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Green Infrastructure for Urban Livability in Southeastern Nigeria: Bolstering Regional Environmental Integration

Amobi P. CHIAMOGU[1] & Henry A. OGU[2]
[1]Department of Public Administration, School of Business Studies, Federal Polytechnic Oko, Anambra State; https://orcid.org/0000-0003-1745-2591
[2]First City Monument Bank(FCMB), Owerri Branch, Imo State

Abstract
Urbanization in Southeastern Nigeria has precipitated considerable environmental challenges, including flooding, air pollution, and the loss of green spaces, all of which detrimentally affect urban livability. Adopting a documentary research design, this study investigates how green infrastructure (GI) can serve as a sustainable solution by incorporating natural systems into urban environments, thereby enhancing the quality of life for residents. The research explores the potential of GI to improve urban livability in Southeastern Nigeria through its environmental, social, and economic benefits. Environmentally, GI enhances air and water quality, mitigates urban heat islands, and boosts biodiversity. Socially, it provides recreational spaces that promote physical and mental well-being and foster community cohesion. Economically, GI can elevate property values, attract tourism, and lower healthcare costs. The study addresses implementation challenges such as environmental degradation, inadequate infrastructure, and insufficient green spaces. It proposes strategies for effective GI implementation, including policy integration, community engagement, public-private partnerships, and education. The paper concludes with recommendations for policymakers and urban planners to integrate GI into urban development plans, emphasizing the need for comprehensive policies, capacity building, and regional environmental integration for sustainable urban growth in Southeastern Nigeria.
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Corresponding Author's Email: amobi.chiamogu@federalpolyoko.edu.ng

Introduction

Urbanization in Southeastern Nigeria has accelerated rapidly over the past few decades, driven by population growth and economic activities, particularly in cities such as Enugu, Aba, Onitsha, Owerri, and Abakaliki. The expansion of these urban areas, largely unplanned, has introduced significant environmental challenges, including deforestation, biodiversity loss, poor air quality, waste mismanagement, and land degradation. As urban centers become more congested, traditional approaches to urban planning have failed to incorporate environmental sustainability, exacerbating these issues. Green infrastructure, defined as a network of natural and semi-natural systems that deliver environmental, social, and economic benefits, offers a viable solution to enhance urban livability and sustainability (Benedict & McMahon, 2006).

The environmental challenges faced by Southeastern Nigeria are compounded by the region's high population density and inadequate infrastructural development. Cities like Onitsha and Aba, major commercial hubs, struggle with solid waste management, air pollution from vehicular and industrial emissions, and water contamination due to poor sanitation practices (Uwadiegwu & Iyi, 2015; Nwofe, 2018). Furthermore, deforestation and loss of green spaces have contributed to urban heat islands and increased vulnerability to gully erosion, a significant threat in the region's hilly areas (Igwe & Eze, 2017). Green infrastructure offers a promising approach to addressing these environmental challenges while promoting sustainable urban development. Its application in developing regions like Southeastern Nigeria, however, remains limited due to lack of awareness, inadequate policy frameworks, and insufficient funding (Ogunba & Abegunde, 2019). Globally, cities are increasingly adopting green infrastructure to improve urban resilience, mitigate climate change impacts, and

enhance public health (Hansen & Pauleit, 2014). In Southeastern Nigeria, a coordinated effort involving government agencies, urban planners, environmentalists, and local communities is essential to integrate green infrastructure into urban planning. This study aims to explore the potential of green infrastructure in enhancing urban livability in Southeastern Nigeria, focusing on how collaborative strategies can foster regional environmental integration and sustainable development.

Review of Literature and Theoretical Framework

Concept and Definition of Green Infrastructure

Green Infrastructure (GI) refers to a strategically planned network of natural and semi-natural areas designed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings. The concept of green infrastructure is rooted in the recognition that the environment can provide critical services that benefit human populations, such as clean air and water, climate regulation, and recreational opportunities (Benedict & McMahon, 2006). Unlike traditional infrastructure, which focuses on gray solutions like pipes, roads, and buildings, green infrastructure emphasizes the integration of natural systems into urban planning to create more resilient and sustainable communities. Green infrastructure is defined as "an interconnected network of green spaces that conserves natural ecosystem values and functions and provides associated benefits to human populations" (Benedict & McMahon, 2002, p. 12). It is a holistic approach that considers the environment as a vital component of the urban fabric, offering a multitude of benefits that go beyond mere aesthetic improvements. These benefits include the enhancement of biodiversity, improved air and water quality, climate adaptation, and the provision of recreational spaces (Gill et al., 2007).

Components of Green Infrastructure

Green Infrastructure encompasses a variety of components that work together to support the health of the environment and improve the quality of life for urban residents. These components include:

a) **Green Spaces and Urban Forests**: Parks, gardens, and urban forests are central to green infrastructure. These areas provide essential habitat for wildlife, help regulate the urban microclimate, and offer recreational spaces for communities (Tzoulas et al., 2007).
b) **Green Roofs and Walls**: Green roofs and living walls are innovative components that incorporate vegetation into the architecture of buildings. These installations reduce the urban heat island effect, improve insulation, and contribute to storm water management by absorbing rainwater (Oberndorfer et al., 2007).
c) **Wetlands and Water Bodies**: Wetlands, ponds, rivers, and lakes are critical components of green infrastructure. They play a vital role in water purification, flood control, and maintaining biodiversity. Restoring and protecting these water bodies is essential for urban resilience (Ahern, 2007).
d) **Green Corridors**: Green corridors, such as riparian zones, street trees, and greenways, connect fragmented habitats, allowing for the movement of wildlife and the flow of ecosystem services. These corridors also provide routes for non-motorized transportation, such as walking and cycling, contributing to the overall well-being of urban populations (Davies et al., 2006).
e) **Permeable Surfaces**: Permeable pavements and other surfaces allow rainwater to infiltrate the ground rather than running off into storm drains. This reduces the risk of flooding and recharges groundwater supplies. These surfaces are integral parts of green infrastructure, particularly in urban areas where impermeable surfaces dominate (Fletcher et al., 2015).
f) **Community Gardens and Urban Agriculture**: Community gardens and urban farms provide food security, promote social interaction, and contribute to the local economy. They are also key

components of green infrastructure, supporting biodiversity and reducing the carbon footprint associated with food transportation (Viljoen et al., 2005).

The concept of green infrastructure represents a paradigm shift in how urban and rural environments are planned and managed. By incorporating natural and semi-natural elements into the built environment, green infrastructure provides a sustainable approach to addressing environmental challenges such as climate change, biodiversity loss, and water management. Its components ranging from green spaces to permeable surfaces work together to create a resilient and healthy environment that benefits both people and the planet.

Concept of Urban Livability

Urban livability refers to the quality of life in cities, emphasizing how well urban environments meet the social, economic, and environmental needs of their inhabitants. It encompasses a wide range of factors that contribute to the well-being and satisfaction of urban residents, including access to affordable housing, transportation, public services, green spaces, safety, and social opportunities. In essence, urban livability measures how conducive a city is to living, working, and thriving in a sustainable way. Livable cities provide not only economic opportunities but also enhance residents' physical and mental well-being through well-designed spaces, amenities, and services (Newman, 2013). According to Gehl (2010), a livable city promotes human interaction, safety, and comfort while ensuring environmental sustainability. It is a holistic concept that bridges economic vitality with social equity and environmental health, creating an urban ecosystem that fosters inclusion, resilience, and sustainability (McCrea, Shyy & Stimson, 2006). Urban livability is strongly associated with urban planning that integrates social infrastructure and green spaces. Green infrastructure, such as parks, green roofs, and urban forests, plays a crucial role in enhancing urban livability by improving air quality, reducing heat island effects, promoting biodiversity, and offering recreational spaces (Haaland & van den Bosch, 2015). Moreover, livable cities prioritize accessibility to services, equitable distribution of resources, and policies that promote health and safety (Dempsey, Bramley, Power, & Brown, 2011).

In the context of Nigeria, urban livability has become an increasingly important concept, particularly as the country experiences rapid urbanization and population growth. Urban livability is often described as the ability of an urban area to provide a high quality of life to its residents, characterized by adequate housing, access to services, safety, and environmental quality (Pacione, 2003). This concept is closely linked to the notion of sustainable urban development, where cities are expected to meet the needs of current and future generations without compromising environmental, social, and economic resources (Evans, 2002).

Green Infrastructure and Urban Livability

Green infrastructure (GI) encompasses a broad range of natural and semi-natural systems that provide essential ecosystem services in urban environments, including air and water purification, climate regulation, and recreational spaces. These systems are integral to sustainable urban development, contributing significantly to urban livability by enhancing environmental quality, public health, and social cohesion (Hansen & Pauleit, 2014). In Nigeria, the concept of green infrastructure is gaining attention as a potential solution to the environmental and social challenges posed by rapid urbanization. Rapid urbanization has led to significant environmental degradation, including deforestation, loss of biodiversity, and increased pollution levels (Ogunbode, 2013). These issues are exacerbated by inadequate urban planning frameworks that often prioritize economic development over environmental sustainability. Despite these challenges, there is growing awareness of the need

for green infrastructure to enhance urban livability and mitigate the adverse effects of urbanization (Ogunba & Abegunde, 2019).

Urban Livability and Environmental Sustainability

Urban livability refers to the quality of life experienced by residents in an urban area, encompassing factors such as access to green spaces, air and water quality, housing, transportation, and social services (Vasishth & Sloane, 2002). In Nigeria, the decline in urban livability is closely linked to environmental degradation, with many cities experiencing poor air quality, inadequate waste management, and limited access to recreational spaces (Nwankwoala & Mmom, 2008). The integration of green infrastructure into urban planning is seen as a viable solution to these challenges, offering multiple benefits, including enhanced public health, reduced heat island effects, and increased biodiversity (Akintoye et al., 2019).

Green Infrastructure in Nigeria

Nigeria, the most populous country in Africa, is experiencing rapid urbanization, which exacerbates environmental challenges such as flooding, deforestation, air pollution, and waste management issues. These problems are particularly pronounced in cities like Lagos, Abuja, and Port Harcourt, where urban sprawl and inadequate infrastructure contribute to the degradation of natural ecosystems. GI offers a pathway to address these challenges by integrating natural systems into the urban fabric. Although the National Urban Development Policy (2012) and other regulatory frameworks mention the need for sustainable urban development, explicit strategies for promoting GI are limited. Policy gaps, weak institutional coordination, and insufficient public awareness have delayed the widespread adoption of GI in Nigerian cities. Nigeria's policy environment concerning GI is still developing. The role of non-governmental organizations (NGOs) and community-based organizations (CBOs) has been significant in promoting green spaces and environmental awareness. Initiatives by groups like the Nigerian Conservation Foundation (NCF) and local environmental advocacy organizations have helped raise awareness of the benefits of GI, especially in the context of environmental conservation and climate resilience.

Nonetheless, several projects and initiatives highlight the potential for GI to transform urban environments:

a) **Urban Parks and Public Green Spaces:** Public green spaces like the Millennium Park in Abuja and the Lekki Conservation Centre in Lagos provide some examples of green infrastructure in Nigerian cities. These spaces serve as vital ecological systems that offer recreational, educational, and conservation benefits while reducing the environmental impacts of urbanization.
b) **Wetland Restoration:** Wetlands, such as those found in the Niger Delta, serve as critical components of GI by providing natural flood protection, water purification, and carbon sequestration. However, these wetlands face significant threats from oil exploration, urban encroachment, and pollution. According to Adekola et al. (2015), restoring and protecting wetlands in Nigeria is crucial for maintaining ecosystem services, particularly in regions vulnerable to climate-related risks like flooding.
c) **Flood Management Systems:** Lagos, Nigeria's commercial capital, is highly prone to flooding due to its coastal location and rapid urban growth. GI solutions, including permeable surfaces, urban trees, and bioswales, could help manage storm-water and reduce the frequency and severity of floods. While there have been limited efforts to implement GI in Lagos, the potential for these systems to complement traditional infrastructure is significant (Adegun, 2017).

d) **Urban Agriculture and Green Roofs:** Urban agriculture and green roofs are emerging elements of GI in Nigeria. These systems provide environmental benefits such as reducing urban heat islands, enhancing food security, and promoting biodiversity. According to Ugwu et al. (2019), promoting urban agriculture in Nigerian cities could support local economies while improving food supply and environmental quality.

Challenges to Urban Livability in Southeastern Nigeria

The rate of urbanization in Southeastern Nigeria has been rapid and significant, reflecting broader trends across the major cities in the region. Southeastern Nigeria has experienced accelerated urban growth driven by population expansion, migration, and economic activities. Key factors influencing this urbanization trend include rural-to-urban migration, increased economic opportunities in cities, and the quest for better living conditions. Southeastern urban areas, particularly major cities like Enugu, Onitsha, Owerri, Aba, and Abakaliki, face significant challenges that impact livability. One of the primary issues is inadequate housing, where rapid population growth has outpaced the availability of affordable and quality housing. This has led to the proliferation of informal settlements and slums, where living conditions are often poor, with limited access to basic services such as clean water, sanitation, and electricity (Olujimi, 2009). Environmental degradation is another critical factor affecting urban livability in Southeastern Nigeria. Urban areas in the region are plagued by pollution, poor waste management, and deforestation, which contribute to a deteriorating urban environment. For example, air and water pollution are prevalent in many Southeastern cities, leading to health issues among urban residents (Akinbode, 2002). The lack of green spaces and the encroachment of urban development into natural areas further exacerbate these environmental challenges, making cities less livable (Adedayo & Eziyi, 2010).

High levels of poverty and inequality are prevalent in urban areas, which affects access to education, healthcare, and employment opportunities. The informal sector dominates the urban economy, providing livelihoods for many but often without social security or adequate income (Aluko, 2010). Additionally, crime and insecurity, including issues such as kidnapping, armed robbery, and communal conflicts, significantly impact the perception and reality of urban livability in Southeastern cities (Adepoju & Adekola, 2019).

Synergy Between Green Infrastructure and Regional Collaboration

The synergy between green infrastructure and regional environmental collaboration lies in the interconnectedness of ecological systems and the need for coordinated environmental management strategies. Southeastern Nigeria's regional integration efforts can benefit from a shared commitment to implementing green infrastructure as part of broader environmental management initiatives. This could include cross-border collaborations on watershed management, pollution control, and biodiversity conservation. Studies have highlighted the importance of regional environmental frameworks for managing shared resources. According to Ogbonna et al. (2018), collaborative environmental governance across states in Southeastern Nigeria can help mitigate trans-boundary environmental risks, such as pollution from urban runoff or deforestation. Such cooperation can also foster regional economic integration by promoting sustainable tourism and agricultural practices linked to healthy ecosystems.

Theoretical Framework

This study is anchored on ecological modernization theory (EMT) to provide a comprehensive lens for understanding the relationship between green infrastructure, urban livability, and regional environmental integration in Southeastern Nigeria. Ecological modernization theory emerged in the

early 1980s in response to growing concerns about environmental degradation and the limitations of traditional environmentalism. The theory originated in Western Europe, particularly in Germany and the Netherlands, as scholars sought to reconcile economic development with environmental sustainability. It was a reaction to the more pessimistic and critical perspectives on industrialization and ecological harm that dominated environmental discourse in the 1970s, such as the "limits to growth" thesis and radical ecological approaches, which advocated slowing economic growth to protect the environment.

The theory was largely developed by sociologists like Joseph Huber (1985)**,** Martin Jänicke (1986)**,** and Arthur P.J. Mol (1995), who played a central role in articulating its key ideas. They argued that technological innovation, economic progress, and environmental protection are not necessarily in conflict and can be aligned through institutional and technological reforms. Their work focused on the possibility of "ecological modernization" through the restructuring of production and consumption processes in ways that reduce environmental harm without compromising economic growth. EMT posits that environmental protection can be aligned with economic growth through the adoption of sustainable technologies and practices. This theory suggests that environmental challenges, such as urbanization and pollution, can be addressed by modernizing infrastructure to incorporate ecological considerations. EMT emphasizes the role of green infrastructure such as green roofs, urban forests, and rain gardens as technological innovations that integrate nature into urban spaces to enhance livability and reduce environmental degradation.

EMT is particularly relevant to the context of Southeastern Nigeria, where rapid urbanization has led to environmental challenges like deforestation, flooding, and loss of biodiversity. By adopting green infrastructure, cities in this region can modernize urban planning practices to balance ecological sustainability with economic development. EMT further underscores the role of policy and governance in facilitating this transition, making it a useful framework for understanding how institutional reforms can support green infrastructure development and regional environmental integration.

Methodology

This study adopted a documentary research design to explore the role of green infrastructure in enhancing urban livability and promoting regional environmental integration in Southeastern Nigeria. The documentary research design involves the systematic collection, review, and analysis of existing documents and secondary data to address the research questions. This approach is chosen due to its effectiveness in examining historical and contextual factors, policy documents, and previous research findings related to green infrastructure and urban livability. The documentary research design provides a structured approach to understanding the role of green infrastructure in enhancing urban livability and fostering regional environmental integration in Southeastern Nigeria. By systematically analyzing existing documents and secondary data, the study aims to offer valuable insights and recommendations for advancing green infrastructure and improving urban sustainability in the region.

Discussion of Findings

This study reveals the following findings on the positive impact of green infrastructure on urban livability, the challenges faced in its implementation, and its role in enhancing regional environmental integration in Southeastern Nigeria. Addressing these challenges and leveraging the benefits of green infrastructure can contribute to more sustainable and resilient urban environments in the region:

1. **Enhancement of Urban Livability Through Green Infrastructure**: Green infrastructure can significantly enhance urban livability by improving air quality, providing recreational spaces, and

reducing urban heat islands in Southeastern Nigeria. Green infrastructure, including urban parks, green roofs, and street trees, plays a crucial role in enhancing urban livability. Studies have shown that these green elements help to mitigate air pollution, offering cleaner air and healthier environments for urban residents (Tzoulas et al., 2007). In Southeastern Nigeria, where rapid urbanization has led to increased pollution and heat, the integration of green infrastructure can mitigate and regulate urban temperatures, reducing the heat island effect that is prevalent in densely built areas (Zhao et al., 2014).

2. **Challenges in Implementing Green Infrastructure**: The implementation of green infrastructure in Southeastern Nigeria faces several challenges, including inadequate funding, insufficient technical expertise, and limited public awareness. Local and state governments frequently struggle with tight budgets and competing priorities, which limits their ability to invest in essential green projects like parks, green roofs, and urban green spaces. The lack of adequate funding hampers both the initiation and sustainability of these projects. There is a noticeable gap in technical knowledge regarding the design and maintenance of green infrastructure (Gómez-Baggethun & Barton, 2013; Kabisch et al., 2017). Public support and understanding of green infrastructure are also lacking, which hampers the effectiveness of these projects.
3. **Impact on Regional Environmental Integration:** Green infrastructure contributes to regional environmental integration by fostering collaboration among cities and enhancing the overall ecological connectivity within Southeastern Nigeria. Green infrastructure projects often require collaboration across different administrative levels and jurisdictions, which can lead to improved regional environmental integration. In Southeastern Nigeria, green infrastructure can promote connectivity between urban and rural areas, urban and cities, intercity collaborations across states facilitating ecological processes such as wildlife movement and water management (BenDor et al., 2015). Regional initiatives, such as the creation of green belts and ecological corridors, enhance the ability of cities to manage environmental issues collectively and sustainably (Elmqvist et al., 2015). These collaborative efforts not only address local environmental challenges but also contribute to broader regional goals of ecological conservation and sustainable development.

Conclusion

The study demonstrates that green infrastructure plays a crucial role in enhancing urban livability in Southeastern Nigeria. By improving air quality, providing recreational spaces, and mitigating heat islands, green infrastructure contributes to healthier and more sustainable urban environments. However, the successful implementation of these initiatives is impeded by challenges such as limited funding, lack of technical expertise, and insufficient public awareness. Additionally, green infrastructure supports regional environmental integration by fostering collaboration and enhancing ecological connectivity across urban and rural areas.

Addressing the challenges identified and leveraging the benefits of green infrastructure are essential for advancing urban sustainability and regional environmental goals in Southeastern Nigeria.

Recommendations and Implementation Strategies

Based on the foregoing findings, we propose the following strategies for achieving greater urban livability in Southeastern Nigerian urban areas:

1) **Increase Funding and Investment**: Allocate more resources and funding to green infrastructure projects. Governments at local, state, and even federal levels should prioritize these investments and explore public-private partnerships to support green initiatives. This can be achieved by

developing funding mechanisms, such as green bonds or grants, to provide financial support for green infrastructure projects.

2) **Enhance Technical Expertise and Capacity Building**: Invest in training and capacity-building programs for urban planners, developers, and municipal staff to improve their knowledge and skills in designing and maintaining green infrastructure. By collaborating with polytechnics and similar technical institutions, and international organizations to provide workshops, certification programmes, and technical assistance.
3) **Promote Public Awareness and Engagement**: Increase public awareness and engagement through educational campaigns and community involvement initiatives. Educate residents about the benefits of green infrastructure and encourage their participation in green projects. Launch public awareness campaigns, organize community workshops, and involve local stakeholders in the planning and implementation of green infrastructure projects.
4) **Foster Regional Collaboration**: Strengthen regional collaboration among cities and local governments to enhance the effectiveness of green infrastructure and promote ecological connectivity. Establish regional networks and partnerships to coordinate green infrastructure initiatives, share best practices, and address common environmental challenges.
5) **Monitor and Evaluate Green Infrastructure Projects**: Implement robust monitoring and evaluation systems to assess the performance and impact of green infrastructure projects. Use this data to inform future projects and policies. Develop performance metrics and evaluation frameworks to track the outcomes of green infrastructure initiatives and make data-driven decisions.

By addressing these recommendations, Southeastern Nigeria can enhance the benefits of green infrastructure, overcome existing challenges, and advance toward more sustainable and livable urban environments.

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