration of the vegetation health in the forests.

67 United Nations Environment Programme (UNEP). (2003). City of Nairobi environment outlook. Nairobi: UNEP.
68 Green Belt Movement. (n.d.). Karura Forest: A history of restoration and protection. Retrieved from https://www.greenbeltmovement.org/node/908 (Accessed: [03/05/24])
69 Esri StoryMaps. (n.d.). Karura Forest: A forest reclaimed. Retrieved from https://storymaps.arcgis.com/stories/53174eecf0f143d4ae25b2dd12c77439 (Accessed: [03/05/24])
70 ibid
71 UNEP (2003) City of Nairobi Environment Outlook
72 Oloo F, Murithi G, Jepkosgei C. Quantifying Tree Cover Loss in Urban Forests within Nairobi City Metropolitan Area from Earth Observation Data. Environmental Sciences Proceedings. 2021; 3(1):78. https://doi.org/10.3390/IECF2020-07952




*Map 18: Tree cover in 2000 and cumulative tree cover loss between 2000 and 2019 in selected forests in Nairobi Metropolitan area*[73]

73 Oloo F, Murithi G, Jepkosgei C. Quantifying Tree Cover Loss in Urban Forests within Nairobi City Metropolitan Area from Earth Observation Data. Environmental Sciences Proceedings. 2021; 3(1):78. https://doi.org/10.3390/IECF2020-07952

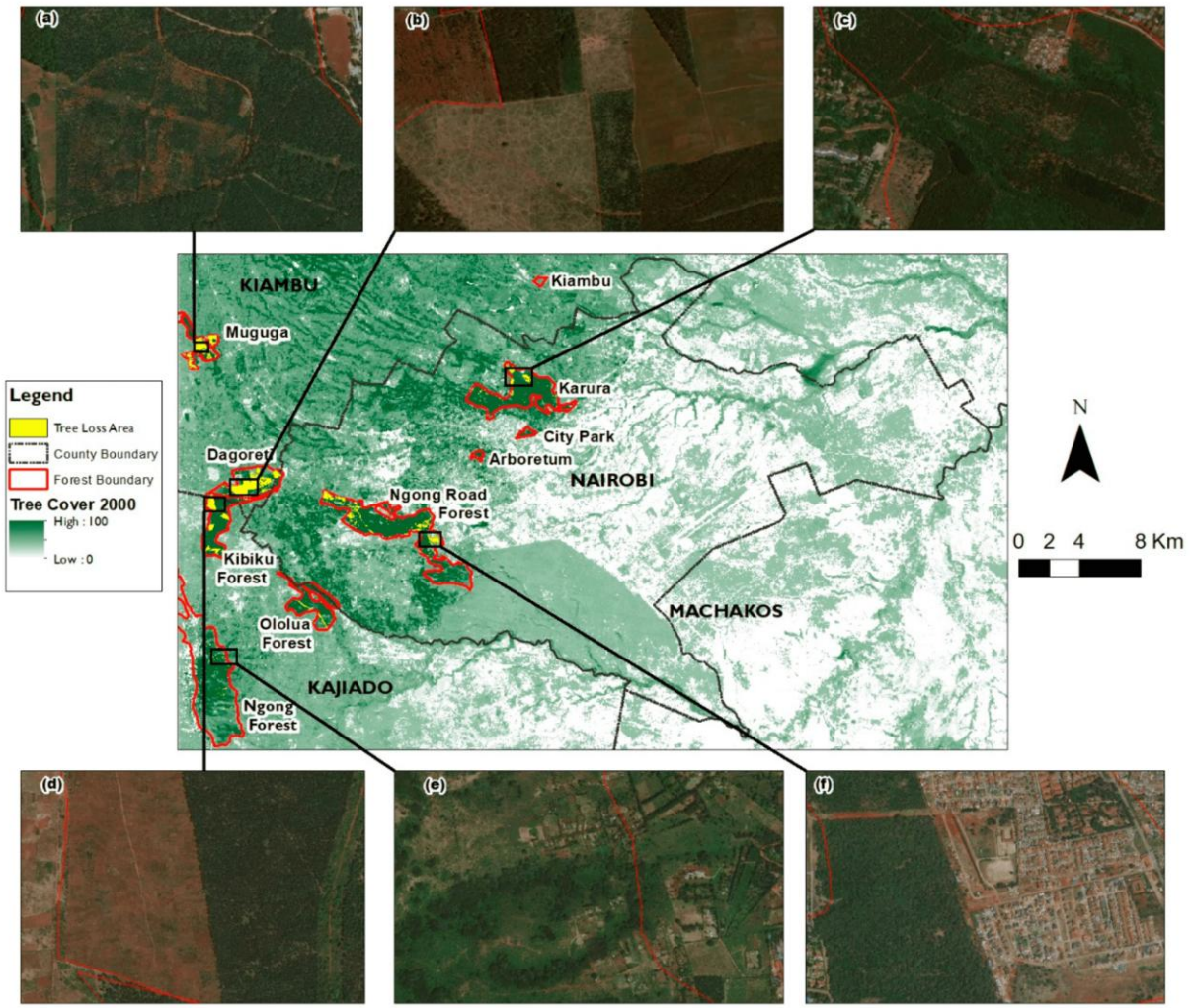



*Figure 16: Tree cover loss and satellite imagery for tree cover loss areas (snapshots a-f are the aerial photographs showing human activities at locations which were experiencing tree cover loss).*

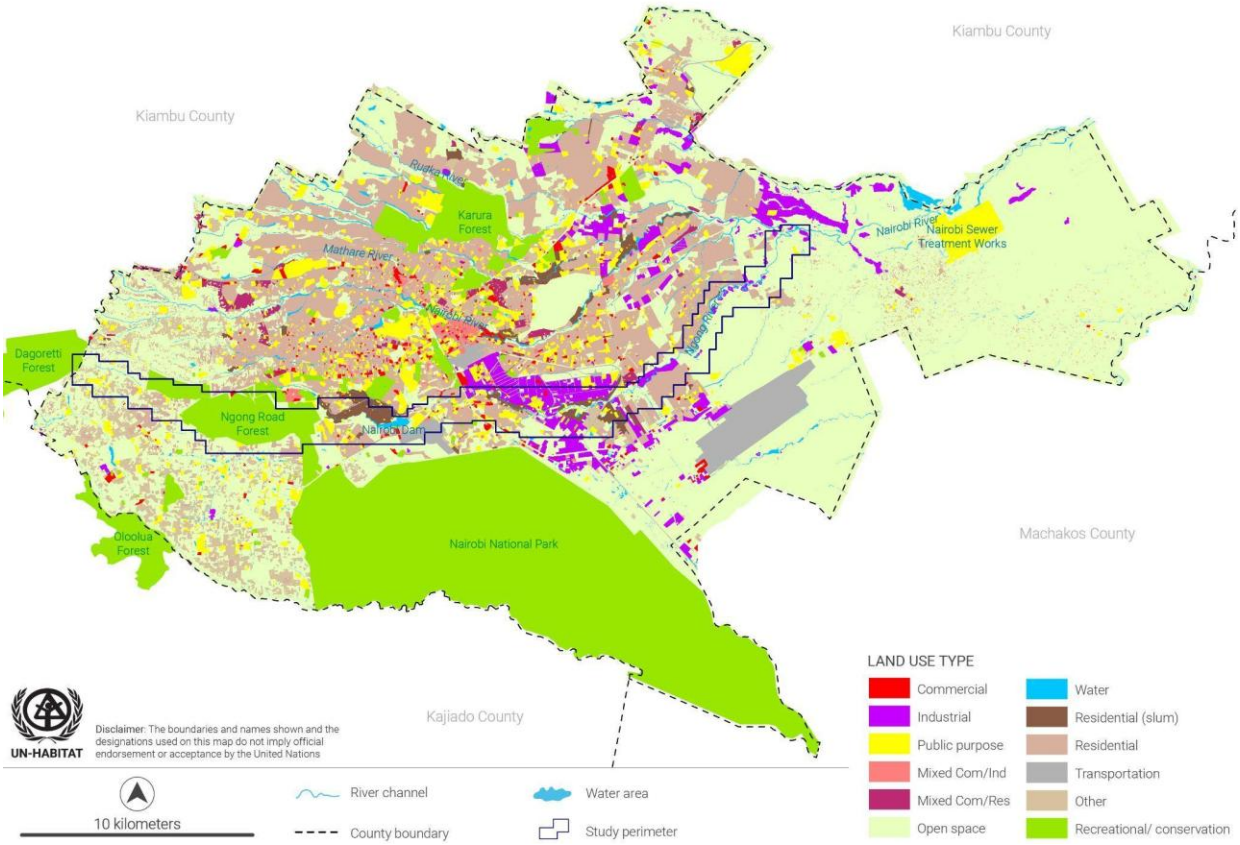
The loss of urban forests in Nairobi is likely to have implications for the city's microclimatic conditions, subsoil, and subsurface watercourses. It also reduces the city's overall forest cover in the context of increasing emissions into the atmosphere.

**iii) Ecosystem services in the Motoine/Ngong River basin**

a) Water provision: The Ngong River basin provides essential water resources for both domestic and agricultural use. In the upstream section of the Ngong River, the waters are used for domestic use including cleaning as well as irrigation of crops including maize, bananas etc.
b) Biodiversity support: The Ngong River basin supports a rich diversity of diverse plant and animal species, contributing to the conservation of biodiversity. The river also supports bamboo and nappier grass which grow on the river banks. This includes providing habitats for various wildlife and supporting ecological balance.
c) Climate regulation: The forests, including Ngong Road Forest and wetlands including the Nairobi Dam in the basin contribute to carbon seizure, helping to mitigate climate change and regulate local microclimates, which in turn supports human and agricultural productivity.

d) Recreational and cultural services: The natural landscapes of the Ngong River basin offer recreational opportunities and hold both historical and cultural significance for local communities, enhancing human well-being as well as preserving community and the city's heritage.

### f. Land use / Anthropogenic activities - Macro scale and basin level

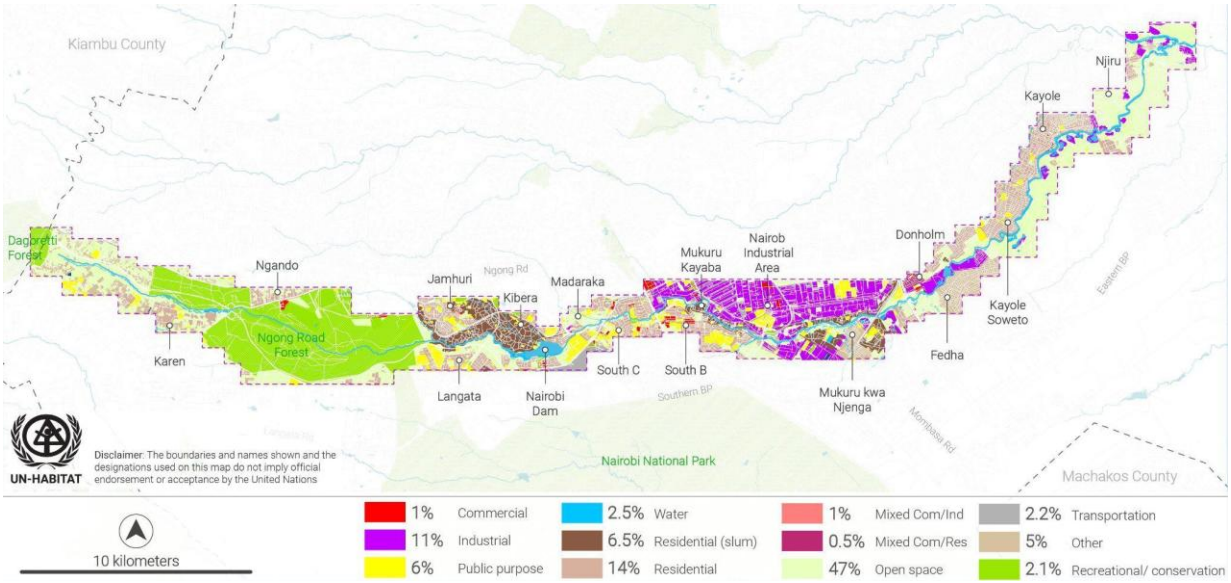



*Map 19: Landuse of Nairobi Metropolitian Area (Source: UNH)*

The main land use activities in the **upper catchment** area of the Motoine Ngong River Basin are crop and livestock farming. Both large-scale commercial and small-scale farming practices in this area involve extensive utilisation of inorganic fertilisers and manure. Consequently, this has led to an excessive influx of nutrients into the river, resulting in nutrient overload. Moreover, farming activities within the floodplain of the basin, including along the river banks, contribute to soil erosion, subsequently causing sedimentation and siltation in the rivers that form the basin. As a result, turbidity increases, and there is a reduction in the amount of light that can penetrate the water to support primary productivity[74]. Unsustainable agricultural practices in the upper catchment area have resulted in a decrease in vegetation cover within the river basin. This reduction in vegetation cover has had adverse effects on biodiversity, leading to the loss of habitats for various plants, small and large mammals, insects, and birds. Additionally, groundwater abstraction for agricultural and residential purposes within and around the source of the river may be affecting the water table and therefore the reason for the reduced surface water

74 Makathimo, M. and Guthiga, P. (2010) Land use policies and natural resource management in Kenya: The case of Nairobi river basin

flow in the basin, especially during the dry season. Grazing of livestock in wetlands impacts on the soil structure and vegetation cover.




*Map 20: Land use analysis of Nairobi River corridor (Source: UNH)*

A large section of the **midstream** of the Ngong river basin is a floodplain[75] predominantly occupied by the urban poor living in the various informal settlements along its banks. From 2002 and 2010, the Ngong River's riparian areas underwent a transformation from mostly undeveloped to fully developed, primarily due to the establishment of informal settlements. Approximately 56%[76] city residents live in these informal settlements along the river banks[77]. Within this stretch, there are also residential estates, both informal and formal, such as Kibera, Nairobi West, South C, Kayole, Soweto, Kibarage, Embakasi, Tassia, Mukuru Kayaba, Fuata Nyayo, Mukuru kwa Rueben, Mukuru Viwandani, and Mariguini [78] and the city's industrial area where it picks up raw sewage and uncollected solid waste. Direct discharge of raw sewage from housing and untreated industrial effluents is quite common. The river serves as a conduit for a significant amount of waste-water from these settlements, leading to its characterization as an open sewer. Additionally, the dumping of solid waste is a prevalent practice in these areas, further exacerbating the pollution occurring in the river. Notably, in this section, a lot of properties (in industrial areas/formal neighbourhoods in Nairobi west) that are adjacent to the river ignore its presence, with buildings facing away from the river and very few windows looking out onto the river. At the same time, the properties also encroach on the riparian area by extending their building lines using security features such as masonry walls, planted hedges and electric fences. This leaves the river inaccessible at these points, discouraging the river's use as a public amenity – a form of privatisation of the river (source: reconnaissance walk).

75 Juma, B. et al. (2021) Analysis of rainfall patterns in the Ngong River Basin of Kenya: Towards integrated urban flood risk management
76 Sobowale, R. (2019) River Restoration in Nairobi Kenya: Exploring Public Participation and Learning Outcomes.
77 Andersen, J. et al. (2021). Perspectives of Local Community Leaders, Health Care Workers, Volunteers, Policy Makers and Academia on Climate Change Related Health Risks in Mukuru Informal Settlement in Nairobi, Kenya—A Qualitative Study.
78 Preparatory Survey for Integrated Solid Waste Management in Nairobi City, JICA

The **downstream catchment** area of the basin is primarily characterised by residential land use, particularly semi-formal settlements (permanent housing but underserved with basic services) located on riparian land. Practices such as illegal waste disposal[79], including the direct discharge of untreated sewage[80] from housing into the river channels is common. Consequently, the rivers in this area have fully transformed into open sewer, becoming significant pollution hotspots. Before the Ngong River joins the Athi River Basin, the lower section of the river basin experiences minimal land use activities, mainly focused on agriculture. At this stage, the basin receives both treated sewage and untreated water[81] from the Dandora Sewage Treatment Plant. Additionally, stormwater inflow from various city drainage channels contributes to the pollution of the river. Further downstream, in the Ruai area, there are thriving agricultural farms that rely on water from the river for irrigation.

The various land use systems within the basin contribute significantly to pollutants, pollution and water quality degradation as well as to changes in river hydrology,

| **Different points in the Ngong river** | **Anthropogenic Activities** |
|---|---|
| Sampling Point 1 Ngong Forest boundary (36.773918, −1.316723) | Informal settlements near the forest boundary<br>Small scale farming |
| Sampling Point 2 Kibera Lindi Mosque (36.789409, −1.314737) | Kibera informal settlements<br>Ongoing road construction in close vicinity<br>Raw sewer discharge into the river<br>Solid waste dumping |
| Sampling Point 3 Nairobi dam (36.801664, −1.318324) | Informal reclamation and encroachment of the dam by residents<br>Small scale farming of sugarcane, kale, spinach, arrowroot, maize farming<br>Extraction of papyrus reeds from the dam<br>Animal husbandry |
| Sampling Point 4 Outering Rd Bridge (36.891182, −1.306702) | Illegal dumpsite & Mukuru Informal settlements |
| Sampling Point 5 Enterprise Rd Bridge (36.861962, −1.315906) | Industrial activities<br>Industrial discharge evident—black in colour<br>Paint and paper industries within the vicinity<br>Informal settlements—Mukuru slums<br>Direct sewer discharge<br>Solid waste dumping—leachate observed |
| Sampling Point 6 Likoni Rd Bridge (36.854686, −1.315993) | Dumpsite<br>Use of river water to clean polythene papers for recycling<br>Industrial discharge noted |
| Sampling Point 7 Mukuru Kayaba (36.849808, −1.313388) | Solid waste dumped into the river channel<br>Sewer pipes channelled to the river<br>Informal settlements, Mukuru Kayaba |

79 Preparatory Survey for Integrated Solid Waste Management in Nairobi City, JICA
80 NCWSC and AWSB, (2009). Strategic Guidelines for Improving Water and Sanitation Services in Nairobi's Informal Settlements
81 Makathimo, M. and Guthiga, P. (2010) Land use policies and natural resource management in Kenya: The case of Nairobi river basin

| | |
|---|---|
| Sampling Point 8 Soweto Embakasi Bridge (36.909088, −1.292102) | Informal settlements<br>Dumpsite |
| Sampling Point 9 Kayole (36.918681, −1.281739) | Informal settlements<br>Sewage discharge<br>Dumpsite |
| Sampling Point 10 Matopeni Twiga (36.934911, −1.265998) | Informal Settlements<br>Dumpsite—medical waste evident<br>Quarry site<br>Small scale farming |
| Sampling Point 11 Njiru-Kangundo Rd Bridge (36.945836, −1.248449) | Informal settlements<br>Factory<br>Dumpsite, dumping of medical waste evident |
| Sampling Point 12 Mong'etho before confluence (36.9541, −1.244761) | Informal settlements<br>Small scale agriculture - Pig farming<br>Dumpsite<br>Domestic runoff drains channelled to river |

*Table 2: Summary of land use and anthropogenic activities observed at different points in the Motoine/Ngong river basin*[82]

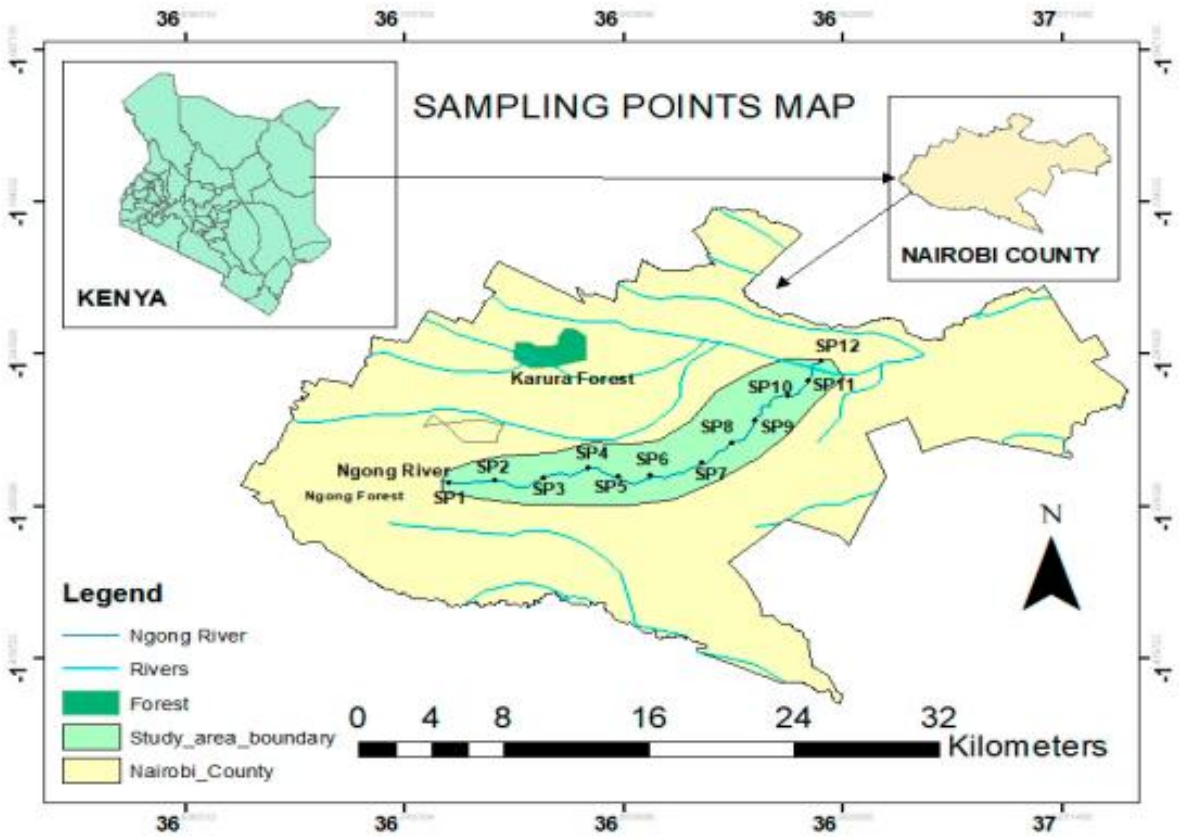
### g. Water Quality and Pollution

Twelve water samples were systematically collected in twelve study sites between April and August 2021 and analysed in the laboratory for various water quality parameters. The sampling points were namely; SP1 - Ngong Forest boundary, SP2 - Kibera Lindi Mosque, SP3 - Nairobi Dam, SP4 - Outering Rd Bridge, SP5 - Enterprise Rd Bridge, SP6 - Likoni Rd Bridge, SP7 - Mukuru Kayaba, SP8 - Soweto Embakasi Bridge, SP9 - Kayole, SP10 - Matopeni Twiga, SP11 - Njiru-Kangundo Rd Bridge, SP12 - Mong'etho before confluence[83].

Anthropogenic stresses, including industrial, unsustainable agricultural practices, and population growth, were identified as significant contributors to water pollution in the Athi and Nairobi rivers basins. In the case of Ngong River, significant water pollution primarily occurs as it flows through Nairobi city, exacerbated by the discharge of domestic and industrial effluents. This pollution poses a risk to the quality of water in urban waterways and can impact food crops grown using this contaminated water. Anthropogenic activities cause significant water quality degradation in the basin, reducing the available water resources in the basin while increasing competition in water usage and conflicts[84].

Anthropogenic activities have significant effects on the levels of biochemical oxygen demand (BOD) and subsequent degradation of water quality. Increased BOD levels can lead to a depletion of essential oxygen required for aquatic life, thereby compromising the overall integrity of the ecosystem. The measurement of total coliforms indicates high levels of faecal bacterial contamination, specifically Escherichia coli (E. coli), throughout the entire Ngong River basin.

82 Mary Ngatia, Shadrack M. Kithiia and Mihai Voda, Effects of Anthropogenic Activities on Water Quality within Ngong River Sub-Catchment, Nairobi, Kenya
83 Ngatia, M.; Kithiia, S.M.; Voda, M. Effects of Anthropogenic Activities on Water Quality within Ngong River Sub-Catchment, Nairobi, Kenya. Water 2023, 15, 660.https://doi.org/10.3390/w15040660
84 A critical analysis of the water quality impacts on water resources in the Athi River Drainage Basin, Kenya, Kithiia, M., 2021




*Map 21: Sampling points at different locations along the Motoine/Ngong river basin*[85]

The presence of faecal bacteria was even detected at the source, indicating some degree of faecal contamination due to direct sewage discharge at multiple points within the river basin. This contamination has a detrimental impact on water quality, rendering it unsuitable for both domestic and agricultural use. According to the effluent discharge standards set by the National Environmental Management Authority (NEMA), the maximum allowable limits for E. coli and total coliform counts are nil count/100 mL and 30 counts/100 mL, respectively. However, the findings of the study suggest that the actual counts of these faecal bacteria in Ngong River exceeded these limits.

The analysis of BOD values shows interesting patterns along the Ngong River. Low BOD values were recorded at the source of the river, Ngong Forest boundary, and the encroached part of Nairobi dam, both during the wet and dry seasons. This suggests that these areas have relatively less pollution affecting the water quality. However, a significant increase in BOD values was observed at the Lindi Mosque site in Kibera, with readings of 230 mg/L during the wet season and 370 mg/L during the dry season. At Mukuru Kayaba, the BOD level was recorded at 30 mg/L. However, downstream of Mukuru Kayaba, at Likoni bridge, the BOD level was found to be the highest, measuring 450 mg/L.[86] This indicates that pollutants from the Mukuru Kayaba slums are being transported downstream during the rainy season, leading to a significant increase in BOD levels at Likoni bridge. Overall, high BOD levels were observed at all sampled sites compared to the levels at the river's source. This suggests an increase in organic loads from sewage

85 Ngatia, M.; Kithiia, S.M.; Voda, M. Effects of Anthropogenic Activities on Water Quality within Ngong River Sub-Catchment, Nairobi, Kenya. Water 2023, 15, 660.https://doi.org/10.3390/w15040660
86 Ngatia, M., Kithiia, S., & Voda, M. (2023). Effects of Anthropogenic Activities on Water Quality within Ngong River Sub-Catchment, Nairobi, Kenya. 15(4). doi:https://doi.org/10.3390/w15040660

discharges, downstream contributing to the pollution of the river.

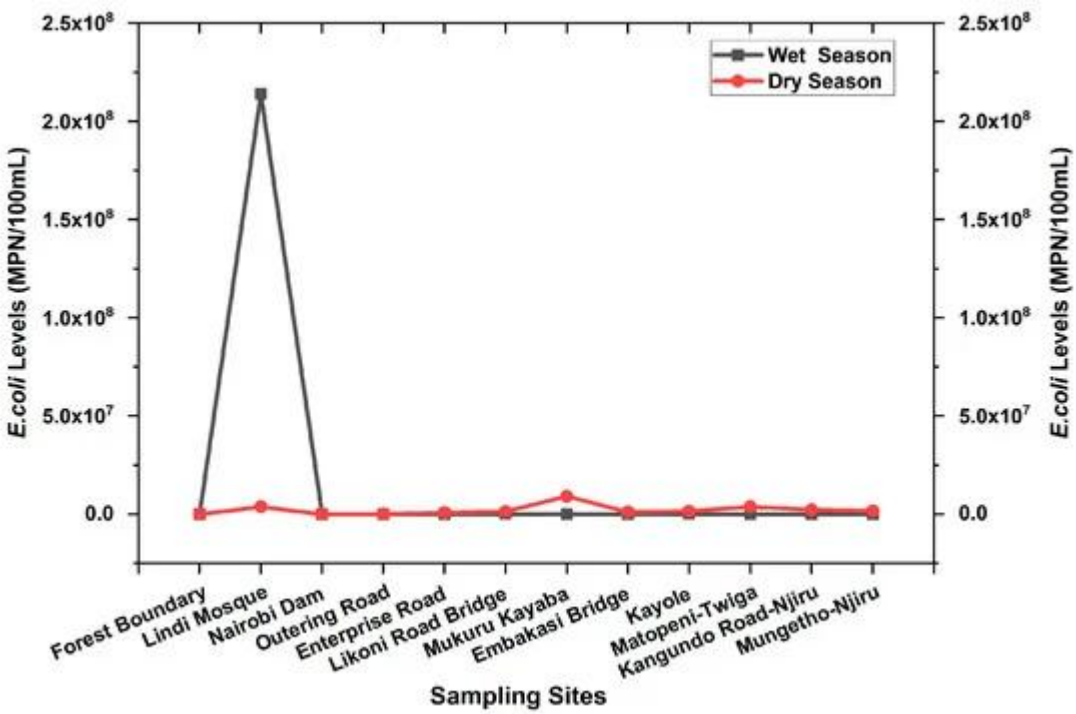



*Figure 17: E. coli levels in Ngong River measured between April and August 2021.*

The analysis of Chemical Oxygen Demand (COD) levels in Ngong River revealed varying values across different sampling sites and seasons. During the wet season, the COD levels ranged from 106 mg/L to 2182 mg/L, while during the dry season, the range was 35 mg/L to 1411 mg/L.[87] The Ngong Forest boundary consistently had the lowest COD values during both seasons, indicating relatively lower pollution levels in that area. On the other hand, the Lindi Mosque site in Kibera recorded the highest COD values for both seasons. This can be attributed to the discharge of a wide range of pollutants. Interestingly, the Nairobi dam exhibited a low COD value of 35 mg/L during the wet season and no detection of *E.coli*, suggesting a degree of self-purification of the water. The Ngong Forest boundary, despite having the lowest COD values, still recorded a relatively high value of 106 mg/L during the wet season.[88] This indicates the presence of upstream pollution, potentially from decaying plant matter from the forest and sewage contamination. Downstream from Kibera to Njiru, the COD values increased significantly due to anthropogenic activities such as sewage discharge, effluent discharge, and improper garbage disposal along the river basin. Due to the dilution capacity of the river, the wet season COD values were generally lower than those during the dry season, indicating the role of surface runoff and rainwater in the self-purification of the river.

The measured high conductivity levels indicate concentration of dissolved substances, minerals, metals and metal ions, implying that industries along the river profile are discharging more raw effluents into the river. This further means that water quality in the river will remain low, since these dissolved ions cannot be removed from the water by normal conventional water treatment methods.

87 Ngatia, M., Kithiia, S., & Voda, M. (2023). Effects of Anthropogenic Activities on Water Quality within Ngong River Sub-Catchment, Nairobi, Kenya. 15(4). doi:https://doi.org/10.3390/w15040660

88 Ibid

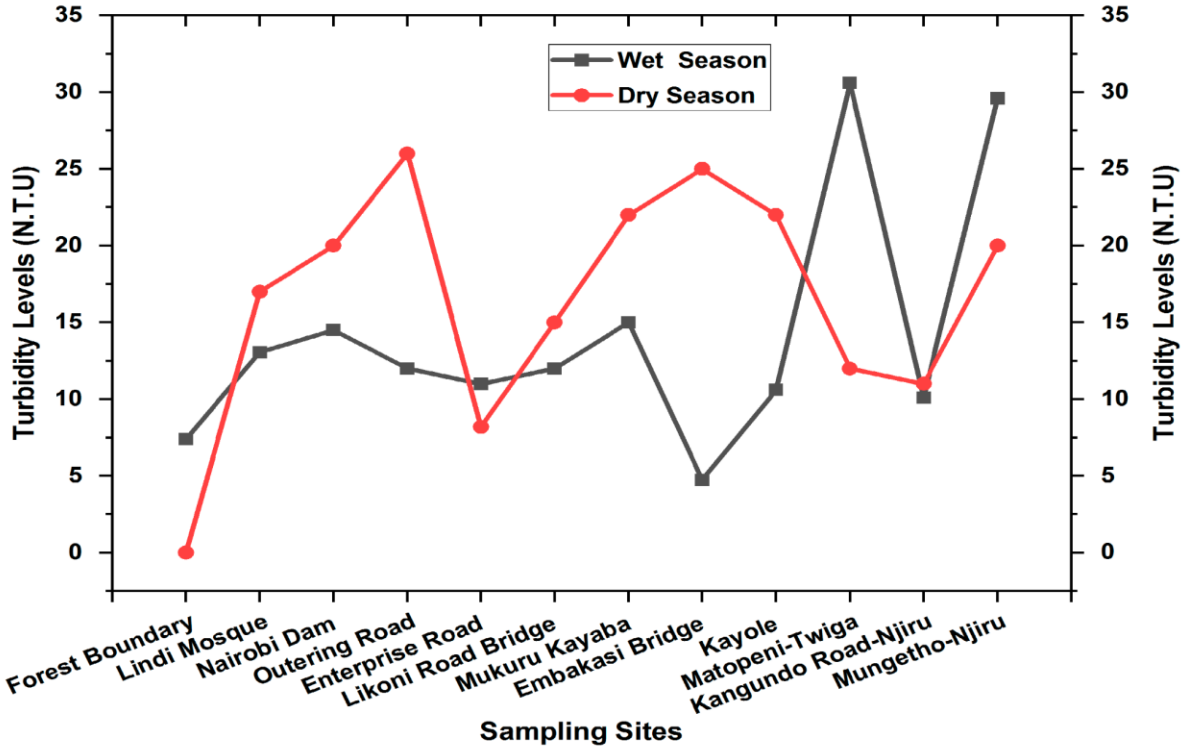


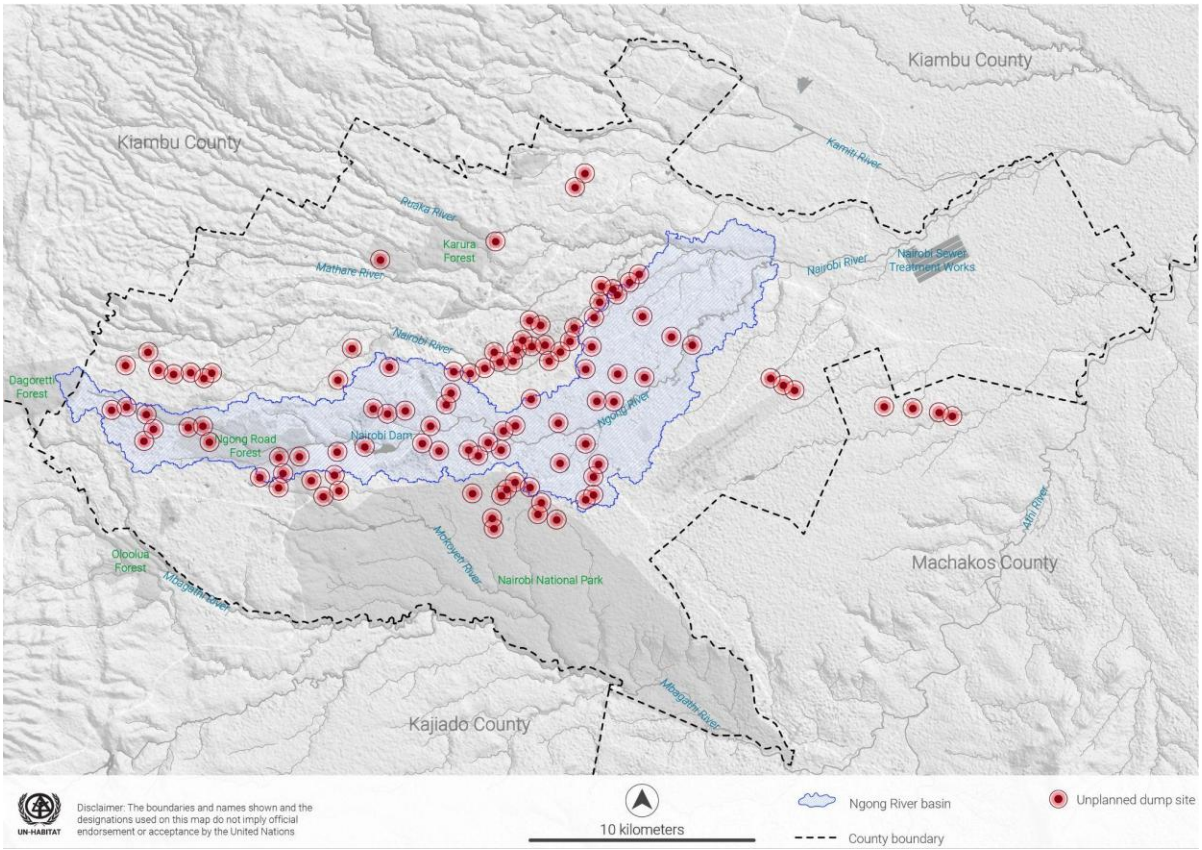

*Figure 18: Turbidity levels for Ngong River measured between April and August 2021*

The quality of the water used to irrigate crops along the Ngong River valley influenced soil characteristics, especially of the top 0-30 cm layer in both farms. Heavy metals were recorded mostly in the stem and leaves, which raise health concerns since leaves are harvested for human consumption in this crop. As expected, the soils and the plant samples contained high bacterial and parasitic loads.

The map below highlights a significant amount of illegal dumping activities occurring within the Ngong and Nairobi river basin, posing a threat to the environmental integrity and water quality of the rivers. Illegal dumping may introduce chemicals, biohazards, and non-biodegradable materials into the water and soils, leading to contamination and degradation of the river ecosystem. The accumulation of waste along the riverbanks obstructs water flow, causing flooding and potential damage to surrounding habitats and communities.

All is not lost, evidence shows that Ngong River has a strong recovery capacity. The effect of dilution increases downstream and especially at Ol Donyo Sabuk and Malindi town (Sabaki outlet) about 156 km and 650 km below the city of Nairobi. In addition, there is an effect of self purification of the river due to aeration conditions, settling, deposition of sediments and additional inflows into the main rivers from other tributaries with less polluted or good quality water. This evidence points to less interference with land use systems and anthropogenic activities will improve the water quality in the basin[89].

89 Kiithia, S. 2007. An assessment of water quality changes within the Athi and Nairobi River basins during the last decade.



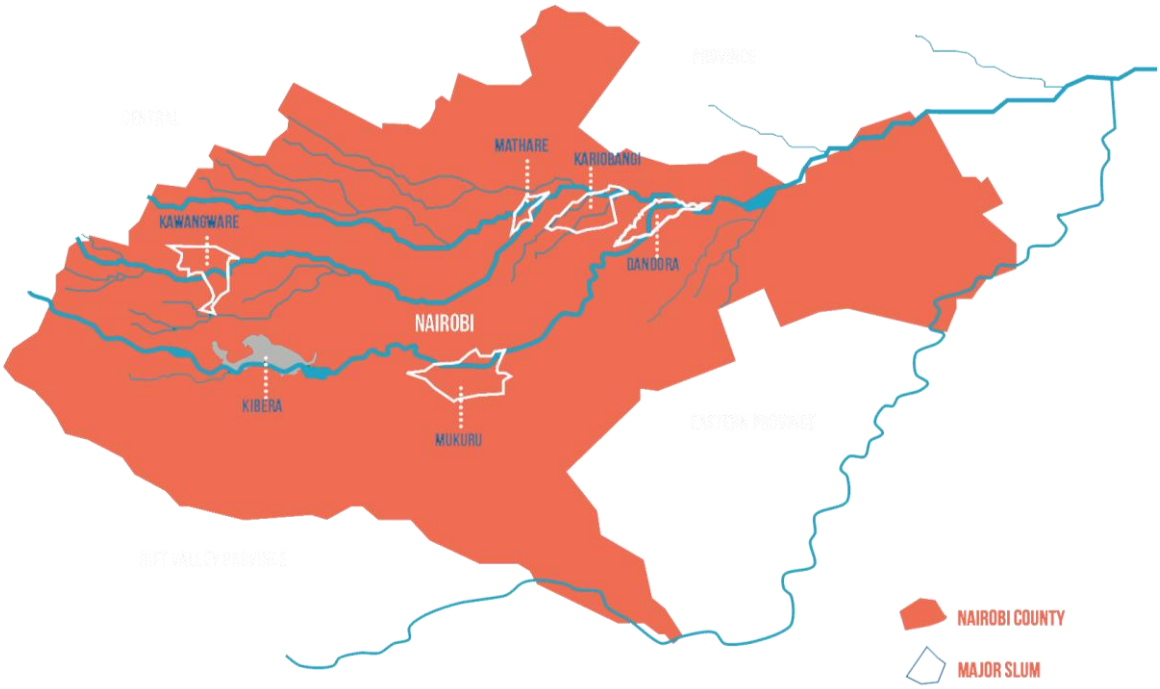

*Map 22: Ilegal dumpsites along the Ngong River Corridor (Source: UNH)*[90]

### h. Multi-hazards assessment

The frequency and intensity of disaster risks vary considerably across cities and urban areas, and so do their impacts. Climate change continues to amplify vulnerability in low-income communities across Nairobi, with many urban livelihoods at great risk to the impacts of flooding and extreme heat. Informal settlements in Nairobi are often located in low-lying or flood-prone areas close to waterways traversing the city. These sites are considered the most vulnerable land within cities, typically areas deemed undesirable and unfit for human habitation and at high risk of landslides, flooding, disease outbreaks and fires. They are made even more vulnerable by overcrowded living conditions, unsafe housing, inadequate nutrition, poor health, insufficient infrastructure and lack of safety nets. When a disaster hits, impacts can include the loss of basic services, damage or destruction of homes, reduction or loss of livelihoods, threats to food security, and the rapid spread of malnutrition and water- and vector-borne diseases[91].

90 Essence of Environmental Governance in Solid Waste Management: A Spatial Analysis of the unplanned Dumpsites in Nairobi County Authors: Ogutu Florence Akinyi, Kimata Dennis, Kweyu Raphael: African Research Journal of Education and Social Sciences, 5(2), 2018 ISSN (online): 2312-0134 |

91 Sunday Julius Abuje, Bernard Moirongo Otoki, Bernard Mugwima Njuguna, Gerryshom Munala. The Vulnerability of Nairobi to the Effects of Climate Change Between 1984 and 2016. Landscape Architecture and Regional Planning. Vol. 5, No. 2, 2020, pp. 38-45. doi: 10.11648/j.larp.20200502.14




*Map 23: Distribution of informal settlements along Nairobi's major rivers (Source: KDI, 2015)*

Climate change has ushered in a new era of unpredictable weather patterns and extreme events, with El-Nino being a potent catalyst for intensified rainfall, flooding and unprecedented damage to property, destruction of vital infrastructure, the natural environment and loss of lives. Kenya and other African countries are grappling with this reality, as rising temperatures fuel El-Nino events, resulting in heightened flood risk across the continent[92]. Additionally, a shift in regional weather patterns has made it hard to predict or expect the events of extreme rainfall and drought seasons.

The risks associated with flooding, especially in urban informal settlements, are multifaceted and profound. These densely populated areas are particularly susceptible to the devastating consequences of flooding due to inadequate infrastructure, limited access to clean water and sanitation, and overcrowded living conditions. Floodwaters can lead to the destruction of homes, disruption of livelihoods, and the spread of waterborne diseases, leaving vulnerable communities even more marginalised.

92 M. Kilavi et al. Extreme rainfall and flooding over Central Kenya including Nairobi city during the long-rains season 2018: causes, predictability, and potential for early warning and actions.

*Figure 19: Flooding in Kibera in 2015 (Source: KDI, 2015)*

*Figure 20: Effects of an extreme weather event in Kibera (Source: KDI, 2019)*

By 2050, two-thirds of the world's population may face water shortages and 90% of all disasters are water-related. The situation is predicted to become more intense and frequent because of

climate change.[93] Climate change also affects water quality in ecosystems to provide important ecosystem services. Land use stresses in the Athi River basin have led to water quality degradation affecting the flow characteristics of the rivers in the basin. Available water resources in the basin against the projected water uses and increasing population compounded by the impacts of water pollution and climate change. This is likely to increase incidences of water shortage and food insecurity in many parts of the basin. Kenya's renewable internal freshwater resources stand at 412 $m^3$/capita which is less than the global accepted value of 1000 $m^3$/year/capita. The overall implication is reduced water availability for various uses in the basin and hence affecting people's livelihood potential and leading to increased vulnerability to climate change. This is likely to have negative impacts on the people's livelihood in the basin since the majority relies on rain-fed agriculture and irrigation activities[94].

Urban areas are most at risk from heat waves and act as heat islands trapping the sun's heat in concrete building surfaces and roads. About 70% are facing the negative effects of climate change and nearly all are at risk. By 2050, 1.6 billion people in more than 970 cities will be exposed regularly to extreme high temperatures[95]. Temperature measurements and monitoring in 3 informal settlement neighbourhoods – Kibera, Mathare, and Mukuru (located within the Nairobi/Ngong river basin system) – and other control stations in the city reveal that temperatures in informal settlements in Nairobi are several degrees higher than in many residential areas. This can be attributable to the lack of vegetation, high density and the high albedo of metal housing. This exposes residents, especially infants and the elderly to heat- related illness. Large neighbourhoods of informal settlements are characterised by dense metal housing, little vegetation, and limited access to public utilities and government services. The population residing in these settlements are potentially highly vulnerable to heat exposure due to a lack of information on heat wave occurrence and risk, inadequate access to routine health services, limited access to potable water, limited household ventilation and cooling centres[96].

Air pollution in Mukuru, located in the city's industrial area, is a significant concern. Many residents in Mukuru rely on biomass fuels such as charcoal, firewood, and kerosene for cooking, heating, and lighting, which are associated with high emissions of particulate matter. Additionally, the burning of materials like plastics and cloth rags in outdoor areas contributes to the pollution problem.

Initial findings from a study[97] indicate that levels of particulate matter are high both outside and inside the houses in Mukuru. Peaks in particulate matter concentrations are observed indoors during evening meal preparation when cooking activities are most intense. Poor ventilation exacerbates the issue, as closing windows and doors during cooking leads to dangerous levels of pollutants accumulating indoors. The health impact of this air pollution is particularly severe for vulnerable groups, such as families with children, pregnant women, and the elderly. These groups are more susceptible to the adverse effects of exposure to high levels of particulate matter. The study also identified high levels of nitrogen dioxide ($NO_2$) and ammonia ($NH_3$) in Mukuru. Ammonia levels were especially pronounced across the nine measurement sites, with an average

93 UN statistic
94 A critical analysis of the water quality impacts on water resources in the Athi River Drainage Basin, Kenya, Kithiia, M., 2021
95 UN statistic
96 Scott A., et al. (2017). Temperature and heat in informal settlements in Nairobi. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0187300
97 West, S. E., Büker, P., Ashmore, M., Njoroge, G., Welden, N., Muhoza, C., Osano, P., Makau, J., Njoroge, P. and Apondo, W. (2020). Particulate matter pollution in an informal settlement in Nairobi: Using citizen science to make the invisible visible. Applied Geography, 114. 102133. https://doi.org/10.1016/j.apgeog.2019.102133

concentration of 45.73 µg/m3 – thirteen times higher than levels recorded at a reference site.[98] Open dumpsites and the presence of free-flowing human waste were identified as potential sources of ammonia emissions.

**Interconnected major concerns and environmental issues within the Ngong River Basin**

| **Major Concern** | I. Land Use systems & activities | II. Land Cover Change | III. Unsustainable exploitation | IV. Fresh water shortage | V. Global Change |
|---|---|---|---|---|---|
| **Environmental Issues** | **Pollution**<br><br>1. Microbiological<br><br>2. Eutrophication<br><br>3. Chemical<br><br>4. Solid wastes<br><br>5. Suspended particles<br><br>6. Dissolved metals and ions | 7. Loss of ecosystems and habitat loss<br><br>8. Increased streamflow<br><br>9. Reduction in baseflow<br><br>10. Extreme flooding<br><br>11. Heat Island effect | 12. Over-exploitation of ground water sources<br><br>13. Pollution | 14. Modification of stream flow<br><br>15. Pollution of existing supplies<br><br>16. Water table changes | 17. Shifts in climate patterns<br><br>18. Changes in hydrological cycle<br><br>19. Sea level change<br><br>20 . Extreme weather events |

*Table 3: Adapted and modified from Royal Swedish Academy of Sciences (2004)*

### Iii. Social –Spatial Mapping

The state of urbanisation and population increase continues to be more pronounced and causes a strain between the human population and freshwater bodies.[99] Globally, over 50% of the global population lives closer than 3 km to a surface freshwater body and only 10% of the population lives further than 10 km away. This has led to high levels of freshwater pollution, primarily attributed to physical, socio-economic and cultural factors.[100]

This chapter looks into the socio-spatial factors impacting the Ngong River. In this section, we analyze the types of settlements, the demographics, livelihoods, and the social and cultural dynamics of the communities living along the river corridor. By studying their settlement patterns and economic activities, we understand the interactions between human activities and the river's ecosystem.

Moreover, this chapter highlights the cultural diversity and social networks that shape and are shaped by the river, providing a deeper understanding of the complex relationship between the Ngong River and the riparian communities.

98 Ngatia, M., Kithiia, S., & Voda, M. (2023). Effects of Anthropogenic Activities on Water Quality within Ngong River Sub-Catchment, Nairobi, Kenya. 15(4). doi:https://doi.org/10.3390/w15040660
99 Connor, R. (2015). The United Nations world water development report 2015: water for a sustainable world (Vol. 1). UNESCO Publishing.
100 Bonaiuto, M., Fornara, F., Ariccio, S., Cancellieri, U. G., & Rahimi, L. (2015). Perceived residential environment quality indicators (PREQIs) relevance for UN-HABITAT City Prosperity Index (CPI). Habitat International, 45, 53-63.

### a. Settlement typologies

The Ngong River flows through four administrative counties: Nairobi, Kiambu, Kajiado and Machakos. Along its course, human settlements have emerged, exhibiting diverse typologies and facing various challenges. The settlements along the Ngong River can be categorised into urban and peri-urban areas. Their distribution is influenced by factors such as topography, accessibility, economic activities, and historical development. In the peri-urban areas, human settlements are often found in proximity to the river, taking advantage of its water resources for agriculture and domestic purposes.

*Figure 21: Kibera informal settlements during the high rainfall season © Uwezo Foundation*

Informal settlements such as Kibera, Mukuru (Viwandani, Ruben and Njenga) and Kayole, are characterized by high population density, inadequate infrastructure, substandard housing conditions, and a lack of essential services such as sanitation, clean water, and electricity. The land tenure in these settlements is often informal, contributing to the precarious living conditions of residents. The lack of proper waste disposal systems leads to direct discharge of sewage and solid waste into the river, while the high population density increases pollution levels, contributing to water contamination and the spread of waterborne diseases.

Medium density settlements such as Jamhuri, Langata, South B, South C and Madaraka are better planned with better infrastructure and services, compared to the lower income areas. These areas generally have better waste management and sewage systems, reducing direct pollution. However, run-off from paved surfaces often carry pollutants such into the river, affecting its quality.

The neighbourhoods of Karen and Ngando are located upstream with low densities. These are well-planned neighborhoods with high-quality infrastructure, extensive green spaces, and comprehensive access to basic services and amenities.These areas typically have efficient waste disposal and sewage treatment systems. However, some of these developments have been built on riparian areas, highly impacting the river's ecosystem.


*Map 24: Building densities within the Ngong river basin (Prepared by S.K Imujaro, UNH, 2023*

*Figure 22: The Karen neighbourhood in Nairobi, Kenya*

In the industrial area and major commercial and mixed-use zones along the river, the developments significantly impact the river. Industrial discharges, including chemicals, heavy metals, and untreated wastewater, as well as commercial effluents are significant sources of pollution.

Despite the differences in the challenges experienced in various settlements along the river, there are a number of cross-cutting challenges associated with their proximity to the river, such as pollution and the increased risk of flooding during periods of heavy rainfall[101]. Additionally, erosion along the riverbanks often leads to land degradation and threatens the stability of nearby settlements.

### b. Demographics

The Ngong River flows through densely populated regions, particularly informal settlements such as Kibera and Mukuru, which are among the largest slums in Nairobi.

Kibera, one of the largest slums in Africa, is home to an estimated population of between 250,000 to 300,000 people within an area of about 2.5 square kilometres, resulting in a population density of approximately 100,000 to 120,000 people per square kilometre[102]. Similarly, Mukuru hosts over 100,000 residents in a comparably small area, leading to very high population densities. Mukuru is divided into several sections, including Mukuru Kwa Njenga, Mukuru Kwa Reuben, and Mukuru Viwandani, each with its own unique population

[101] Parikh, P., Parikh, H., & McRobie, A. (2013). The role of infrastructure in improving human settlements. *Proceedings of the Institution of Civil Engineers-Urban Design and Planning*, *166*(2), 101-118.
[102] UN-HABITAT (2006). *Kibera Integrated Water, Sanitation and Waste Management Project*. Nairobi, Kenya.

and challenges[103].

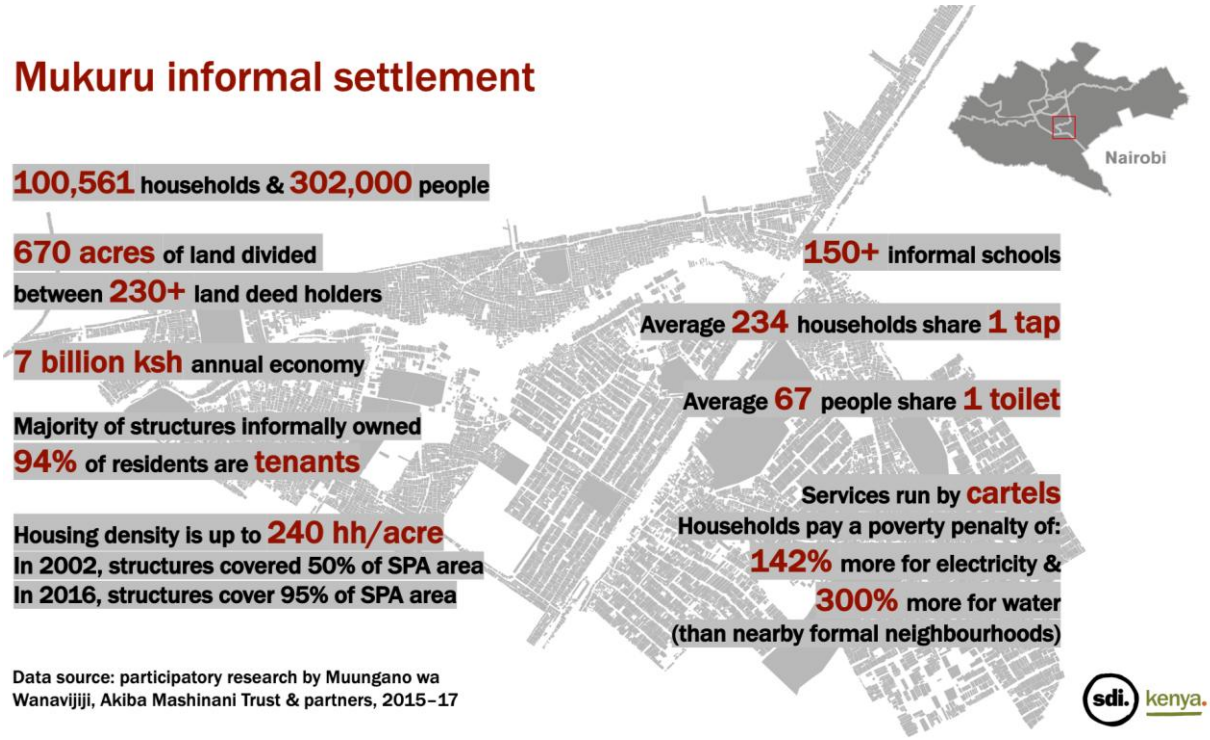



*Figure 23: Mukuru informal settlement facts, 2017*

Mukuru Kwa Njenga, for instance, has a population of approximately 70,000 people living in an area of about 1.2 square kilometres, yielding a population density of around 58,000 people per square kilometre. Mukuru Kwa Reuben and Mukuru Viwandani also have similarly high population densities, contributing to the overall crowded conditions in the Mukuru area[104].

These areas are characterized by significant challenges related to poverty and inadequate infrastructure. The population in these settlements comprises a mix of ethnic groups and includes many low-income earners engaged in informal economic activities such as small-scale trading, casual labour, and artisanal work. The lack of basic services such as clean water, sanitation, and healthcare exacerbates the hardships faced by the residents. Additionally, the overcrowded living conditions contribute to various social and environmental issues, including crime, pollution, and vulnerability to diseases.

[103] Amnesty International (2009). *Kenya: The Unseen Majority - Nairobi's Two Million Slum-Dwellers*. London: Amnesty International Publications.
[104] African Population and Health Research Center (APHRC) (2014). *Population and Health Dynamics in Nairobi's Informal Settlements: Report of the Nairobi Cross-sectional Slums Survey (NCSS) 2012*. Nairobi, Kenya.

*Figure 24: Pollution of the Ngong river (Source: KDI, 2023)*

Kibera and Mukuru also face significant environmental challenges due to their proximity to the Ngong River. The river, often polluted with waste and sewage from the settlements, poses health risks to the residents who may rely on its water for domestic use. Efforts to manage waste and improve sanitation are often hampered by the dense population and limited infrastructure. In Kibera, for example, inadequate waste management systems result in the accumulation of garbage in the streets and the river, further contaminating the water supply[105].

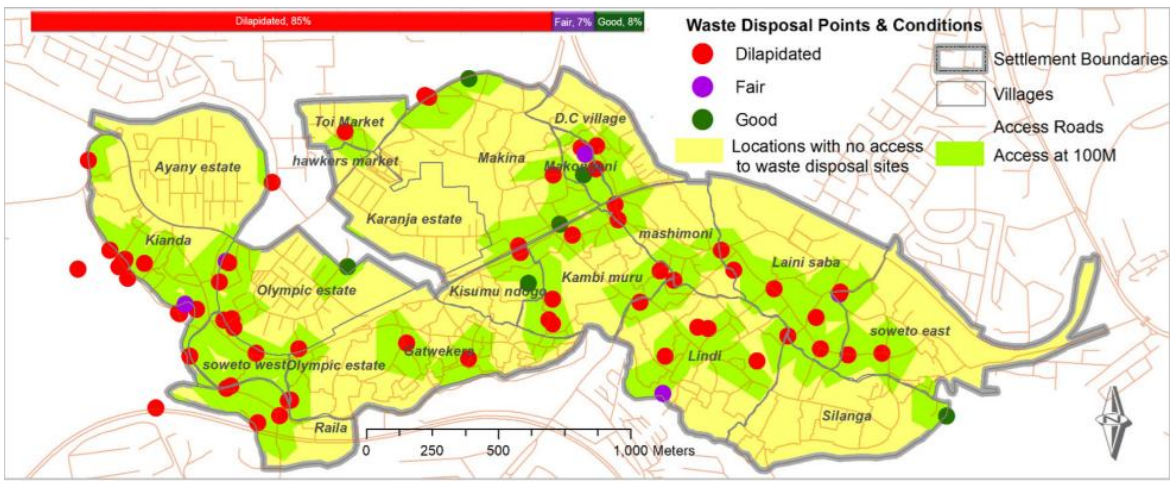



*Figure 25: Distribution and condition of waste management facilities in Kibera settlements © UN Habitat, 2020*

Education and employment opportunities are also limited in these areas. Many children are unable to attend school regularly due to economic pressures, and the quality of education in informal settlements is often substandard. In Mukuru, for example, schools are frequently overcrowded, with teacher-to-student ratios far exceeding recommended levels. Unemployment and underemployment rates are high, with many residents relying on

105 Mungai, D. N., & Adams, W. M. (2005). Peri-urban Water Quality and Health: A Case Study of Ngong River in Kenya. Nairobi: Kenya Water Institute.

precarious informal jobs that offer little security or benefits[106]. In Kibera, beyond access to facilities, it is noted that the settlement is compact, and over 90% of the education facilities are in cramped spaces that do not meet general space standards for schools.

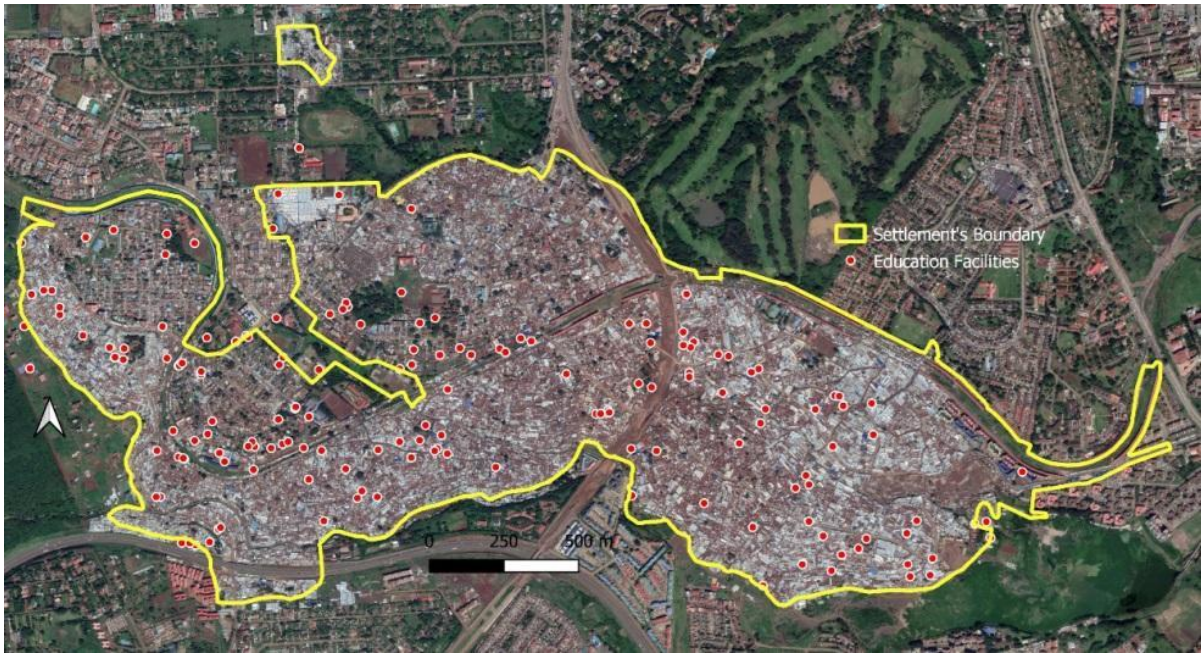



*Figure 26: Distribution of educational facilities in Kibera settlements © UN Habitat, 2020*

Despite these challenges, the communities in Kibera and Mukuru exhibit resilience and resourcefulness. Numerous local and international non-governmental organizations (NGOs) operate in these areas, providing various forms of assistance, including healthcare, education, and economic empowerment programs. Community-based initiatives also play a crucial role in improving living conditions and advocating for the rights of residents. In Mukuru, for instance, initiatives like the Mukuru Slum Development Project work to improve housing and infrastructure, while in Kibera, programs such as Shining Hope for Communities (SHOFCO) provide essential services and support.

### C. Livelihoods

The livelihood typologies of the population along the Ngong River basin vary depending on the location, economic activities, and available resources. These include Agriculture and Farming which forms a significant livelihood typology along the Ngong River basin. Farmers cultivate crops such as vegetables taking advantage of the fertile soil and access to water resources. Livestock rearing, including cattle, goats, and poultry, is also prevalent. Both subsistence and commercial farming practices can be observed, with farmers selling their produce in local markets or to larger urban centres.

The River supports fishing activities in certain areas (upstream). Fishermen engage in small-scale fishing, using traditional techniques or modern methods. In addition, aquaculture, the farming of fish and other aquatic organisms, may be practised in some sections of the river or in dedicated fish ponds. Fish and other aquatic resources contribute to the local economy

106 UNESCO (2010). Education for All Global Monitoring Report 2010: Reaching the Marginalized. Paris: UNESCO.

and provide a source of protein for communities.

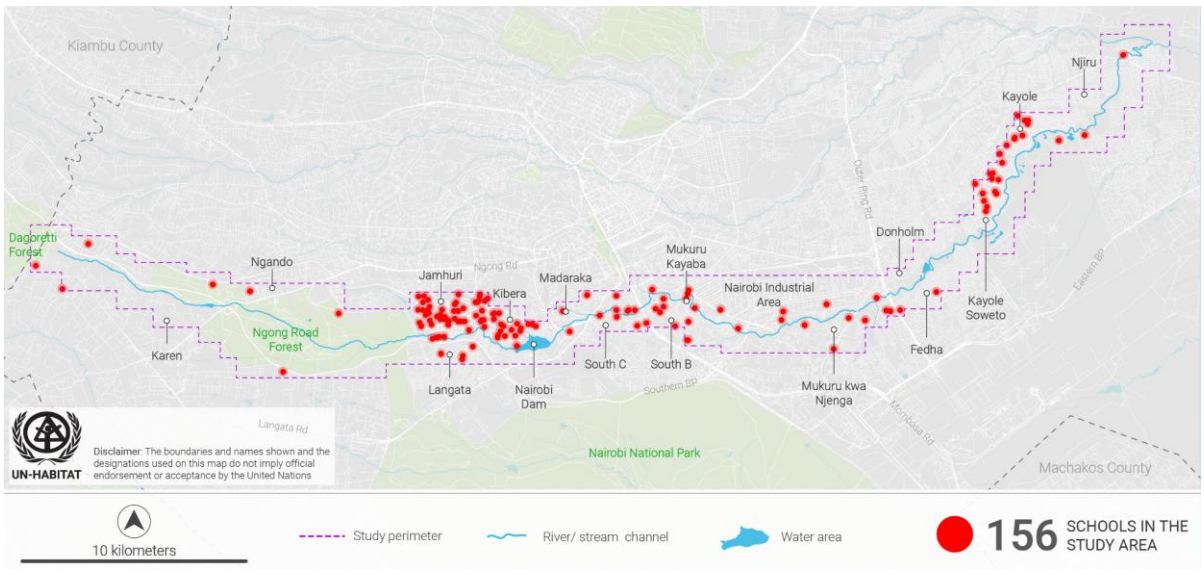
Additionally, with its scenic beauty and proximity to Nairobi, the river in certain areas attracts tourists and visitors. Settlements located in tourist hotspots, such as Karen and its environs, engage in tourism and hospitality-related livelihoods. These include guesthouses, hotels, restaurants, tour operators, and souvenir shops.

The human settlements situated closer to urban centres, such as Nairobi, often engage in trade and commerce activities. These settlements may have vibrant marketplaces, small shops, and businesses that cater to the needs of both the local population and visitors. Trading involves a variety of goods, including agricultural produce, crafts, household items, and other commodities. Manufacturing and industrial activities exist along the Ngong River which hosts factories, processing plants, and workshops that contribute to local and national economies. Industries such as food processing, textile manufacturing, construction materials, and small-scale enterprises can be found.

*Figure 27: Section of the Ngong River in the Nairobi Industrial Area © Nation Kenya*

### d. Social and Cultural services

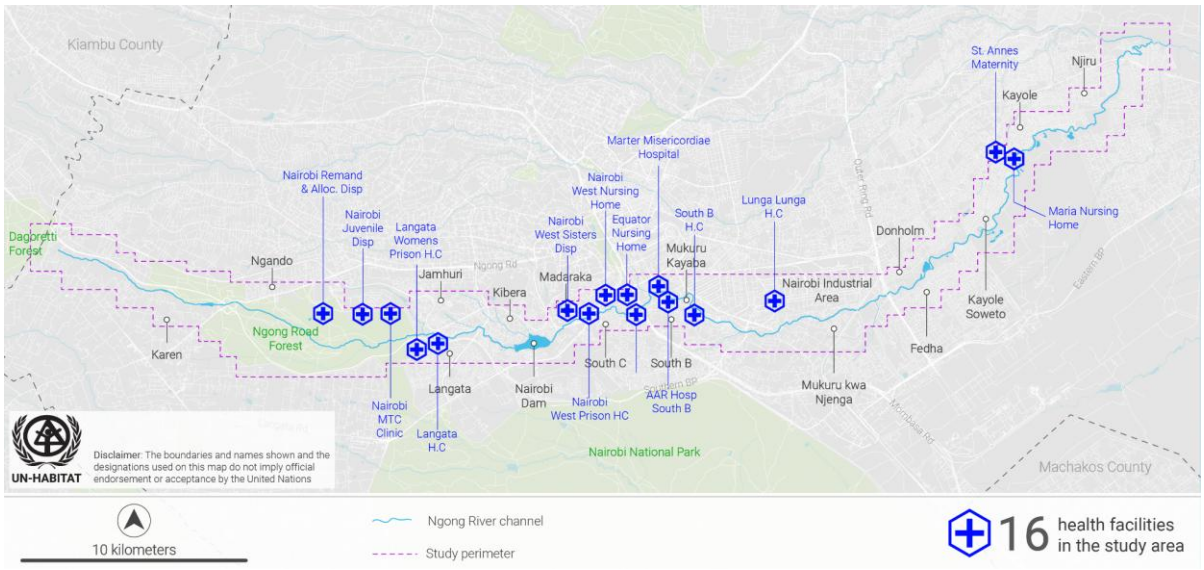
There are various social and cultural services that cater to the needs and well-being of the communities residing in the areas around the Ngong River Basin. These services include educational facilities that play a vital role in providing formal education to the population. These include primary schools, secondary schools, and vocational training centres. The map below shows some of the schools located within the basin area.




*Map 25: Educational facilities within the Ngong river basin (Prepared by S.K Imujaro, UNH, 2023)*

Along the Ngong River Basin, there are a number of health clinics, dispensaries, and hospitals that provide medical care, treatment, and preventive services. These facilities play a significant role in promoting public health and addressing healthcare needs.

Other services that exist along the stretch of this basin are community centres, religious institutions, markets and commercial hubs that all serve the communities and residents living along the basin.




*Map 26: Health facilities within the Ngong river basin (Prepared by S.K Imujaro, UNH, 2023)*

e. Subsection Summary (emerging trends/concerns; recommendations)

From the assessment, the following have been identified as the main issues:

### IV. Spatial-Economic Assessment (at macro scale)

1. Formal and informal Economic Activities
2. Wealth indicators (data needs to be added - primary data)
3. Subsection Summary (emerging trends/concerns; recommendations)

### V. Infrastructure Analysis

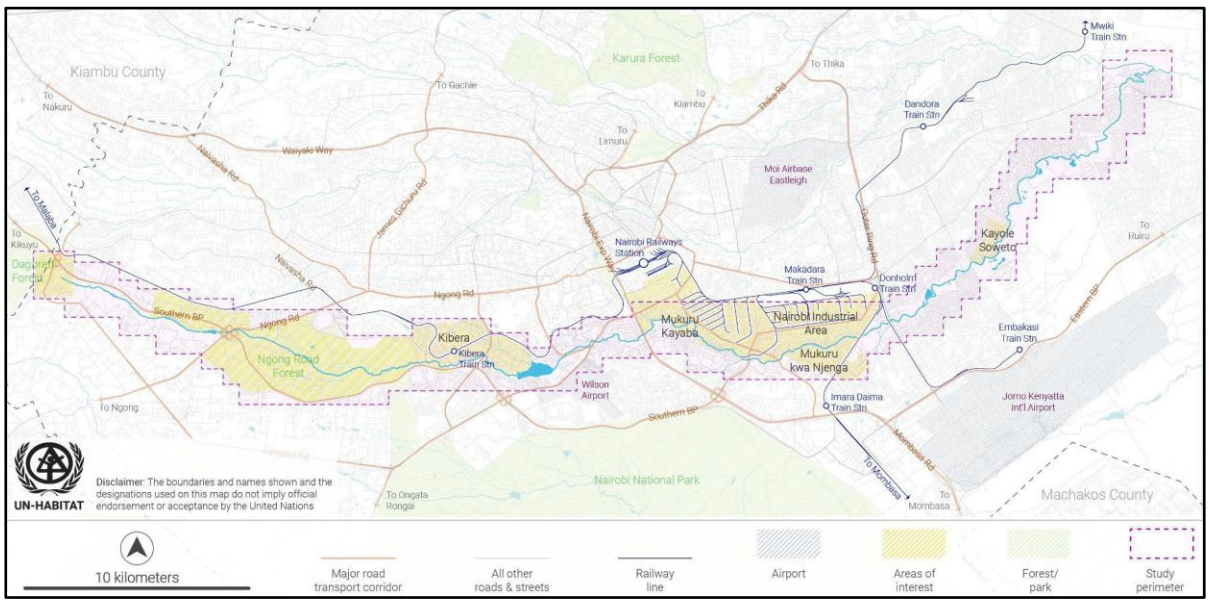
This chapter examines the infrastructure within the Ngong River basin, focusing on access and transport, fresh water and wastewater systems, solid waste management, and drainage. It begins with an analysis of transport infrastructure, highlighting how road networks and accessibility impact the watershed. Next, it explores fresh water and wastewater infrastructure, assessing the systems in place for water supply and sewage treatment. Solid waste management is evaluated, detailing the collection, disposal, and recycling mechanisms. The section also reviews the drainage system, discussing its role in flood prevention and water flow management. The chapter concludes with a summary of emerging trends and concerns, such as increasing urbanization and its impact on infrastructure.

**Access/Transport infrastructure**

Nairobi is accessible by air and land through JKIA & Wilson as well as a network of roads that connect to the rest of the counties and neighbouring countries. The Ngong River is accessible through a network of major and minor roads that cover almost the entire Nairobi City. Some of the main access roads are Southern Bypass, Ngong, Missing Link Road 12, Lang'ata Road, Enterprise Road, Outer Ring Road, and Mombasa Road/ ExpressWay. The map below shows these major roads. The Classification System defines roads in two classes; National Trunk Roads and County Roads as provided for in the Constitution 2010. The Constitution of Kenya 2010, classifies roads into two classes, that is, national trunk roads and county roads. Both classes form a network that connects various parts of the city and connects the city to the neighbouring counties and beyond through Nairobi, with Mombasa Road and Thika Superhighway.

Most county infrastructures including transport infrastructure have not been adequately maintained thus significantly frazzled. There is a need for proper rehabilitation aimed at bringing them back to a desirable condition. In Nairobi City County, road transport stands as the main transport mode and caters to the movement of more than 80 % of goods, services as well as people both within and beyond the City. Nairobi's road network for the past one and half decade has largely stayed inelastic with a total of about 2970 kilometres, 42%existing as earthen, 20 % murram and just 38 %being of bitumen quality.[107] Dumping often leads to blocked drainage infrastructure, which in turn repeatedly results in flash floods. Unending efforts aimed at unblocking and expanding the drainage infrastructure is required in order to prevent both loss of lives and destruction of property in the rainy season.

107 Nairobi City County County (2018). County Annual Development Plan 2019/2020. Available at: https://nairobiassembly.go.ke/ncca/wp-content/uploads/paperlaid/2018/ADP-for-the-FY-2019-20.pdf (Accessed 6 July 2023)




*Map 27:Transportation infrastucture along Ngong River (Prepared by S.K Imujaro, UNH, 2023)*

**Fresh Water & waste water infrastructure/systems**

Water Access

The Constitution of Kenya 2010, Article 43 (d) states that "every person has the right to clean and safe water in adequate quantities and to reasonable standards." However, Nairobi City, like many other fast-growing cities in developing economies, faces water challenges. The City's water supply cannot meet the ever-growing demand for clean water.[108] Quite a good number of the city residents do not have direct piped water connections at the household level. Those connected to this critical commodity do not often have a constant supply of it. The lack of reliability pushes many city dwellers to find alternatives, including informal water suppliers. The Nairobi City Water and Sewerage Company (NCWSC) is the main supplier of piped water in Nairobi, with offices across the city, including in Kibera and Kayole Soweto.

Most of these unregulated providers obtain water from utility companies and supply the same at a fee that is higher than the cost of legal fees. The situation is worse in informal settlements, making the scenario a perfect example of what befits the term 'poverty tax'. Despite paying more for the commodity, there is never a guarantee of clean water. Since these informal water vendors are unregulated, they can easily occasion artificial water shortages by either disconnecting water supply pipes or by diverting the water supply to other places that are convenient for them.[109] Even though such acts of vandalism are illegal, deemed criminal offences, and punishable by law, the practice continues to thrive hence the water supply challenge continues.

Figures from the Water Services Regulatory Board shows that as of 2020, up to 79% of Nairobi residents have access to water compared to 77% in 2019. According to Kenya

108 Ledant, M. (2019). 'Water in Nairobi: Unveiling inequalities and its causes', Open Edition Journal, vol. 263, Available at: https://doi.org/10.4000/com.6951 (Accessed 12 July 2023).
109 Owino H (2021), 'Aerial Piped Water Improving Lives in Kenya's Kibera Slum' Available at https://infonile.org/en/2021/11/aerial-piped-water-improving-lives-in-kenyas-kibera-slum/ (Accessed 7 July 2023).

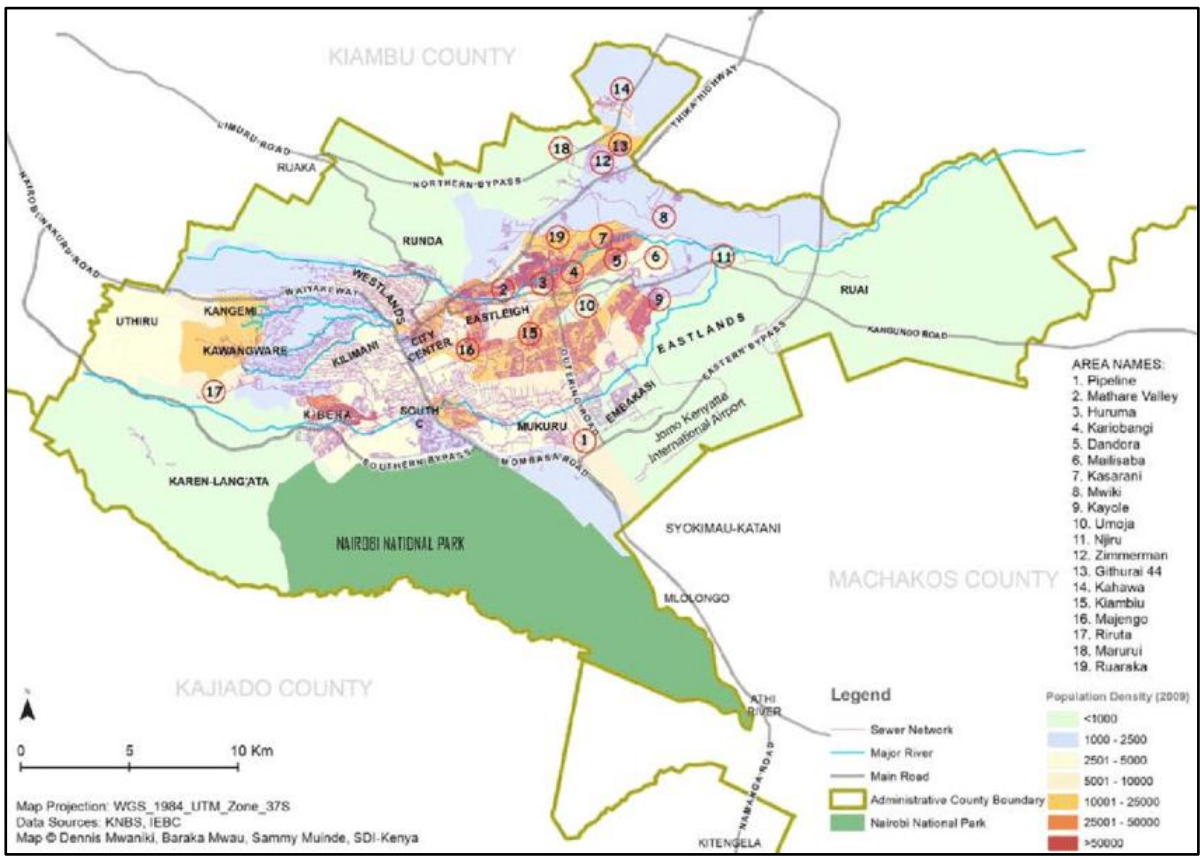
Population and Housing Census 2019, 45.1% of Kibera residents rely on public tap/standpipes, while 20.6% have water piped to yard/plot and 11% have water supply piped to their dwellings. Residents who depend on water vendors account for 16.1%, bottled water 3.8%, and protected wells/springs 1.7%, while other sources, including harvested rainwater, boreholes etc, account for 1.5%. Most of the piped water within these low-income neighbourhoods are plastic water pipes that run above the ground, along rivers, trenches, and drainages, exposing them to breakage, intentional tampering, contamination, and exploitation.

**Wastewater infrastructure**

The Nairobi City Water and Sewerage Company (NCWSC) has a duty to supply clean water and provide sewerage services to Nairobi City County. As the legally mandated agency, NCWSC is expected to provide these critical services in the most financially sustainable way and in line with the laid down government regulations.[110] According to Kenya Population and Housing Census, 2019, the city had a population of 5.9 million, and the Nairobi County Integrated Development Plan projects that in three years, the population would rise to 5.9 million residents. Athi Water Works Development Agency (AWWDA) is the asset-holding body of NCWSC and is responsible for developing key infrastructure for water and sewerage. Despite the efforts to lay the necessary infrastructure, the fast population growth challenges NCWSC in terms of providing adequate sewerage for the City's dwellers.

One of the impediments to the provision of sewer services in different parts of the city includes wayleave encroachment and subsequent delays occasioned by the extended time needed to secure the wayleaves. Most of the encroachment on the riparian wayleaves has happened around the low-income neighbourhoods and mostly the city's informal settlements. This poses a major challenge to laying down the sewer lines and in turn limiting access to the sewerage system in the city. To a greater extent, the challenge of wayleaves emanates from conflicting sections of multiple sectoral laws, including EMCA, Physical Planning and Land Use Act, Chapter 286.[111] The situation is further worsened by the poor enforcement of the existing policies by the responsible authorities.

110 Athi Water Services Board (2018). Provision of sewerage in major towns in Kenya: A case study of Nairobi City. Available at: https://www.oagkenya.go.ke/wp-content/uploads/2023/01/Provision-of-Sewerage-in-Major-Town-A-Case-of-Nairobi-City-County-2018.pdf (Accessed: 1 July 2023).
111 Athi Water Services Board. (2018) Provision of sewerage in major towns in Kenya: A case study of Nairobi City. Available at: https://www.oagkenya.go.ke/wp-content/uploads/2023/01/Provision-of-Sewerage-in-Major-Town-A-Case-of-Nairobi-City-County-2018.pdf (Accessed: 1 July 2023).




*Map 28: Sewer line coverage in Nairobi (UNH, 2023)112*

A 2018 audit by the AWSB revealed that sewerage is not well maintained in Nairobi, leading to frequent bursts and overflow on different parts of the city. The blockages and overflows that are often witnessed in the city are partly a result of the dumping of waste into the open manholes. According to the Nairobi Metropolitan Area (NMA) infrastructure report 2021, the sewerage coverage of Nairobi City County stood at 19%. Most of this formal sewer network only caters to formal neighbourhoods or the high-income areas. Informal settlements and low-income areas are often forced to use other forms including unsewered public toilets and direct injection into the rivers forming a major source of river pollution in Nairobi.

As part of the Government of Kenya's efforts to address the challenge of sewerage in urban areas in Kenya including Nairobi, it has invested in capital-intensive projects such as the Nairobi Rivers Sewerage Improvement Project (NaRSIP). Other initiatives that the government has undertaken to improve access to sewerage services include the Nairobi Water and Sewerage Emergency Physical Investment Project (NWSEPIP) Mukuru Sewers, which involved laying sewer lines in Mukuru kwa Njenga. Apart from that, the government has made efforts to implement innovative sewer solutions such as the simplified sewer system (SSS). NCWSC and stakeholders at Mukuru kwa Ruben's Mosque Road implemented SSS that entailed both improvement and extension of the sewer system to ensure better sanitation.[113] Further, the pilot was aimed at demonstrating the effectiveness of SSS in

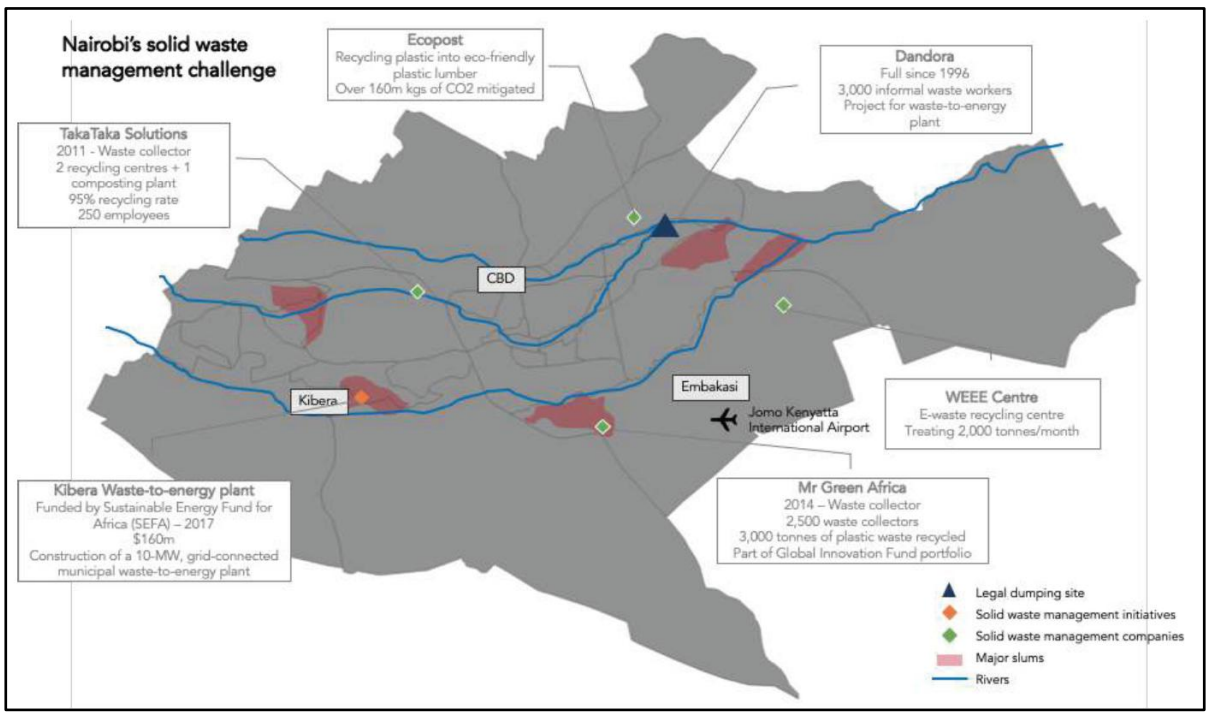
112 Mwau, B., Sverdlik, A., & Makau, J. (2020). Urban transformation and the politics of shelter: Understanding Nairobi's housing markets. International Institute for Environment and Development (IIED). Retrieved from https://www.iied.org/sites/default/files/pdfs/migrate/10876IIED.pdf (Accessed: 3/07/23).
113 Nairobi City Water and Sewerage Company. (2023). Simplified sewer system project on course. Retrieved from https://www.nairobiwater.co.ke/simplified-sewer-system-project-on-course/ (Accessed: 10/07/23).

mitigating sanitation issues within informal settlements.

### Solid Waste Management infrastructure/systems

Despite the existence of the Nairobi City County Solid Waste Management Act which came into force in 2015, Nairobi City still suffers from poor solid waste management. This lack of has seen the emergence of illegal dumpsites in many areas across the city including on rivers and their riparian reserves. The highest sources of water quality variations in Nairobi's Ngong River water are a result of anthropogenic activities. The degree of the river's pollution is relatively high because of domestic effluents as well as sewer discharge, especially from the informal settlements which do not have proper mechanisms of waste disposal including sewer disposal, drainage, sanitary facilities as well as sewerage works. Further, industrial discharge is a major source of contaminants for the Ngong River, as established in a study where different points where water quality parameters were also greatly compromised.

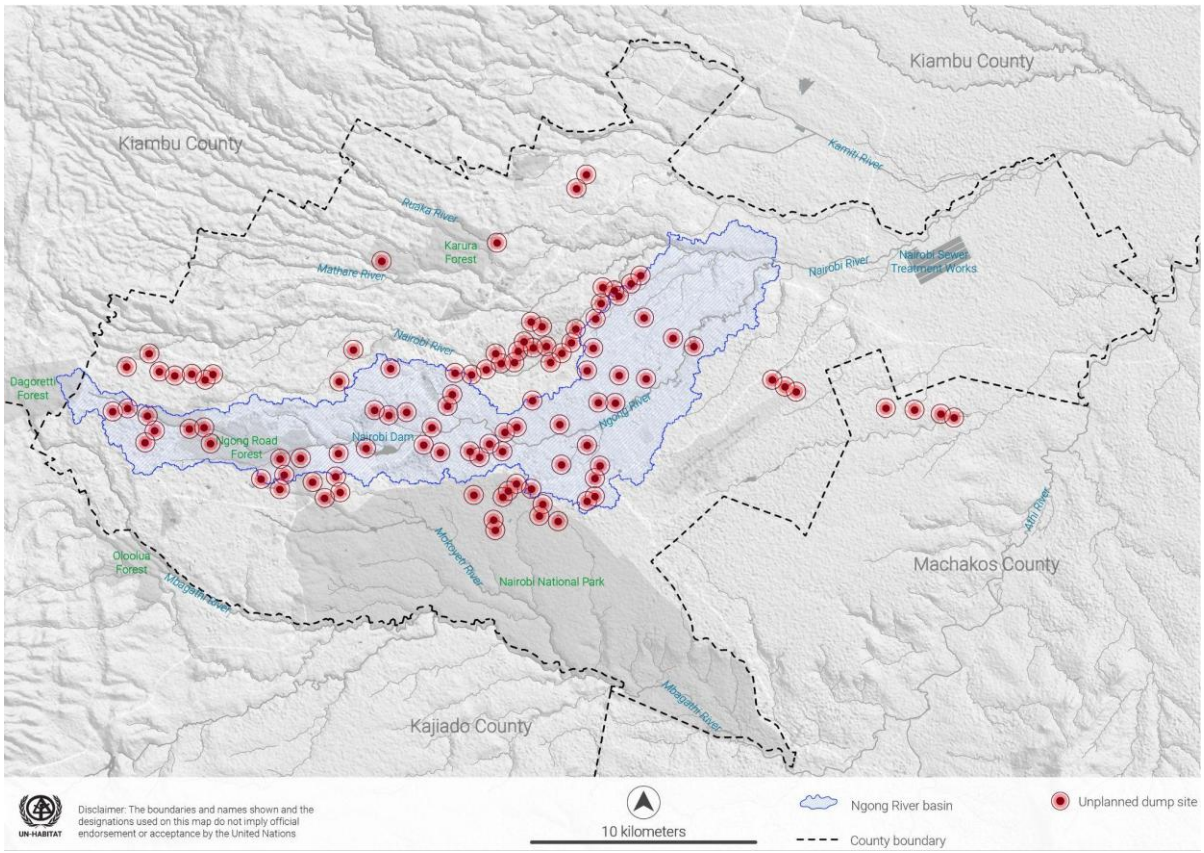
Nairobi City produces about 2,475 tonnes of waste daily, and while up to 95% of the waste can be recycled, only a paltry 5% is recycled. Only approximately 33% of waste collected in Nairobi City County is collected for dumping at Dandora which is the only City's official dumpsite while the rest is disposed of in illegal dumpsites. Such illegal dumping occurs because the city lacks proper and adequate waste disposal systems and where such exist, then they operate under capacity. These limited formal facilities and infrastructure for solid waste disposal are limited to certain areas of the city. Most of the low-income and middle-income neighbourhoods lack access to the facilities and cannot easily pay for collection like in the high-income neighbourhoods.




*Map 29: Dumping site and SWM initiatives in Nairobi*[114]

114 Catapult. (2021). Nairobi solid waste management & storm water drainage and flooding. Retrieved from https://cp.catapult.org.uk/wp-content/uploads/2021/02/Nairobi-ULA-Market-Intelligence.pdf (Accessed: 3/07/23).

Illegal dumping both by households, communities and both the formal and semi-formal collection services often leads to visible pollution linked to apparent impacts on both health and well-being. Open dumping areas on the river banks owing to the existing informal settlements compound the degradation of Ngong River and loss of its aesthetic appeal. The challenge is worse in most of the low and middle-income neighbourhoods that are characterised by high population density and a lack of waste management infrastructure and waste disposal service provision compound these problems. More than half of the city's population reside in low-income areas or informal settlements spread across the country.




*Map 30: Informal/illegal waste dump sites in Nairobi*[115]

### Energy infrastructure/systems

Nairobi City County is served by the national grid under Nairobi, which is one of its four administrative regions; the other four include Mount Kenya, West Kenya, and Coast. Out of the four regions, Nairobi has the highest power demand, which stands at 993 megawatts. The electricity access rate for urban areas, including Nairobi, stands at 100%, while in the rural areas, this stands at 65%.[116] Power used in Nairobi is generated everywhere and carried over high voltage power lines to the city under the management and operation of Kenya Electricity Transmission Company (KeTRACO). At the moment, power distribution is solely done by

115 Ogutu, A. F., Kimata, D., & Kweyu, R. (2018). Essence of environmental governance in solid waste management: A spatial analysis of the unplanned dumpsites in Nairobi County. African Research Journal of Education and Social Sciences, 5(2), 112–123. Retrieved from https://arjess.org/social-sciences-research/essence-of-environmental-governance-in-solid-waste-management-a-spatial-analysis-of-the-unplanned-dumpsites-in-nairobi-county.pdf (Accessed: 06/07/23).
116 International Trade Administration. (2022). Energy – Electrical power systems. Retrieved from https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems (Accessed: 19/08/23).

Kenya Power which operates Kenya's grid as well as a few off-grid stations in remote parts of the country.

Access to electricity and connectivity remains a challenge facing Nairobi City's informal settlements. The electricity grid in informal settlements is often poorly connected, hence leaving many households and small and medium enterprises without formal power connectivity. Kenya Power faces a major challenge in undertaking its mandate for provision of power to households, especially in the informal settlements, as they are never guaranteed of providing power safely and getting paid for the service. While Kenya Power delivers power to informal neighbourhoods, up to 50% of the power supplied in these areas is lost through cartel pilferage.[117] The poorly done and unsafe connections have caused several injuries from electrocutions.

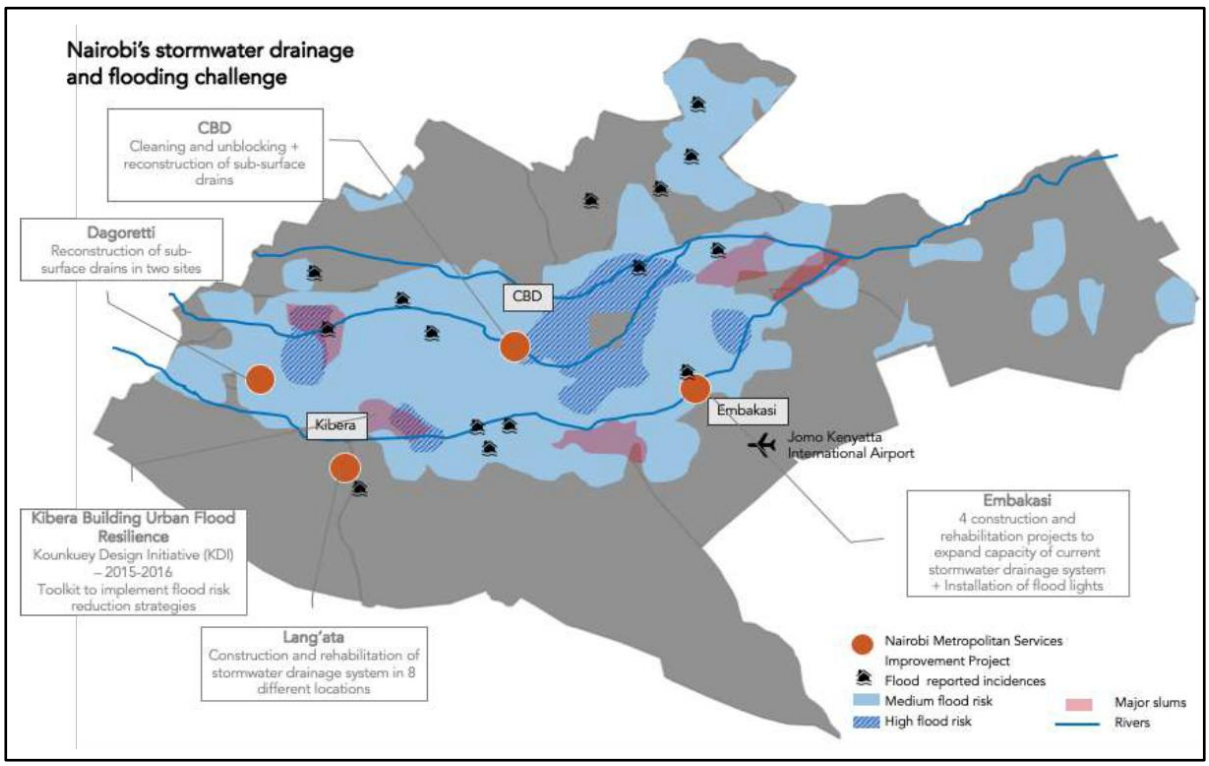
Despite the issues, the government has made efforts through a number of initiatives aimed at improving access to electricity in informal settlements. One such initiative is through the Global Partnerships for Result-Based Aid (GPRBA) under the Kenya Electricity Expansion Project (KEEP). Through the project, settlements such as Kayole Soweto had improved access to electricity through formal electricity connections. The initiative was informed by the fact that many households in informal settlements use illegal power connections rather than formal connection, a situation that is linked to the high cost required to get a formal connection.

**Drainage**

The city's old drainage was designed to cater for a population of half a million, but the population has ballooned over the years and stands at over four million as per the last Census. According to City Hall the drainage designs were made post-independence and were meant to serve the city's population at the time. The strain on the drainage system has seen the city experience water stagnation whenever it rains. Reports indicate that the city authority lacks adequate funds to revamp the drainage system to better serve the city. Efforts to upgrade and realign the drainages has faced challenges including the need to demolish some structures including buildings. The situation has further been compounded by the existence and the ever-increasing construction in the city's informal settlements.

Nairobi City lacks a storm-water master plan and the inadequate storm-water infrastructure has been blamed for the flooding issues that the City faces from time to time. The challenge has been complicated by the existence of developments and constructions on the riparian reserves.[118] The storm water from the different city sections end up in the natural waterways including the Nairobi, Mathare and Ngong Rivers. However, development along these rivers and their tributaries hampers their capacity to receive and accommodate the storm water hence serious flooding challenges on the areas adjacent to the watercourses.

117 Kenya Power. (2021). Annual Report and Financial Statements for the year ended 30 June 2021. Retrieved from https://www.kplc.co.ke/img/full/KPLC%20Annual%20Report%20and%20Financial%20Statements%20for%20the%20year%20ended%2030.6.2021.pdf (Accessed: 11/07/23).
118 Krhoda, G., & Munene, A. (2016). Impact of urbanisation on the morphology of Motoine/Ngong River Channel, Nairobi River Basin, Kenya. Journal of Geography and Regional Planning, 9(3), 36–46. https://doi.org/10.5897/JGRP2015.0528




*Map 31: Nairobi's stormwater drainage and flooding challenge119*

There are a number of efforts that have been initiated with the goal of addressing the city's drainage challenge such as the Nairobi Rivers Sewerage Improvement Project (NaRSIP II). The project cost stood at Ksh. 500 million out of which 75% of the total amount was allocated to Nairobi alone owing to the city's severe drainage challenge. Among the equipment that were acquired under the project to address the city's drainage issues include a flasher unit meant to unclog culverts that may experience intense blockages during storms. The NaRSIP project targets to regenerate the ecosystems of the City's rivers including Ngong, Nairobi and Mathare among others and improve livelihoods. The blockages on the already strained drainage system has been blamed on dumping of solid waste into the drains which is connected to the lack of adequate waste disposal facilities in the city's neighbourhoods.

**Summary**

From the assessment of the different infrastructure services in the Ngong River basin, the following have been identified as the main issue.

- The main issue regarding transport in the Ngong River basin is the inadequate maintenance of county transport infrastructure, resulting in significantly degraded roads that need proper rehabilitation to improve their condition and functionality.
- The main water access issue in Nairobi City is the inadequate and unreliable supply of clean water, leading many residents to rely on unregulated and often more expensive informal water suppliers, particularly in low-income and informal settlements.

119 Catapult (2021). Nairobi Solid Waste Management & Storm Water Drainage and Flooding. Available at: https://cp.catapult.org.uk/wp-content/uploads/2021/02/Nairobi-ULA-Market-Intelligence.pdf (Accessed: 03/07/2023).

- The main water infrastructure issue in Nairobi City is the challenge of providing adequate sewerage services due to rapid population growth, wayleave encroachments, poor maintenance, and inadequate coverage, particularly in low-income and informal settlements.
- The main solid waste management issue in Nairobi City is the inadequate waste disposal systems and infrastructure, leading to widespread illegal dumping, especially in low and middle-income neighbourhoods, resulting in significant pollution of the Ngong River and posing health risks to residents.
- The main drainage issue in Nairobi City is the outdated and inadequate drainage infrastructure, designed for a much smaller population, which leads to frequent flooding and water stagnation exacerbated by informal settlements, lack of a storm-water master plan, and insufficient funds for necessary upgrades.

# Chapter 5: Opportunities for EbA for River Regeneration

Climate resilience in urban contexts requires integrated, adaptive, and inclusive approaches that address both ecological degradation and socio-economic vulnerability. One promising pathway is through Nature-based Solutions (NbS), which advocate for the use of natural and semi-natural systems, such as rivers, wetlands, riparian zones, and green spaces, as integral infrastructure in urban planning, design, and construction.

Unlike conventional “grey” infrastructure, which often depends on finite, non-renewable, and ecologically harmful materials, NbS restore and enhance the natural ecosystems that regulate water, mitigate heat, absorb carbon, and reduce exposure to natural hazards. In urban areas like Nairobi, this includes recognising the value of rivers such as the Ngong as part of a wider green and blue infrastructure network that can address challenges like flooding, stormwater management, water pollution, and urban heat.

There is growing global recognition of the importance of protecting and rehabilitating ecosystems such as wetlands and peatlands, not only for water regulation but also for carbon sequestration.[120] These systems are increasingly being leveraged to support national climate mitigation goals and to enhance local resilience against climate-related shocks.

Importantly, NbS do not reject technological innovation. Rather, they promote a paradigm shift by encouraging citizen participation in the co-design, co-management, and co-benefit sharing of ecosystems[121]. Their maintenance is typically less resource-intensive than that of grey infrastructure, benefiting from community stewardship and natural regenerative cycles. Moreover, access to nature has been shown to significantly improve mental and physical well-being—strengthening the social rationale for nature-based approaches[122].

120 ICLEI. (n.d.). Advancing the implementation of nature-based solutions: The influence of language in showcasing Africa’s efforts. ICLEI – Local Governments for Sustainability.
121 IUCN. (2021). Planning and delivering nature-based solutions in Mediterranean cities: First assessment of the IUCN NbS Global Standard in Mediterranean urban areas. Málaga, Spain: International Union for Conservation of Nature (IUCN). 173 pages.
122 euPOLIS Project. (n.d.). Integrated NbS-based urban planning methodology. Retrieved from https://eupolis-project.eu

Within this broader framework, Ecosystem-based Adaptation (EbA) refers to the use of biodiversity and ecosystem services as part of an overall climate adaptation strategy. EbA seeks to reduce vulnerability and build resilience for both people and ecosystems by working with nature. Its core principles include the sustainable management, restoration, and conservation of ecosystems to deliver climate adaptation outcomes.

In the context of the Ngong River Basin, EbA presents an urgent and contextually appropriate opportunity. The river and its catchment are under immense pressure from unplanned development, informal settlement growth, poor waste management, and weak governance. These pressures are compounded by Nairobi's increasing exposure to climate impacts—including flooding, droughts, and urban heat—demanding a comprehensive strategy that links ecosystem restoration with inclusive urban resilience planning.

## 5.1 Adaptation Needs and Futures

Based on climate projections and findings from this assessment, several critical adaptation needs have emerged for the Ngong River Basin. Informal settlements such as Kibera, Mukuru, and Kayole Soweto face significant flood risk due to their location on floodplains and the absence of adequate drainage systems, highlighting the urgent need to improve flood resilience in these areas. Additionally, many densely populated neighbourhoods across the basin suffer from extreme urban heat, exacerbated by limited vegetation cover, which negatively impacts both health and overall habitability—pointing to the need for targeted urban heat mitigation.

Water quality and waste management also require substantial improvement, especially in the middle and lower sections of the river, where industrial discharge and domestic waste have led to severe pollution. Addressing this challenge will be essential for safeguarding both environmental and public health.

Furthermore, more effective climate adaptation in the basin will depend on stronger coordination among county departments, utilities, and community stakeholders. Without coherent governance and collaborative planning, implementation efforts risk being fragmented and ineffective.

Ecosystem-based Adaptation (EbA) provides a promising pathway to meet these interconnected needs. By regenerating natural systems, fostering community involvement, and promoting integrated resilience strategies, EbA can support more sustainable and inclusive responses to the basin's evolving climate challenges.

## 5.2 Ecosystem Opportunities: Protecting and Expanding Natural Assets

The assessment identified a range of underutilised or degraded ecological assets within the Ngong River Basin that present strong potential for ecosystem-based adaptation (EbA) interventions. If restored and integrated into local planning efforts, these areas could serve as critical foundations for climate resilience.

One major opportunity lies **in riparian zone restoration**, especially in the lower basin areas such as Mukuru and Embakasi. Re-establishing native vegetation along riverbanks and enforcing development setbacks can help stabilise these zones, reduce erosion, and absorb stormwater runoff, offering both ecological and flood management benefits.

Another key intervention is **urban reforestation**. In the upper basin, home to areas like Ngong Forest and parts of Dagoretti, pockets of green space still remain, though they are increasingly under threat from land conversion. Reforesting degraded slopes with native species can enhance water infiltration, reduce surface runoff, and improve local microclimates. Meanwhile, in the middle basin, informal settlements such as Mukuru and Kayole Soweto experience intense heat exposure due to minimal vegetation cover. These areas are ideal candidates for small-scale, community-led greening efforts, which can improve both habitability and health.

In the middle and lower reaches of the river, particularly near Donholm, Tassia, and Embakasi—there is significant potential for **wetland protection and creation**. Restoring existing wetlands or constructing new ones in flood-prone areas can help filter polluted runoff, enhance biodiversity, and act as natural flood detention basins. Industrial zones along Lunga Lunga Road and near the Sewage Treatment Works could particularly benefit from nature-based water treatment systems.

Improving **green corridors and connectivity** across the basin is also critical. Linking fragmented green and blue spaces can facilitate better stormwater dispersion and support urban biodiversity restoration. Alongside this, the **restoration of tributaries and feeder streams**—which are often polluted, blocked, or encroached upon—offers further opportunity. Targeted clean-up, daylighting (uncovering buried streams), and revegetation efforts can improve flow capacity and reduce localised flooding, especially during heavy rains.

These interventions are most impactful when developed with and for the surrounding communities. Across the basin, local youth groups, environmental collectives, and women's organisations are already taking action on conservation and waste management. Strengthening these efforts through technical support, formal recognition, and integration into county development plans will be essential to achieving lasting ecological and social impact.

To be effective and sustainable, these nature-based solutions must be embedded within formal planning frameworks and implemented through genuine partnerships with community groups, many of whom are already acting as environmental stewards on the ground.

## 5.3 EbA Interventions for River Regeneration

The assessment highlights a range of specific Ecosystem-based Adaptation (EbA) interventions that can support the regeneration of the Ngong River and strengthen climate resilience across the basin. These strategies aim to work with nature, rather than against it, by restoring ecological processes, improving urban livability, and actively involving communities in long-term solutions.

One of the most pressing needs is **nature-sensitive drainage and flood mitigation**. Flood-prone areas in both formal and informal settlements along the river could benefit from green infrastructure such as **bioswales, rain gardens, and permeable pavements**, which help absorb and filter runoff. Restoring natural drainage paths will also reduce pressure on overstretched engineered systems, enhancing flood management while supporting ecological regeneration.

**Community-led solid waste management** presents another key opportunity. Supporting local waste cooperatives to lead composting, reuse, and regular river clean-up efforts can dramatically reduce pollution entering the river. Additionally, establishing **vegetated buffer zones** between settlements and the river can serve as a first line of defence, preventing solid waste from being washed into waterways during heavy rains.

To address the growing challenge of rising urban temperatures, **urban cooling and microclimate regulation** should also be prioritised. Planting **shade trees and native vegetation** in schools, along road reserves, in markets, and in communal areas will provide much-needed relief from heat, while improving the overall quality of public space. In more built-up zones, **green roofs, vertical gardens, and shaded structures** offer further cooling benefits and can be integrated into building upgrades or retrofits.

The basin also presents opportunities for **wetland revitalisation and water filtration**. Constructing wetlands in **low-lying, flood-prone areas** can provide overflow capacity during heavy rainfall events, while naturally treating wastewater and improving biodiversity. These systems are most effective when managed by local organisations—**community-based organisations (CBOs)** should be engaged in both maintenance and monitoring, ensuring these spaces are sustainable and community-owned.

Finally, incorporating **green infrastructure into public space redevelopment** is essential for holistic urban transformation. This could include **green embankments along roads**, **eco-bridges over canals**, and other vegetated features that merge infrastructure with environmental function. Using **participatory design approaches** ensures that these spaces reflect community priorities, enhance access, and provide inclusive benefits for all residents.

Together, these EbA interventions present a cohesive, community-driven path forward for restoring the Ngong River and building climate resilience in some of Nairobi's most vulnerable urban environments.

## 5.4 Policy and Institutional Alignment

For Ecosystem-based Adaptation (EbA) interventions to be effective, sustainable, and scalable, they must be supported by a strong and enabling policy and governance framework. Institutional alignment and cross-sector collaboration are key to embedding nature-based approaches into long-term urban development.

A critical first step is the integration of EbA and nature-based solutions (NbS) into formal urban planning instruments, such as County Integrated Development Plans (CIDPs), spatial plans, and zoning bylaws. Embedding these strategies at the planning level ensures that

future developments account for ecological processes, risk reduction, and inclusive public space.
Cross-sector coordination is equally important. Collaboration among county departments—particularly environment, water, lands, and urban planning—is essential for coherent implementation. Partnerships with national regulatory agencies such as the National Environment Management Authority (NEMA) and the Water Resources Authority (WARMA) can further align regulatory frameworks and support integrated catchment management.

To implement EbA effectively, capacity building is needed across all levels. This includes training for local government staff, planners, and community representatives in the design, implementation, and monitoring of EbA interventions. Building this knowledge base will ensure that climate-resilient strategies are not only adopted but maintained over time.
Finally, financing and resource mobilisation must be addressed to move beyond pilot projects. Leveraging funds from established climate financing mechanisms—such as County Climate Change Funds or the Green Climate Fund—can support the scaling of EbA across Nairobi. Additionally, offering micro-grants can incentivize grassroots innovation and support community-led solutions that align with broader climate adaptation goals.

## 5.5 From Assessment to Action

This assessment provides a comprehensive spatial, institutional, and ecological foundation for identifying priority areas along the Ngong River for Ecosystem-based Adaptation (EbA). Building on these insights, the next phase of the 3EP programme offers a clear opportunity to move from analysis to action through targeted, community-driven interventions.

As a starting point, pilot sites should be selected across the river's upper, middle, and lower segments, allowing for place-specific adaptation strategies that respond to each area's unique risks and opportunities. These pilots can serve as demonstration sites to test and refine EbA approaches in different urban contexts.

To ensure meaningful impact, the programme should prioritise community-led adaptation planning, using participatory tools and spatial data to inform decision-making. This approach will not only ground interventions in local knowledge but also foster ownership and long-term stewardship.

At the same time, strengthening multi-stakeholder collaboration is essential. Aligning efforts across community groups, county departments, national agencies, and civil society partners will help embed EbA into formal governance structures and support its institutionalisation.

Finally, establishing a monitoring and learning framework will be key to tracking outcomes, capturing lessons learned, and informing strategies for scaling up successful interventions across the basin.

Together, these next steps lay the groundwork for translating assessment findings into action—moving toward a more resilient, inclusive, and ecologically restored Ngong River corridor.

## 6. Conclusion

The Ngong River Basin Assessment Report underscores the urgent need for coordinated, multi-level action to restore ecological health and enhance the resilience of riverine communities in Nairobi. Through a combination of environmental, socio-spatial, and infrastructural analysis, the report provides compelling evidence of the degradation facing the Ngong River due to rapid urbanization, weak infrastructure, and policy fragmentation.

The findings affirm that the river is not only a natural asset but a vital socio-ecological system that influences public health, livelihoods, and urban sustainability. The challenges facing the basin, from polluted waters and encroachment to fragmented governance, are deeply interconnected, and therefore require holistic, inclusive, and place-based responses.

The 3EP initiative provides a compelling framework for such a response, demonstrating how ecosystem-based adaptation can be operationalised at scale, led by communities, and aligned with national and global policy goals. Going forward, implementation of this report's recommendations will require strong institutional coordination, sustained community engagement, and targeted investment in nature-based solutions.

Restoring the Ngong River is not only an environmental imperative but a social and economic one, essential for safeguarding Nairobi's future in the face of climate change.

.

## References


Andersen, J., et al. (2021). *Perspectives of local community leaders, health care workers, volunteers, policy makers and academia on climate change related health risks in Mukuru informal settlement in Nairobi, Kenya—A qualitative study*.

Aryampa, S., Maheshwari, B., Sabiiti, E., Bateganya, N. L., & Bukenya, B. (2019). Status of waste management in the East African cities: Understanding the drivers of waste generation, collection and disposal and their impacts on Kampala City's sustainability. *Sustainability, 11*(19), 5523. https://doi.org/10.3390/su11195523

Athi Water Services Board. (2016). *Consultancy services for preliminary and detailed design and tender documentation for the Nairobi Rivers Sewerage Improvement Project (NARSIP) Phase II*. https://www.awwda.go.ke/wp-content/uploads/2022/07/Responses-to-Clarifications-No-2_-Dandora-Inlet-Works_full.pdf

Athi Water Services Board. (2018). *Provision of sewerage in major towns in Kenya: A case study of Nairobi City*. https://www.oagkenya.go.ke/wp-content/uploads/2023/01/Provision-of-Sewerage-in-Major-Town-A-Case-of-Nairobi-City-County-2018.pdf

Bonaiuto, M., Fornara, F., Ariccio, S., Cancellieri, U. G., & Rahimi, L. (2015). Perceived residential environment quality indicators (PREQIs) relevance for UN-HABITAT City Prosperity Index (CPI). *Habitat International, 45*, 53–63.

Catapult. (2021). *Nairobi solid waste management & storm water drainage and flooding*. https://cp.catapult.org.uk/wp-content/uploads/2021/02/Nairobi-ULA-Market-Intelligence.pdf

Connor, R. (2015). *The United Nations world water development report 2015: Water for a sustainable world* (Vol. 1). UNESCO Publishing.

Convention on Biological Diversity. (1992). *Convention on Biological Diversity*. https://www.cbd.int/doc/legal/cbd-en.pdf

Du Toit, M. J., Cilliers, S. S., Dallimer, M., Goddard, M., Guenat, S., & Cornelius, S. F. (2018). Urban green infrastructure and ecosystem services in sub-Saharan Africa. *Landscape and Urban Planning, 180*, 249–261.

Esri StoryMaps. (n.d.). *Karura Forest: A forest reclaimed*. https://storymaps.arcgis.com/stories/53174eecf0f143d4ae25b2dd12c77439

euPOLIS Project. (n.d.). *Integrated NbS-based urban planning methodology*. https://eupolis-project.eu

Friends of Karura Forest. (n.d.). *Friends of Karura Forest*. https://www.friendsofkaruraforest.org

Green Belt Movement. (n.d.). *Karura Forest: A history of restoration and protection*. https://www.greenbeltmovement.org/node/908

ICLEI. (n.d.). *Advancing the implementation of nature-based solutions: The influence of language in showcasing Africa's efforts*.

International Trade Administration. (2022). *Energy – Electrical power systems*. https://www.trade.gov/country-commercial-guides/kenya-energy-electrical-power-systems

IUCN. (2021). *Planning and delivering nature-based solutions in Mediterranean cities: First assessment of the IUCN NbS Global Standard in Mediterranean urban areas*. International Union for Conservation of Nature.

Juma, B., et al. (2021). Analysis of rainfall patterns in the Ngong River Basin of Kenya: Towards integrated urban flood risk management.

Kenya Meteorological Department. (2021, June). *State of the climate in Kenya 2020*. https://meteo.go.ke/sites/default/files/downloads/STATE%20OF%20THE%20%20CLIMATE%202020_14042021.pdf

Kienja, K. (2017). *Pollution of urban waterways in Nairobi: A case study of Mathare 4B Village, Nairobi, Kenya* [Master's thesis, University of Nairobi].

Kithiia, S. M. (2007). An assessment of water quality changes within the Athi and Nairobi River basins during the last decade. *Journal of Environmental Science and Engineering*.

Kithiia, S. M. (2021). A critical analysis of the water quality impacts on water resources in the Athi River Drainage Basin, Kenya. *Water Resources Authority Report*.

Ledant, M. (2019). Water in Nairobi: Unveiling inequalities and its causes. *Open Edition Journal, 263*. https://doi.org/10.4000/com.6951

Makathimo, M., & Guthiga, P. (2010). *Land use policies and natural resource management in Kenya: The case of Nairobi River Basin*. Kenya Institute for Public Policy Research and Analysis (KIPPRA).

Monene, A. K. (2017). Effects of land use change on streamflow, channel erosion and river geomorphology: A case study of Motoine/Ngong River Sub Catchment. *International Journal of Mathematics and Physical Sciences Research, 5*(1), 113–120.

Mundia, C. N., & Aniya, M. (2006). Dynamics of land use/cover changes and degradation of Nairobi City, Kenya. *Land Degradation & Development, 17*(1), 97–108.

Mwau, B., Sverdlik, A., & Makau, J. (2020). Urban transformation and the politics of shelter: Understanding Nairobi's housing markets. *International Institute for Environment and Development (IIED)*. https://www.iied.org/sites/default/files/pdfs/migrate/10876IIED.pdf

Nairobi City County. (2018). *County annual development plan 2019/2020*. https://nairobiassembly.go.ke/ncca/wp-content/uploads/paperlaid/2018/ADP-for-the-FY-2019-20.pdf

Nairobi City Water and Sewerage Company. (2023). *Simplified sewer system project on course*. https://www.nairobiwater.co.ke/simplified-sewer-system-project-on-course/

Ngatia, M., Kithiia, S. M., & Voda, M. (2023). Effects of anthropogenic activities on water quality within Ngong River Sub-Catchment, Nairobi, Kenya. *Water, 15*(4), 660. https://doi.org/10.3390/w15040660

Ogutu, A. F., Kimata, D., & Kweyu, R. (2018). Essence of environmental governance in solid waste management: A spatial analysis of the unplanned dumpsites in Nairobi County. *African Research Journal of Education and Social Sciences, 5*(2), 112–123. https://arjess.org/social-sciences-research/essence-of-environmental-governance-in-solid-waste-management-a-spatial-analysis-of-the-unplanned-dumpsites-in-nairobi-county.pdf

Scott, A., Beckham, K., Mberu, B., Ezeh, A., & Monteiro, C. (2017). Temperature and heat in informal settlements in Nairobi. *PLoS ONE, 12*(11), e0187300. https://doi.org/10.1371/journal.pone.0187300

Sobowale, R. (2019). *River restoration in Nairobi, Kenya: Exploring public participation and learning outcomes* [Master's thesis, Wageningen University].

Sunday, J. A., Otoki, B. M., Njuguna, B. M., & Munala, G. (2020). The vulnerability of Nairobi to the effects of climate change between 1984 and 2016. *Landscape Architecture and Regional Planning, 5*(2), 38–45. https://doi.org/10.11648/j.larp.20200502.14

Tibaijuka, A. (2007). Cities can achieve more sustainable land use if municipalities combine urban planning and development with environmental management.

UNESCO. (2010). *Education for All Global Monitoring Report 2010: Reaching the marginalized*. Paris: UNESCO.

UNEP. (2003). *City of Nairobi environment outlook*. Nairobi: UNEP.

UNFCCC. (1992). *United Nations Framework Convention on Climate Change*. https://unfccc.int/resource/docs/convkp/conveng.pdf

UNISDR. (2015). *Sendai Framework for Disaster Risk Reduction 2015–2030*. https://www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030

United Nations. (2015). *Paris Agreement*. https://unfccc.int/process-and-meetings/the-paris-agreement

USAID & Sustainable Water Partnership. (2021). *Kenya country profile: Water security, sanitation, and hygiene*. https://winrock.org/wp-content/uploads/2021/08/Kenya_Country_Profile-Final.pdf

West, S. E., Büker, P., Ashmore, M., Njoroge, G., Welden, N., Muhoza, C., Osano, P., Makau, J., Njoroge, P., & Apondo, W. (2020). Particulate matter pollution in an informal settlement in Nairobi: Using citizen science to make the invisible visible. *Applied Geography, 114*, 102133. https://doi.org/10.1016/j.apgeog.2019.102133