RESILIENCE AND LIVABLE CITIES IN A WARMING WORLD

A FESTSCHRIFT IN HONOUR OF

TPL. DR. JOSHUA ADEWUMI ADEBISI FNITP, RTP

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ISBN: 978-978- 63753-0-4

Published By:

The Nigerian Institute of Town Planners,
Oyo State Chapter,
Quarter 704, Iyaganku GRA, Ibadan.

Supported By:

Center for Sustainable Urban Planning,
Logistics, Infrastructure and Future Transport
3B, Upper Ijesha Road, Taiwo Estate, Iponri, Lagos.

Printed By:
DCrowns Multiventures,
P. O. Box 27796, Ibadan.
oludarebiyi@gmail.com | +234-8053896026

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ISBN: 978-978- 63753-0-4

CHAPTER
04

APPRAISAL OF THE EFFECTIVENESS OF GREEN INFRASTRUCTURE AND ECOSYSTEM-BASED APPROACHES IN ENHANCING URBAN RESILIENCE IN SUB-SAHARAN AFRICAN CITIES

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Abstract
In Sub-Saharan Africa, urban resilience has become part of sustainable development as urbanisation, climate change, and environmental degradation pressure are increasing in urban centres. These rush forces have heightened vulnerabilities and solutions which are innovative integrations of nature in the urban systems, are needed. This study presents how the ecological solution of ecosystem and green infrastructure can be the adaptable solution to the development of urban resilience in the selected cities in Africa. The study is based on a desk-based study covering a spectrum of fields and a comparative study of Lagos (Nigeria), Nairobi (Kenya) and Cape Town (South Africa) in order to explore the role of such features as urban forests, wetlands, green roofs, and sustainable drainage systems in bringing about ecological balance, reduction of flood risks and enhancement of urban livability. This paper has shown that even though the potential of ecosystem-based and green infrastructure is well-acknowledged, its application in urban planning is low. The major weaknesses are the poor coordination of institutions, insufficiency of funding, and disjointed governance structures. Nevertheless, Nairobi and Cape Town, as case studies show, show some positive changes with localized policies resulting in real changes in climate adaptation, biodiversity conservation, and human well-being. In the study, it is recommended that in order to make green infrastructure a standard part of urban development, cities need to become more firmly governed, be able to encourage stakeholder collaboration, and engage in sustainable financing strategies. Finally, increased scale of ecosystem-based interventions is a realistic and participatory solution to resilient, low-carbon, and sustainable urban futures in Sub-Saharan Africa.

Keywords: Green infrastructure, ecosystem-based approach, urban resilience, sustainable urban development

1.0 Introduction

Urban resilience has become one of the main themes of modern discourse on sustainable urban development especially in Su - Saharan Africa where urbanisation is more rapidly accelerating as compared to the ability of the cities to provide sufficient urban infrastructure, social services and environmental security. Some of the most rapidly expanding urban centres in the world can be found in this area such as Lagos, Nairobi, Kinshasa and Addis Ababa. The growth of the population in these cities has been high due to the natural demographic growth, sustained rural urban migration, and the reduction in the economic opportunities in the rural regions (United Nations-

basis of weak urban structures, in form of weak infrastructures, extensive informal slums, lax planning laws and also the lack of effective institutional resources. These structural loopholes pose a high risk to the urban population that is susceptible to environmental risks like floods, heat waves, droughts and other risks associated with climate change. This leads to the increased threat to the health of the city population, economic performance, and the environment (Adelekan et al., 2020).

Climate change, fast urbanisation and environmental degradation combine to present an intricate set of issues that pose a threat to the long-term sustainability of cities in Sub-Saharan Africa (Idowu and Ajibade, 2024). The urban growth has continued to encroach on the ecologically sensitive environments like wetlands, forests, and mangrove ecosystems and convert them into residential, commercial and industrial development. Such conversion affects the ability of natural ecosystems to offer the required ecological services, such as flood control, carbon capture, and temperature regulation, thus exacerbating urban exposure to environmental shocks (Elmqvist et al., 2019). Moreover, the loss of natural permeable surfaces to impermeable surfaces (asphalt and concrete) and deforestation, as well as improper waste management styles, is also a major contributor to air and water pollution (Abass et al., 2021). Climate change further worsens such conditions by creating uneven rainfall distributions, extended drought and increased temperatures, thus creating further strain in already overstrained urban facilities. Thus, extreme weather events have become more common and severe in most African cities to upset livelihoods, destroy infrastructure, and dislocation of vulnerable populations (IPCC, 2022).

The urban vulnerability is further increased by socioeconomic inequality. Many of the low-income households are located in locations which are environmentally vulnerable like floodplains, coastal regions or ill-serviced neighbourhoods where environmental degradation already exists in high concentrations. Climate change, accelerated urbanisation, and ecological degradation interacting to create a risk cycle therefore has a disproportionately negative impact on marginalised peoples. To solve this interdependent issue, there is a need to move beyond traditional methods of city management which are largely based on traditional grey infrastructure, including concrete drainage systems and seawalls. Rather, the necessity to adopt adaptive and restoration-oriented urban models that re-establish natural activities in the planning and development of cities is becoming a popularized idea (Kabisch et al., 2020).

In that scenario, the term urban resilience goes further than technological or engineering-related interventions. It includes ecological integrity, social and institutional capacity. The ecosystems of cities with degraded ecosystems are normally less resilient since the natural buffering mechanisms that check environmental disturbance are absent. On the other hand, sustainability of urban ecosystems has the potential of enhancing the ability of cities to take, adapt and get back on its feet to different environmental pressures. It is these intertwined issues of climate change, uncontrolled urbanisation and environmental degradation that necessitate interdisciplinary approaches that acknowledge the crucial role of ecosystems in the urban landscape (Cohen-Shacham et al., 2019).

The past few years saw the emergence of nature-based solutions (NbS) and ecosystem-based adaptation (EbA) as viable solutions to the problem of creating urban

resilience and facilitating sustainable urban development. They are natural systems and ecological processes approaches that are used to encourage climate adaptation, disaster risk reduction and biodiversity conservation. They tend to offer cost-effective, multifunctional, and locally flexible solutions compared to conventional infrastructure, which makes them especially appropriate to the fast-growing African cities (Mensah et al., 2021). They are demonstrated in practical cases in various African contexts. An example is the wetland restoration projects in Lagos, which have proven to be very effective in mitigating the risks of floods at the same time enhancing the quality of water and biodiversity. Urban green spaces and green roofs have been developed in Nairobi to minimize the urban heat island effect, increasing aesthetic value, and improving mental health of people living there. Likewise, watershed management practices that are based on ecosystems in Cape Town have been used to promote water security as well as to sustain local livelihoods (Pauleit et al., 2021).

Elements of green infrastructure, including urban forests, urban bioswales, permeable surfaces, and sustainable urban drainage systems, have various environmental and socioeconomic advantages. These interventions can help in enhancing the quality of the air, recreational value, and overall urban livability besides restoring degraded ecosystems and better carbon sequestration. They also lower their maintenance infrastructural expenses over the long term and make cities more appealing to investors since they ensure healthier and more climate-resilient environments (Raymond et al., 2022). Although these benefits exist, nature-based approaches are not adopted and implemented in most of the Sub-Saharan African cities. Among the major limitations are the lack of proper institutional coordination, lack of proper land governance structures, lack of technical expertise, and access to sustainable systems of financing (Kiribou et al., 2024).

Based on the foregoing, this study assesses the potential of green infrastructure and ecosystem-based solution to increase urban resilience by assessing the ability of these strategies to reduce environmental risks, enhance adaptive capacity, and sustain urban development in Sub-Saharan African cities. The aim of the study is to determining the effectiveness of green infrastructure (GI) and ecosystem-based adaptation (EbA) measures on the effectiveness of urban resilience in Sub-Saharan Africa in chosen cities. Hence, the study is restricted spatially in three major cities within Sub-Saharan Africa namely Lagos (Nigeria), Nairobi (Kenya), and Cape Town (South Africa). The selection of these cities is due to their different ecological conditions, mode of governance and the level of application of the ecosystem-based strategies.

2.0 Literature Review

2.1 Conceptual Framework

2.1.1 Socio-Ecological Systems

Socio-Ecological Systems (SES) framework is a resiliency thinking expansion in the meaning that it recognizes the reciprocal relationship between people and ecosystems. SES perspective of human societies and natural ecosystems, the concept presented by Berkes and Folke (1998) not only considers the human societies and

natural ecosystems as a system, but a co-evolution system. The ecological outcome of this methodology in literature applied to the urban context shows the aspect of perception that social choices, cultural priorities and economic practices change the ecological performance and vice versa. Within the SES system, cities are dynamic systems of ecology in which social processes (governance, technology and community behavior) interact with ecological processes (hydrology, biodiversity, and nutrient cycling). One of the components being weakened is bound to weaken the other. Thus, maintaining the integrity of the ecosystem through GI and EbA interventions does not only make the environment more stable but also socially well-being. As an example, the rehabilitation of wetlands in Lagos can tame floods and improve the livelihood of the people through fisheries and agriculture. Similarly, urban green belts in Nairobi possess recreational and psychological benefits and contribute to the biodiversity preservation (Elmqvist et al., 2019).

The SES framework revolves around the issue of feedback mechanisms: how can social vulnerability be caused by ecological degradation and how can sustainable management lead to reinforcing benefits? It also gives great emphasis on cross-scale connectivity and it understands that local activities can either have local or global impact on the environment. The implementation of the SES thinking in planning enables a holistic approach to governance of the urban areas in which the services provided by the ecosystem is accorded importance as an essential element of economic and social wellbeing. The SES approach can be applied to the case of Sub-Saharan Africa whereby informal settlements, resource deprivation and dismal institutions have affected ecological sustainability. The framing of cities as socio-ecological organizations enables planners to identify leverage points, the interventions in the management of the ecosystem can be created to promote human well-being in parallel, therefore, continuing to healthy and inclusive urban development (Pauleit et al., 2021).

2.1.2 Adaptive Governance

Adaptive governance is a more recent development as an expansion of resilience and socio-ecological systems thinking which is concerned with how institutions and policies can adapt flexibly to complex environmental pressures. It is based on cooperation, education and flexibility at various levels of decision-making. Folke et al. (2005) define adaptive governance as social processes of coordination that facilitate ecosystems and human systems to manage change and uncertainty. It entails the involvement of flexible institutions, participation of stakeholders and co-production of knowledge among scientists, policymakers, and communities. Adaptive governance plays an important role in the planning of urban resilience as it handles uncertainty of climate and socio-economic change. In contrast to the rigid, top-down organizational structures, the adaptive systems are based on the polycentric network of actors, whose functioning is at local, regional, and national levels, to exchange the information, resources, and responsibilities (Chaffin et al., 2016).

Stakeholders can change strategies as new knowledge is acquired through an iterative learning and trial process. In the case of the GI and EbA implementation, adaptive governance will help introduce the ecological factors into the process of urban planning. It promotes participatory processes in which the local inhabitants are involved

in co-planning and management of group green areas, which instills in them a sense of ownership and custodianship. In Sub-Saharan Africa, institutional fragmentation and insufficient financial capacity often limit environmental efforts, where adaptive governance offers a channel to establish belief, harmonize goals, and move resources across spheres (Kiribou et al., 2024). Furthermore, the adaptive form of governance promotes integration of policy where the environment is coupled with housing, transport as well as economic planning. It makes the process of urban planning more inclusive and responsive by the dialogue between the governmental and non-governmental actors. Finally, the adaptive governance is the key to the success of the ecosystem-based strategy because it facilitates the sustenance of learning, innovation, and flexibility in the management of urban ecological systems (Raymond et al., 2022).

2.2 Empirical Review

The past decades have seen an increased pace of urbanisation in Sub-Saharan Africa that has transformed space, social and environmental dynamics of cities in the region. The UN-Habitat estimates that cities in Africa are growing faster than any other part of the world and by the next few decades the population in urban areas would have increased two-folds. Reporting on the rapid urbanization of cities has often highlighted the rapid growth of cities, including Lagos, Nairobi, and Kinshasa, has been accompanied by poor planning institutions, inadequate infrastructure, and suboptimal investments in sustainable cities (UN-Habitat and IHS-Erasmus University Rotterdam, 2018). The previous global evaluations by UN-Habitat also emphasize that sustainable city prosperity entails the cities to balance their economic growth and environmental sustainability as well as social inclusion by proper governance and robust infrastructural support (UN-Habitat, 2012).

The analyses by scholars also show that in developing countries urbanisation usually increases more rapidly than the abilities of cities to cope with spatial development and environmental hazards. The National Bureau of Economic Research working papers like Henderson and Turner (2020) state that cities in the developing world tend to undergo untimely urban growth without corresponding growth in infrastructure and institutional capacity. Such an imbalance causes the cities to be more susceptible to environmental stressors as well as climate-related hazards especially in fast-growing African urban centres. Also, Akanmu et al. (2024) suggest that climate adaptation in Nigerian cities involves adopting ecological planning concepts and ecofriendly infrastructures as a part of urban development. These strategies can reduce flood risks, improve the environmental sustainability and increase the liveability of the urban environment such strategies include urban wetlands, green corridors and sustainable drainage systems (Akanmu, Gbadamosi & Omole, 2022). In another similar study by Akanmu (2023), findings revealed that that environmental factors have a substantial effect on the efficiency of urban infrastructure systems especially transportation systems denoting in frequent delays during downpour, flooding and associated climate change attributes (Akanmu, Salisu, Gbadamosi & Sonde, 2025; Akanmu 2023).

Meanwhile, the wider relationships between urban livability, resilience and infrastructure systems are also reflected in empirical research. In an example, Akanmu

et al (2022) established that the transport is an important factor in livability and sustainable urban operation. In a similar vein, as Ogunsesan, Akanmu, and Salisu (2022) observe, the sudden urbanisation, as a result of the lack of planning, can escalate the security-related issues and strain of the infrastructure in southwestern Nigerian settlements. These studies, together with others, highlight the importance of combined planning strategies that involve the development of resilient infrastructure in conjunction with ecosystem-based solutions. These strategies are becoming a major roadmap to resilience and sustainable development in urban centres that continue to urbanise at a high rate in Sub-Saharan Africa.

The notions of Green Infrastructure (GI) and Ecosystem-Based Approaches (EbA) have become the mainstays of the modern discourse of sustainable urban planning and resilience building. The two concepts focus on the blending of the natural systems and processes into the built environment to facilitate sustainability, biodiversity, and adaptive capacity. They offer solutions to the traditional grey infrastructure, which depends mainly on designed and energy-consuming solutions to urban problems, like flooding, heat stress, and pollution. Green Infrastructure (GI) is a network of strategically located natural and semi-natural systems that are established to provide a variety of ecosystem services and also improve the quality of the environment and the wellbeing of people.

According to the European Commission (2019) GI is a structured and planned system of natural and semi-natural spaces that includes other environmental elements and is designed and managed to achieve a large range of ecosystem services including water purification, air quality enhancement, recreational space, and climate cooling and adaptation. On the same note, as explained by Benedict and McMahon (2020), GI is an interactive network of greenways, natural landscapes, and green areas that help to sustain the ecological processes and offer advantages to both humans and wildlife. In the urban context, GI encompasses not only green spaces (e.g., parks, forests, urban gardens) but also blue infrastructure (e.g., rivers, wetlands, lakes, and drainage systems) which combine to provide a multi-functional landscape that can be ecologically connected and resilient. The components of Green Infrastructure vary according to scale and purpose but generally include Parks, community gardens, and recreational fields that enhance biodiversity and improve mental and physical health.

In view of the concept of urban sustainability, GI and EbA encourage multi-functional landscapes, which balance the environmental health, social welfare, and economic vitality. They enhance the quality of the air and water, provide recreational and aesthetic areas, improve mental health, and provide green jobs (Ekka et al., 2022). These methods enhance resilient and adaptive governance, social inclusion, and stewardship of the natural resources through participatory and adaptive governance systems that steer cities into low-carbon, resilient, and equitable development pathways.

2.3 Theoretical Framework

2.3.1 Resilience Theory

The basic prism of the concept of green infrastructure (GI) and ecosystem-based methods (EbA) can be interpreted in the framework of urban sustainability with the help of the theory of resilience. The concept of resilience started with ecology, with the first

introduction of resilience by Holling (1973) being the ability of a system to accept the disturbances and reorganize as it is changing in order to maintain its basic structure, functionality, and feedbacks. Resilience is applied to the ecological stability in the context of urban planning to refer to the capacity of social, economic, and infrastructural systems to predict, survive, and recuperate post-shocks (floods, heat waves, economic shock, etc.) (Folke, 2016). This theory also focuses on adaptive capacity, flexibility, and learning as key qualities of coping with uncertainty. Cities are considered complex adaptive systems with human and ecological parts, which are mutually encouraging and subject to ongoing transformation.

In this perspective, GI and EbA are tools of enhancing resilience since they incorporate redundancy, diversity, and ecological connectivity into cities (Saroa, 2017, 2019). As an example, green corridors and wetlands serve as systems that absorb floodwaters, tree canopies and green roofs serve as mechanisms of controlling temperatures and improving air quality functions, which can increase the ability of a city to adapt to environmental shocks. The resilience theory therefore changes the paradigms of planning where it is based on command and control strategies to a dynamic, iterative and responsive management. It promotes multi-scale strategies between ecological recovery, community involvement, and institutional partnerships. Resilience thinking gives a framework on how to incorporate nature-based solutions in urban development to make cities less vulnerable and more sustainable, especially in Sub-Saharan Africa, where institutions and infrastructural capacities are usually weak (Bahadur & Tanner, 2021).

3.0 Materials and Methods

3.1 The Study Areas

3.1.1 Lagos, Nigeria

Lagos is a very fast urbanizing coastal megacity in Africa and it has over 20 million inhabitants. The fact that it has a strategic, however, vulnerable location on the coast of the Atlantic Ocean and within the Niger Delta basin makes it vulnerable to several environmental hazards, such as sea-level rise, floods, and shoreline erosion (Abija et al., 2020). The spatial variable of wetlands, swamps and mangroves around the Lagos Lagoon as illustrated in Figure 1 shows that there have been considerable ecological alterations due to urban growth and land reclaiming. These shifts mean the deterioration of the natural buffers which used to control floods and offer support in the form of biodiversity and therefore making the city more vulnerable to climate risks.

In order to manage those risks, Lagos State has been implementing a number of Green Infrastructure (GI) and Ecosystem-Based Approach (EbA) initiatives that would help increase the ecological resilience and sustainable urban growth. Wetland conservation, sustainable urban forestry, and nature-based flood management are the priority of the Lagos Resilience Strategy (2019) and the Lagos Drainage Master Plan. Practical use of EbA that integrate conservation of biodiversity with climate adaptation can be seen in the Lekki Conservation Centre, Sandfill and Rehabilitation Programme and the green corridor projects along the Lekki-Epe Expressway. In addition, the use of permeable paving systems within residential estates has enhanced storm water

absorption that has reduced surface runoff and the severity of flooding (UN-Habitat, 2023).

Nevertheless, based on the patterns of land-use transformation, as it becomes evident in Figure 1, the sustainability of such efforts is imperiled by institutional fragmentation, insufficient funding and the fast-urban encroachment in ecologically sensitive areas. Enforcement of policies, ecosystem-based planning in urban governance, and community stewardship are essential measures that would lead to the restoration of long-term resilience and creating a balance between the urbanization and environmental sustainability in the city of Lagos.

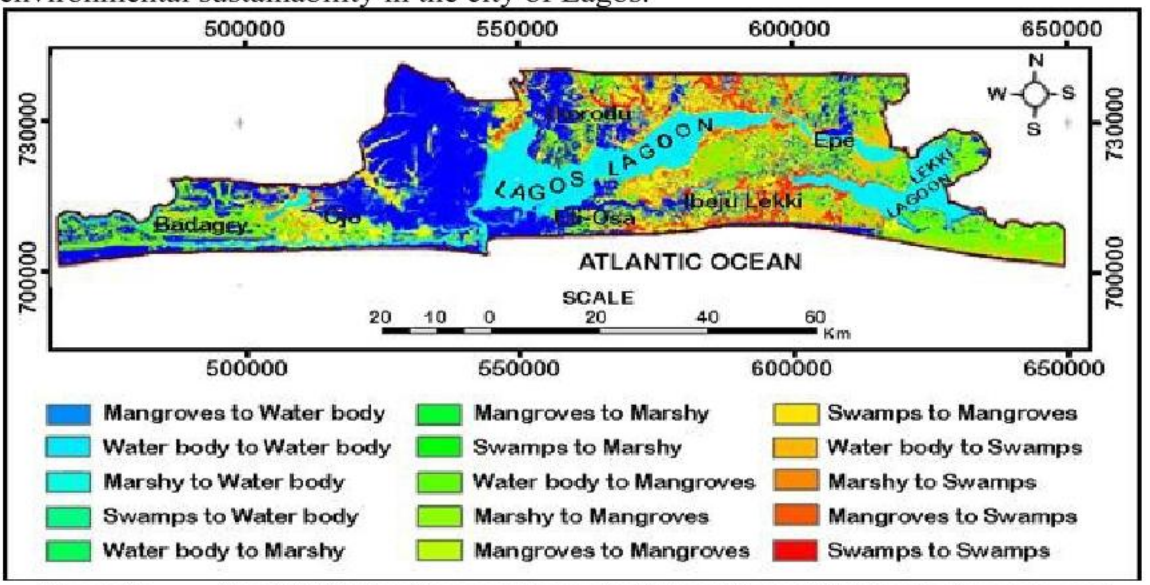

Figure 1: Spatial Distribution and Ecological Transitions of Wetlands, Swamps, and Mangroves in Lagos, Nigeria

Source: Lagos State Ministry of Environment and Water Resources (2023)

3.1.2 Nairobi, Kenya

The capital city of Kenya is Nairobi, which is approximately 1,795 meters above sea level and its ecosystem is a combination of highland forest and savanna. Its ecological integrity has been put in a strain by the rapid population growth, informal settlements and river pollution. Nevertheless, Nairobi has become one of the African urban centers that have adopted ecosystem-based city planning and green infrastructure integration (Nyathi et al., 2024). The Nairobi Rivers Rehabilitation and Restoration Programme is among the major enterprises aimed at cleaning and restoring the Nairobi, Ngong, and Mathare rivers by rehabilitating riparian buffer areas and involving the community (Muketha et al., 2025). Other urban greening initiatives in the city include Urban Forest Restoration Initiative which is a project at Karura forest that wants to restore the degraded forest reserves, enhance biodiversity, and provide recreational areas to the urban dwellers (refer to figure 2).

These interventions are illustrations of how the city planning integrates the role of ecosystem services in flood control, carbon capture and air pollution. The Nairobi

City County Climate Change Action Plan (2020-2025) also mainstreams EbA into the policies of the County development and promotes the application of green roofs, rain gardens, and sustainable drainage systems (SuDS) in new developments. However, the issues remain because of land tenure battles, insufficient technical capability, and poor coordination between urban institutions (Patel et al., 2020). The development of improved governance structures and intensifying community-based interventions are some of the solutions to the continued development of Nairobi.

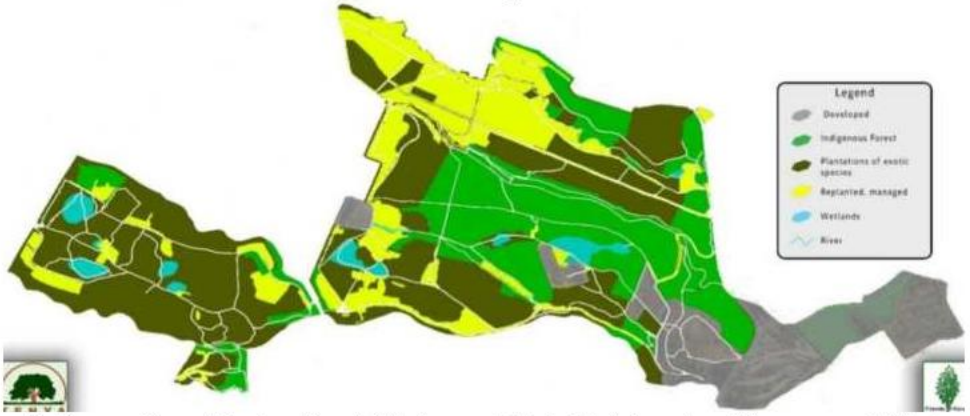

Figure 2: Karura Forest Restoration Initiative and Nairobi Arboretum Management Master Plan
Source: Ministry of Environment and Natural Resources Nairobi, Kenya (2020)

3.1.3 Cape Town, South Africa

Cape Town is one of the most developed models of the implementation of Green Infrastructure (GI) and Ecosystem-Based Approaches (EbA) in the city governance in Africa. The city has a well-organized system of conservation corridors, biosphere reserves, and critical environmental support areas that are embedded in the urban landscape in strategic places as seen in the Biodiversity Network (BioNet) as depicted in Figure 3. Cape Town is located in a Mediterranean climate zone, where the risks of droughts, wildfires, and water stress occur regularly, and the 2015-2018 water crisis has demonstrated the susceptibility of the city and the need to find ecological solutions to manage the use of resources in the most sustainable environment (Pauleit et al., 2021).

The City of Cape Town in its turn responded by creating BioNet and the Green Infrastructure Programme, which is dedicated to maintaining the ecological integrity and increasing urban resilience. According to Figure 3, some of the conserved spaces like Table Mountain National Park, False Bay Ecology Park, Diep River Corridor, and Blaauwberg Conservation Area are parts of a chain of ecological networks that sustain biodiversity, enhance hydrological infrastructure, and act as leisure places among the inhabitants. These projects are the practical examples of the application of the Ecosystem-Based Approaches, that is, the restoration of wetland systems, natural vegetation buffers, and the incorporation of Sustainable Urban Drainage Systems (SUDS) intended to handle stormwater and minimize the risks of floods (Pauleit et al., 2021). In addition, the Cape Town Water Strategy (2019) focuses on the protection of watersheds, elimination of alien vegetation, and management of water catchments in a sustainable way, enhancing ecosystem services and improving the exposure of the city

to climate-related risks (City of Cape Town, 2020). Economic tools, such as the Green Bonds Initiative, have raised funds to finance nature-based infrastructures and recovery showing that ecological planning and economic development are not mutually exclusive.

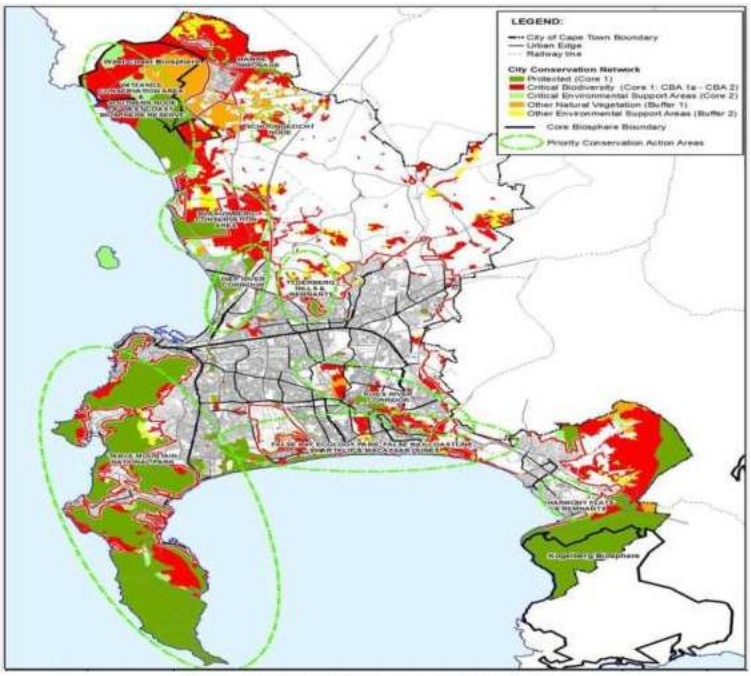

Figure 3: Capet Town, South Africa

3.2 Methodology

The study was carried out based on desk-based, comparative research design to assess the performance of Green Infrastructure (GI) and Ecosystem-Based Approaches (EbA) in fostering urban resilience in the selected cities of Sub-Saharan Africa without conducting surveys on the field but using the available literature, policy documents, institutional reports and demonstrations in the form of case studies. With the help of this approach, it is possible to perform a large-scale comparative evaluation of experiences in various cities and in various governance conditions. Although it lacks quantitative environmental data, and even lacks spatial modeling, it offers a critical insight into interactions between institutional, social and ecological variables in determining the success or failure of ecosystem-based initiatives.

Also, peer-reviewed journal articles, government reports, municipal planning documents, publications of international organizations (e.g., UN-Habitat, World Bank, IPCC) and urban resilience frameworks published between 2015 and 2025 have been reviewed. In such a manner, it is possible to obtain an integrative approach to theoretical, institutional, and practical aspects of GI and EbA implementation.

4.0 Results and Discussion

4.1 Comparative Synthesis across the Three Cases

When Lagos, Nairobi and Cape Town are compared analytically, it can be observed that they have similar problems and distinct approaches to solving the issue of Green Infrastructure (GI) and Ecosystem Based Approaches (EbA) to urban resiliency. Despite the various ecological and governing conditions of the three cities, they all present the awareness growth regarding the nature-based methods as potential solutions to the urban environmental pressure. Lagos with its low land coasts is the most susceptible to floods, wetlands erosion, and land reclamation pressures. The majority of its initiatives such as the wetlands conservation and the Lagos Resilience Strategy are largely reactive and can be viewed as the strategies that address the floods inflicted by the climate change along with the control of the drainage system. Its usage is, nevertheless, still hindered by sham enforcement, fragmented institutions and lack of engagement with the community. In its turn, Nairobi provides an example of the middle way of integrating EbA into the planning schemes.

The urban projects of the Nairobi City, including the Karura Forest Rehabilitation project and the Nairobi Rivers Restoration, are concerned with community participation and ecological restoration because of the pressures exerted on the inner ecological systems by the urbanization activities. The policy tools including the Climate Change Action Plan (2020-2025) in Nairobi depict that there is a growing institutional agreement regarding mainstreaming the green infrastructure. One example of institutionalised ecosystem-based planning is Cape town. Its Biodiversity Network (BioNet), Green Infrastructure Programme and its Water Strategy are all suggestive of a proactive governance-based approach in addition to the high-quality of policy coherence and financing frameworks such as Green Bonds. The urban design makes ecosystem services a growth sustainability asset by bringing together biodiversity conservation and urban design. In comparison, institutional, funding issues bedevil Lagos, participative governance is how Nairobi gets ahead and Cape Town is representative of a systematic, policy-driven action. The synthesis underscores the fact that to be effective, the implementation of GI and EbA needs three broad areas namely; institutional integration, sustainable financing, and responsive governance. It will also be significant to improve such dimensions across Sub-Saharan Africa to amplify nature-based resilience and become long-term sustainable.

Meanwhile the comparative study demonstrates that both Green Infrastructure (GI) and Ecosystem-Based Approaches (EbA) are more applicable to increase urban resilience and adaptive capacity in Sub-Saharan Africa but their impacts depend on institutional maturity and local conditions. Cape Town has been a major climatic adaptation through ecosystem-based planning. Some of these projects include, Table Mountain National Park, False Bay Coastal Protection Scheme and Diep River Wetland Rehabilitation Project among others that have enhanced hydrological control, restrained soil erosion and enhanced biodiversity in the metropolitan area. One of the applications of GI in urban planning with assistance of the Cape Town Biodiversity Network (BioNet) is the ecological processes management mechanism that can not only preserve ecological processes but also guarantee the economic and social sustainability of the system (Pauleit et al., 2021).

Programmes like the Nairobi Rivers Rehabilitation Programme and Karura Forest Restoration which have managed to restore the riparian buffers, mitigated the risk of floods and improved the quality of water have also been observed to make EbA successful in Nairobi. The interventions focus on the prospects of community engagement and urban greening to enhance ecosystem services and climate resilience (Mbugua, 2025). Similarly, to coupled Resilience Strategy, Lagos has already put forward wetland conservation and green corridor-initiated projects that have already exhibited measurable impacts on flood management and aesthetic value. However, the urbanization is not yet complete because of the rapid change in land-use and the leniency of the policies (Ayo-Odifiri et al., 2025). Although the value-adds have been shown, there are great institutional and financial limitations to mainstreaming GI and EbA within African cities. At an institutional level, the lack of coordination is based on institutional fragmentation among ministries, agencies, and municipal departments.

In Lagos, duplication and poor enforcement of the environmental laws are caused by the overlapping mandates of the Ministry of Environment and the Lagos State Physical Planning Authority as well as the local councils. The interdepartmental coordination and data sharing are low in Nairobi even though a county-level framework on climate action is in place (Croese, 2021). The Cape town on the other hand enjoys greater institutional integration, with the Environmental Management Department having close collaborations with urban planning and the water utilities based on adaptive governance structures. Shortage of finances is also paramount. GI and EbA projects are long-term projects that need funding, which most African cities do not have. Lagos heavily relies on donor-based and occasional government budgets, which restrain the continuity of the projects. The financial limitations facing Nairobi are further aggravated by competing economic demands in other cities of housing and transport infrastructure. The green bond utilization and collaboration with individual investors by Cape Town can serve as the example of the sustainable financing that can be implemented by other cities (Croese, 2021).

The local communities, technological innovation and governance networks are critical towards maintaining the GI and EbA implementation. Community participation in Nairobi, as exhibited in neighborhood associations and environmental non-governmental organizations (NGOs), has been essential in the reclamation of the eroded riverbanks and tree planting. These participatory models enable the residents to own their respective environments as well as participate in the stewardship of the ecosystems. Community involvement in flood-control and waste-management projects has also started in Lagos, but awareness of the community and technical training is still inadequate. Citizen-science initiatives and collaborations with higher education institutions in Cape Town have empowered the people in monitoring the ecological situation and data gathering.

Technology provides the impetus to scale up EbA. Remote sensing, Geographic Information Systems (GIS) and digital hydrological models are increasingly utilized in mapping vulnerable ecosystems and using them to direct adaptive planning. As an example, spatial data on wetland conversion in Lagos (Figure 1) and biodiversity in Cape Town (Figure 3) indicate that technology can be used to enhance evidence-based decisions-making. The use of smart urban forestry and water quality monitoring in

Nairobi can be further used as evidence of the usefulness of digital tools in terms of ecological performance tracking and maintenance optimization.

The networks of governance such as partnerships among the governments, the private sector, NGOs and research institutions become the support of the successful implementation. Cape Town is an example of polycentric governance, as networks like the City-Nature Alliance, the ICLEI-Local Governments for Sustainability network allow exchange of knowledge and co-financing. This model of governance is interconnected, which increases the resilience through learning, accountability, and mobilization of resources.

5.0 Conclusion and Recommendations

The study has examined how the resilience of urban areas of three Sub-Saharan African cities Lagos, Nairobi and Cape Town can be enhanced using Green Infrastructure (GI) and Ecosystem-Based Approaches (EbA). The results of the analysis show that even though the conceptual and operational value of ecosystem-based planning is largely agreeable, the results of implementation largely differ due to the difference in the governance structure, financial assets, and social-environmental context.

In all the three cases, GI and EbA can help achieve a lot of climate adaptation, biodiversity protection, and urban sustainability by reinstating ecological systems, upgrading air and water quality, and livelihood. They are also cost effective interchangeable and inclusive as opposed to the traditional engineering solutions. As a result, the following recommendations are made;

i. Mainstream Ecosystem-Based Planning: GI and EbA should be incorporated in the land-use, housing, water, and transportation plans of national and municipal governments. Environmental impact assessment and zoning codes should also specifically contain ecosystem service assessment.
ii. Enhance Institutional Coordination: form interdepartmental task forces or urban resilience councils to coordinate the governmental activities of the environmental, planning, and infrastructure agencies. Horizontal coordination between the local and national institutions is essential as well as the definition of the roles so that implementation is coherent.
iii. Establish Sustainable Financing Structures: African cities must also seek new structures to finance sustainable development, including green bonds, ecological taxation, and the public-private partnership. The large-scale EbA projects can be supported by using international climate funds (e.g., the Green Climate Fund and Adaptation Fund).
iv. Encourage Community involvement and Environmental education: Community involvement will increase community ownership and sustainability in the design, implementation, and monitoring. Ecological and socio-economic advantages of GI and EbA can be improved by campaigns, school curricula, and citizen-science programs to raise public awareness.
v. Improve Data and Technological Capacity: Invest in the spatial data infrastructure, GIS mapping, and environmental surveillance infrastructure to facilitate evidence-based decision-making. There has to be open data platforms

created to support information sharing among the researchers, policymakers and the general population.

vi. Cultivate Regional and Trans-Local Learning Networks: Networks like ICLEI-Africa and Resilient Cities Programme of UN-Habitat need to be strengthened to share best practices, technical skills and lessons learned when using successful projects.

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