

# Urban Greening and Nature Based Solutions Potential in Mitigating Climate Change Impacts in Municipalities

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## Abstract

Climate change continues to exert significant pressure on urban areas, particularly in developing countries where rapid urbanisation intersects with poor infrastructure and fragile ecosystems. Kenyan municipalities are increasingly vulnerable to climate-induced risks, such as flooding, heatwaves, and water scarcity, posing threats to both livelihoods and built environments. In response, urban greening and nature-based solutions have emerged as innovative approaches to mitigate climate change impacts while enhancing urban sustainability and liveability.

This review explores the application and potential of urban greening and nature-based solutions in selected Kenyan urban areas, including Nairobi, Mombasa, Kisumu, Nakuru, Eldoret and Kiambu. It adopts a qualitative methodology that involves a comprehensive review of scholarly literature, national and county policy documents, as well as case study examples drawn from ongoing or completed greening and nature-based solutions projects.

Findings reveal that interventions such as riparian buffer restoration, urban forests, green parks, green belts, and constructed wetlands contribute significantly to carbon sequestration, flood mitigation, and ecosystem restoration. Nairobi's Karura Forest, for instance, demonstrates the long-term benefits of protecting green spaces, while Mombasa's mangrove rehabilitation efforts offer strong evidence for ecosystem-based adaptation. Despite these successes, challenges such as weak enforcement, funding constraints, and lack of technical capacity persist.

This paper recommends the strengthening of institutional frameworks, integration of climate adaptation into urban planning, and multi-stakeholder engagement to scale up nature-based solutions. The review concludes that urban greening, if adequately supported, holds substantial promise in mitigating climate impacts and promoting resilient and inclusive urban environments in Kenya.

## Keywords

Climate, Nature, Urban, Greening, Municipalities

## 1. Introduction

Urban areas globally are increasingly at the frontline of climate change impacts due to their high concentration of populations, infrastructure, and economic activities. According to the international panel on climate change (IPCC) [1], cities are experiencing rising temperatures, erratic rainfall, and more frequent extreme weather events, all of which threaten public health, infrastructure, and economic development. These effects are more pronounced in the Global South, where adaptive capacity remains limited.

Kenya is undergoing rapid urbanisation, with its urban population projected to reach 50% by 2050 [2]. Cities such as Nairobi, Kisumu, Nakuru and Mombasa are experiencing accelerated growth, often in unplanned and ecologically sensitive areas. This urban expansion increases exposure to climate hazards such as urban flooding, heatwaves, and water stress [3]. Conventional grey infrastructure approaches to climate adaptation have proven inadequate in addressing the complexity and scale of urban climate risks [4,5].

Urban greening and nature-based solutions are gaining recognition as viable alternatives for climate mitigation and adaptation. Urban greening encompasses interventions like green spaces, trees, and green roofs that enhance ecosystem services and reduce urban temperatures [6]. Nature-based solutions, on the other hand, are defined as actions that work with and enhance nature to address societal challenges, providing co-benefits for biodiversity and human well-being [7].

This review examines how urban greening and nature-based solutions are being implemented in Kenyan urban areas to mitigate climate change impacts. The paper analyses strategies, evaluates their effectiveness, and identifies barriers and opportunities for scaling up.

Key research questions guiding this review are:

- What are the main urban greening and nature-based solutions approaches adopted in Kenya?
- How effective are they in mitigating the impacts of climate change in municipalities?

The paper focuses on five selected urban areas - Nairobi, Mombasa, Kisumu, Nakuru, and Eldoret—chosen for their ecological diversity, varying climatic exposure, and documented interventions. By reviewing existing initiatives and policies, this paper contributes to understanding how municipalities can mainstream nature-based approaches to promote urban climate resilience in Kenya.

## 2. Conceptual Framework

This review is grounded in the conceptual understanding of urban greening and nature-based solutions as key strategies for ecosystem-based adaptation in urban settings. Urban greening refers to the incorporation of vegetation and ecological elements into urban spaces, including public parks, street trees, green belts, and vegetated rooftops. These elements improve microclimates, air quality, urban aesthetics, and community well-being [8,9].

Nature-based solutions, as defined by the International Union for Conservation of Nature (IUCN) [7], are actions that protect, sustainably manage, and restore natural or modified ecosystems in ways that address societal challenges while simultaneously providing benefits for human well-being and biodiversity. Examples include mangrove rehabilitation, wetland conservation, reforestation, and urban agriculture. Unlike traditional infrastructure approaches, nature-based solutions utilise ecological processes and biodiversity to buffer cities against climate impacts, such as flooding and extreme heat.

The theoretical foundation of this review draws on ecosystem-based adaptation, which emphasises the role of healthy ecosystems in helping communities adapt to climate change [10]. Ecosystem-based adaptation advocates for working with nature to increase resilience through interventions that maintain or enhance ecosystem services. This is closely aligned with the resilience theory, which focuses on a system's capacity to absorb disturbances while maintaining essential functions [11,12].

Ecosystem services provided by urban greening and nature-based solutions are categorised as provisioning (e.g. food through urban farming), regulating (e.g. flood control through wetlands), cultural (e.g. recreation in green parks), and supporting (e.g. biodiversity habitats) [13,14]. These services play a crucial role in reducing urban vulnerability by lessening exposure and sensitivity to climate risks and improving adaptive capacity [6].

The framework adopted in this study suggests that integrating urban greening and nature-based solutions into municipal planning and urban areas spatial plans enhances urban resilience by:

1. Mitigating greenhouse gas emissions through carbon sequestration.
2. Reducing disaster risk by managing storm water flows and temperatures.
3. Improving social cohesion through inclusive green space design.

This conceptual understanding informs the evaluation of interventions in selected urban areas and municipalities and helps assess their design, implementation, and outcomes within the broader goal of urban climate resilience in Kenya.

## 3. Methodology

This study adopts a qualitative review methodology aimed at synthesising existing knowledge and practices concerning urban greening and nature-based solutions for climate change mitigation and adaptation in Kenyan urban areas. The review draws upon secondary data sources including peer-reviewed journal articles, official government policy documents, grey literature from non-governmental organisations (NGOs), and institutional reports published by UNEP, UN-Habitat, and the National Environment Management Authority (NEMA).

Data were collected using a systematic literature search strategy across academic databases such as Scopus, Web of Science, and Google Scholar. Search terms included “urban greening in Kenya,” “nature-based solutions,” “urban climate resilience,” and “climate change in Kenyan cities.” To maintain relevance and rigor, only literature published within the last five years (2019-2024) was considered.

In addition, government documents including the Kenya Climate Change Act (2016, reviewed in 2022), county integrated development plans (CIDPs), and urban development strategies were analysed to examine how urban greening and nature-based solutions are embedded in local planning frameworks [15]. Reports from organisations such as UNEP (2021) [10] and UN-Habitat (2023) [3] provided key insights into the implementation of nature-based solutions across diverse municipal contexts.

Five major urban areas in Kenya were purposively selected for this review based on two criteria: (i) geographic and ecological diversity to represent different climatic zones and ecosystems in Kenya, and (ii) presence of existing urban greening or climate adaptation projects. The selected urban areas—Nairobi, Kisumu, Mombasa, Nakuru, and Eldoret—offer representative case examples of urban centres facing unique but interconnected climate risks.

The review employed thematic analysis to identify recurring patterns related to climate risks, greening strategies, implementation challenges, and outcomes. This approach facilitates a holistic understanding of how urban greening and nature-based solutions contribute to building climate resilience within Kenya's urban landscape.

## 4. Results and Discussions

### 4.1 Climate Change Impacts in Kenyan Municipalities

Urban areas/municipalities in Kenya are increasingly experiencing the adverse impacts of climate change, with effects varying in intensity and type across different regions. Common climate-related risks include urban heat islands, flooding, and water scarcity, all of which are exacerbated by rapid and unplanned urbanisation [16-18].

Urban heat island (UHI) effects are particularly prominent in densely built areas like Nairobi and Mombasa, where limited vegetation and high impervious surface cover cause elevated local temperatures. The Nairobi Metropolitan Services (2022) [19] report indicates that certain inner-city areas can experience temperatures up to 5°C higher than surrounding peri-urban zones, increasing energy demands and heat-related illnesses, particularly among vulnerable populations such as the elderly and low-income residents [20].

Flooding and stormwater runoff pose significant challenges in cities like Kisumu and Mombasa. These cities, located near Lake Victoria and the Indian Ocean respectively, are highly susceptible to intense rainfall and sea-level rise. UN-Habitat reports [3] that informal settlements in Kisumu regularly experience inundation due to blocked drainage, lack of green buffers, and encroachment on riparian zones. Flood events damage infrastructure, displace households, and disrupt public services.

Conversely, municipalities in semi-arid areas in Kiambu, Nakuru and Eldoret are increasingly grappling with drought and water scarcity. These conditions reduce water availability for domestic and industrial use, stressing urban infrastructure and ecosystems. According to national environmental management authority [21], prolonged dry spells have led to the depletion of key water sources like the Menengai Crater catchment in Nakuru, resulting in rising water tariffs and conflict over access.

Regional differences in exposure and vulnerability are influenced by ecological zones, urban form, population density, and governance capacity. For example, Mombasa faces compounding risks from coastal erosion and saltwater intrusion, while Eldoret's relatively higher elevation makes it more resilient to heat but vulnerable to irregular rainfall patterns [22,23].

The socioeconomic consequences of these climate impacts are profound. They include reduced productivity, displacement, health challenges, and loss of livelihoods—especially among the urban poor. Vulnerability is heightened in informal settlements where infrastructure is weak, tenure is insecure, and access to public services is limited [2]. These realities underscore the urgent need for nature-based and inclusive adaptation strategies in Kenyan cities.

### 4.2 Review of Urban Greening and Nature-Based Solutions in Selected Municipalities

#### 4.2.1 Nairobi City

Nairobi has been at the forefront of implementing urban greening and nature-based solutions as part of its climate adaptation and mitigation strategies (Kiribou *et al.*, 2024). Notable green spaces such as Karura Forest and Nairobi Arboretum have been preserved and expanded to enhance ecological balance, carbon sequestration, and provide recreational benefits to city residents. Karura Forest, for example, covers over 1,000 hectares and has become a model for urban forest conservation, contributing to urban cooling and biodiversity protection [24].

Moreover, Nairobi's Green Building Code, revised in 2021, mandates the incorporation of green roofs, permeable pavements, and energy-efficient designs in new developments [25]. These measures help regulate temperatures, manage stormwater runoff, and reduce carbon footprints.

However, Nairobi faces challenges related to rapid urbanisation and informal settlement expansion. Informal areas such as Kibera lack access to green spaces and are disproportionately affected by air pollution, flooding, and poor waste management. The lack of integration of nature-based solutions in informal planning remains a key obstacle to comprehensive urban greening in the city [3].

#### 4.2.2 Kisumu

Located on the shores of Lake Victoria, Kisumu has adopted several nature-based solutions initiatives focused on restoring aquatic ecosystems and building urban climate resilience. The Kisumu Lakefront Development Project includes wetland restoration and the creation of green corridors to manage stormwater, improve water quality, and protect biodiversity [26].

A significant success has been the Dunga Wetlands conservation initiative, which employs nature-based solutions to filter wastewater, buffer against floods, and support fish breeding habitats. Community involvement has been a cornerstone of Kisumu's greening programs. Local youth and women's groups actively participate in tree planting, eco-tourism, and wetland maintenance activities, ensuring ownership and sustainability of the interventions [27]. Kisumu has also joined the "Cities and Climate Change Initiative" led by UN-Habitat, positioning itself as a pioneer in climate-resilient urban planning in the region.

### 4.2.3 Mombasa

Mombasa's coastal location makes it especially vulnerable to sea-level rise, saltwater intrusion, and tropical storms. To combat these risks, the county has focused on mangrove restoration and blue-green infrastructure. Mangrove forests in Tudor and Port Reitz creeks have been rehabilitated through collaborative efforts between the county government, the Kenya Forest Service, and local communities [28].

Mangroves serve multiple functions: they act as carbon sinks, buffer coastlines from erosion, and support fisheries and tourism. The city has also developed green infrastructure solutions, including the establishment of green belts and bioswales to control urban runoff.

Nonetheless, challenges persist in terms of land tenure and encroachment on sensitive ecosystems. In addition, informal settlements along the coastline complicate planning and implementation of nature-based solutions due to overlapping mandates and limited enforcement capacity [10].

### 4.2.4 Nakuru

Nakuru has integrated urban greening into its broader sustainable development agenda. Urban agriculture is increasingly promoted, especially in peri-urban areas, where smallholder farmers cultivate vegetables and fruits in open spaces, backyards, and roadside strips. This not only contributes to food security but also enhances green cover and climate resilience [29].

The county has initiated green belt projects such as the "Greening Nakuru" campaign, which focuses on tree planting along major roads, schools, and public spaces. Another notable example is the ecological conservation of the Lake Nakuru basin. The integration of green infrastructure with natural ecosystems has led to improved water regulation and biodiversity preservation.

Efforts in Nakuru have been supported by partnerships with NGOs and private actors, although sustaining community engagement and securing funding for long-term maintenance remain concerns [30].

### 4.2.5 Eldoret

Situated in a semi-arid region, Eldoret faces unique climate challenges such as irregular rainfall and land degradation. The municipality has embraced riverine rehabilitation programs along the Sosiani River, which include riparian vegetation planting and the establishment of green walkways. These initiatives reduce erosion, improve water quality, and provide scenic recreational areas [31].

Tree planting initiatives in schools and public spaces have also gained momentum, especially under the "Adopt a Tree" programme that links climate education with action. Moreover, the county is experimenting with agroforestry and dryland greening projects to enhance resilience to drought and heat [32].

Despite these strides, Eldoret struggles with urban sprawl and informal development, which undermine planned green initiatives. Furthermore, institutional capacity and financial limitations slow the scaling-up of successful pilot projects.

### 4.2.6 Kiambu County and Thika Municipality

Kiambu County stands out in Kenya for having the highest number of municipalities, including Ruiru, Limuru, Kikuyu, and Thika. Its proximity to Nairobi and its rapid urbanization trajectory make it a key player in climate adaptation and sustainable urban development. Thika, historically known for industry and agriculture, is now transitioning toward a smart city model-embracing data-driven planning, environmental sustainability, and urban resilience strategies [33]. Kiambu County has increasingly invested in urban greening to offset the pressures of rapid urbanization and land use change. Initiatives across its municipalities include:

Ruiru and Kikuyu municipalities have adopted green buffer zones and riverside rehabilitation projects, especially along rivers like Ruiru and Ondiri. These zones aim to control urban sprawl, improve air quality, and offer public green spaces.

Tree planting campaigns are conducted regularly by local authorities in partnership with schools and faith-based organizations. For example, Kikuyu Municipality launched the "One Tree Per Household" initiative in 2022, which has led to over 50,000 trees being planted in residential areas.

Greening schools and urban public spaces, such as parks and road medians, is also prioritized to reduce heat island effects and improve stormwater absorption.

Kiambu has also developed a County Environmental Action Plan (CEAP), which prioritizes green infrastructure and ecosystem-based adaptation to reduce flooding risks and improve biodiversity within fast-developing urban nodes.

### 4.2.7 Nature-Based Solutions in Thika's Smart City Vision

Thika municipality, positioned as an emerging smart city under Kenya's Vision 2030 and the Smart City Agenda, is integrating nature-based solutions into its urban master plan. While smart cities often focus on digital infrastructure, Thika's model includes "green-smart" innovations, which combine ecological and technological solutions [34].

Key nature-based solutions initiatives include:

#### 4.2.6.1 Smart Drainage and Wetland Rehabilitation

Thika River, once heavily degraded by industrial pollution, is now the focus of a restoration project that includes:

- Rehabilitating riparian zones with native vegetation
- Installing permeable pavements to reduce surface runoff
- Implementing sensor-based monitoring systems to track water quality and flood risks

#### 4.2.7.2 Urban Vertical Gardens and Green Roofs

In collaboration with the private sector and Thika Technical Training Institute, pilot projects have introduced green roof systems in selected commercial buildings and schools. These offer both insulation and stormwater retention benefits.

#### 4.2.7.3 Community-Led Nature-Based Solutions Projects

Informal settlements like Kiandutu are being supported by Non Governmental Organizations to plant edible rooftop gardens and establish communal rain gardens that manage greywater while providing vegetables and medicinal plants. These community-based approaches not only offer environmental benefits but also support local food security and livelihoods.

#### 4.2.7.4 Smart Waste and Composting Systems

Under the smart city model, Thika has introduced organic waste-to-compost programs. Compost is used for urban agriculture and greening initiatives, closing the loop between urban consumption and green space maintenance.

#### 4.2.7.5 Integration with Policy and Planning

Kiambu's County Integrated Development Plan (CIDP 2023-2027) [35] explicitly mentions urban greening and sustainable city planning as a development priority. Thika's transformation aligns with national frameworks such as:

- Kenya Smart Cities Blueprint
- National Climate Change Action Plan (2023-2027)
- National Adaptation Plan (2015-2030)

These policies support funding and technical assistance for green infrastructure, urban agriculture, and climate-smart technologies in municipalities.

#### 4.2.7.6 Opportunities and Challenges

Despite its progressive initiatives, Kiambu County faces several challenges:

- Land tenure disputes, especially in peri-urban areas, limit long-term planning for green spaces.
- Rapid population growth and real estate pressure threaten existing natural ecosystems like forests and wetlands.
- Limited technical capacity and funding for large-scale nature-based solutions infrastructure in Thika, especially outside the central business district.

Nevertheless, opportunities include:

- Youth engagement in green entrepreneurship, such as tree nurseries and urban farming
- Private-public partnerships (PPPs) for eco-smart construction and waste recycling
- Scaling pilot nature-based solutions projects through county and national climate funding channels

Kiambu County, and Thika municipality in particular, demonstrate that nature-based solutions and urban greening can be effectively integrated into the smart city agenda. Their initiatives offer replicable models for other municipalities seeking to balance growth, innovation, and ecological sustainability. The blend of community engagement, policy support, and technological tools positions Thika as a beacon of future-ready, climate-resilient urbanization in Kenya [35].

### 4.3 Benefits and Limitations of Urban Greening and Nature-Based Solutions

Urban greening and nature-based solutions in Kenyan urban areas/municipalities offer substantial benefits across environmental, social, and economic dimensions. Environmentally, these interventions enhance urban ecosystems by mitigating heat island effects, improving air quality, and providing natural flood management. For example, tree cover in urban areas reduces surface temperatures, while wetlands absorb excess rainwater, thereby preventing flash floods [3].

Socially, green spaces promote community cohesion, mental well-being, and healthier lifestyles. Parks and community gardens serve as inclusive spaces for recreation and cultural expression. In cities like Kisumu and Nairobi, community-driven greening projects have empowered youth and women's groups through participation and leadership roles [27].

Economically, nature-based solutions create green jobs, particularly in nursery management, landscaping, and ecosystem restoration. They also enhance property values, attract investment, and reduce public health costs linked to

pollution and climate-related diseases. The presence of well-maintained green infrastructure has been linked to increased land values in areas like Kilimani and Westlands in Nairobi [25].

However, several limitations hinder the full realisation of these benefits. Land tenure insecurity, especially in informal settlements, poses significant barriers to long-term planning and implementation. Financial constraints limit the scalability of pilot projects, and many municipalities depend on donor funding, which is not always sustainable. Maintenance of green infrastructure is another challenge due to limited technical capacity and overlapping institutional mandates [21].

Additionally, urban sprawl reduces the availability of open space for greening projects, while weak policy enforcement undermines existing strategies. Addressing these constraints requires a coordinated, inclusive, and well-funded approach to ensure nature-based solutions are embedded within urban development policies and practices [36].

#### 4.4 Policy and Planning Implications

The implementation of urban greening and nature-based solutions in Kenyan municipalities underscores the critical need for integrated urban planning and strong policy frameworks. While several counties have developed environmental and climate change action plans, there remains a gap in harmonising these policies with urban development strategies. For instance, land-use planning often prioritises infrastructure and housing over green spaces, particularly in rapidly growing urban areas like Nairobi and Eldoret.

One major implication is the need to mainstream nature-based solutions into county-level Integrated Development Plans (CIDPs). These plans guide public investment at the local level and must explicitly prioritise green infrastructure. Urban greening should be considered a core component of climate adaptation and not an ancillary activity. Moreover, policies need to promote vertical and horizontal coordination between national and county governments, particularly in resource allocation and technical support.

The 2018 Climate Change Act and its 2021 amendments provide a legal framework for climate governance in Kenya, including the establishment of County Climate Change Funds (CCCCF). However, utilisation of these funds for urban nature-based solutions remains limited due to low awareness, inadequate capacity, and bureaucratic hurdles [37].

Additionally, urban land policies must address the complexities of land tenure, especially in informal settlements. Insecure land tenure discourages long-term investments in green projects. Updating the Urban Areas and Cities Act to include specific provisions on green infrastructure would provide a stronger legal mandate for municipalities.

Capacity-building initiatives for urban planners, environmental officers, and community leaders are also essential. These should focus on participatory planning, sustainable landscape design, and monitoring of green infrastructure. Enhanced data collection on climate impacts and ecosystem services can further inform evidence-based planning.

Public-private partnerships (PPPs) and community-based approaches also hold significant potential. By incentivising private sector involvement through tax rebates and green certification, municipalities can scale up investment in sustainable urban environments.

#### 5. Conclusion and Recommendations

This review has explored the role of urban greening and nature-based solutions in mitigating climate change impacts across selected Kenyan urban areas/municipalities - Nairobi, Kisumu, Mombasa, Nakuru, Kiambu and Eldoret. These urban centres face diverse climate risks, including urban heat islands, flooding, and drought. Despite these challenges, they have implemented various green initiatives such as forest conservation, wetland restoration, and tree planting that offer considerable environmental, social, and economic benefits.

The findings indicate that while promising, the uptake of urban greening and nature-based solutions is uneven, often constrained by weak policy integration, land tenure issues, limited funding, and lack of institutional capacity. In cities like Nairobi and Mombasa, established initiatives such as Karura Forest conservation and mangrove restoration show the potential of nature-based solutions when properly supported. Conversely, in municipalities like Eldoret, projects remain small-scale and often donor-dependent.

To strengthen the role of urban greening in climate resilience, several recommendations emerge. First, urban planning frameworks must fully integrate nature-based solutions. County governments should revise their county integrated development plans (CIDPs) and spatial plans to include greening targets and ecosystem-based adaptation strategies.

Second, land use policy reforms are necessary to address tenure insecurity, especially in informal settlements. Establishing protected green zones and incentivising landowners to adopt sustainable land management can expand the urban green network.

Third, investment in capacity-building for municipal staff and community groups is crucial. Training in ecological design, maintenance, and impact monitoring will help scale up successful projects. Climate finance mechanisms, such as the Green Climate Fund and County Climate Change Funds, should be more accessible and targeted toward urban greening projects.

Fourth, public awareness and stakeholder engagement must be prioritised. Nature-based solutions are most effective when they are community-driven and socially inclusive. Awareness campaigns and participatory planning platforms can foster ownership and sustainability.

Furthermore, fostering inter-municipal collaboration can significantly accelerate the adoption and scaling of successful urban greening and nature-based solutions models across Kenya. For instance, best practices from Nairobi's green building code or Thika's smart stormwater systems can serve as reference points for municipalities with limited planning capacities. Establishing a national knowledge-sharing platform, potentially coordinated by the Council of Governors or National environmental management authority (NEMA), would enhance peer learning, technical capacity, and access to climate finance. Additionally, integrating urban greening and nature-based solutions more deliberately into the devolved governance structures, such as County Integrated Development Plans (CIDPs) and Municipal Charters, would reinforce their long-term sustainability. The government should also prioritize the development of regulatory incentives and maintenance frameworks to address common limitations like funding shortfalls, land tenure conflicts, and urban sprawl. These efforts would align Kenya's local climate action with global frameworks such as the Paris Agreement and Sustainable Development Goals, promoting greener, more resilient urban futures.

Finally, national policy reforms are needed to embed urban greening into legal and regulatory instruments. Coordinated efforts across government, civil society, and the private sector can ensure that urban greening and nature-based solutions become central to Kenya's urban climate resilience agenda.

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