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URBAN AND BUILDING-LEVEL NATURE-BASED SOLUTIONS FOR CLIMATE CHANGE MITIGATION IN NIGERIA: OPPORTUNITIES AND CHALLENGES

***Chukwunonso Obiefuna Umeora[1]; Chijioke Chinyere Onwuzuligbo[1]; Angela Oyileze Akanwa[2]; Charles Chetenna Munonye[1]; Peter Uchenna Igwe[2] & Stella Ngozi Emeka[1]**

[1]Department of Architecture, Chukwuemeka Odumegwu Ojukwu University, Uli Campus, Anambra State, Nigeria
[2]Department of Environmental Management, Chukwuemeka Odumegwu Ojukwu University, Uli Campus, Anambra State, Nigeria

Corresponding author*: co.umeora@coou.edu.ng

Abstract

Nature-Based Solutions (NbS) are strategies aimed at efficiently and adaptively protecting, managing, and restoring natural or modified ecological systems to address societal and environmental challenges. NbS has gained traction in the face of climate change, increased flooding, land degradation, loss of biodiversity, and deforestation for development. Yet the literature increasingly shows that their urban applications deserve more focused synthesis, particularly at the scale of buildings and surrounding built environments. This study employs a systematised narrative review to examine scholarship in building-based NbS and the broader urban NbS discourse. Findings reveal the social and ecological benefits of interventions such as green roofs, living walls, vertical greenery, courtyard greening, rain gardens, bioswales, and other forms of blue-green infrastructure integrated into buildings and neighbourhoods. The review examines the main benefits attributed to these approaches, including urban heat reduction, stormwater management, energy savings, air-quality improvement, biodiversity support, aesthetic enhancement, and physical and mental health co-benefits. It also evaluates major trade-offs and opposing views in the literature, such as high upfront costs, maintenance burdens, performance variability across climates and building types, water demand, uncertain carbon benefits, and concerns about unequal access, green gentrification, and the depoliticisation of structural decarbonisation. Findings also show that existing research has paid greatest attention to technical performance, thermal regulation, runoff control, and economic valuation, with green roofs and walls far more studied than other building-based NbS. By contrast, important gaps remain in long-term monitoring, biodiversity outcomes at the building scale, social justice implications, governance, financing models, and evidence from African and other Global South cities. The paper concludes that building-based urban NbS can make meaningful contributions to climate adaptation, mitigation, and urban liveability when designed as context-specific, multifunctional, and socially just interventions within broader urban settings.

Keywords: Carbon sequestration; Climate change mitigation; Ecosystem restoration; Sustainability governance; Urban-based NbS;

1. INTRODUCTION

The international community responded to sustainability as a societal challenge through, among other frameworks, the United Nations' 2030 Agenda for Sustainable Development and the New Urban Agenda adopted at HABITAT III. In this context, the International Union for Conservation of Nature (IUCN) popularised the term 'Nature-based Solutions (NbS)' to highlight actions that protect, sustainably manage, and restore natural or modified ecosystems while addressing societal challenges and providing human well-being and biodiversity benefits (Cohen-Shacham *et al*., 2019). The European Commission further defined NbS as 'solutions that are supported by nature, which are cost-effective, concurrently provide environmental and socioeconomic benefits, and help build resilience' (European Commission, 2016).

Urban areas strongly influence natural energy exchange and hydrological processes because of the built environment and impermeable surfaces they create, including asphalt roads, paved compounds, and squares (Panduro, Nainggolan, & Zandersen, 2024). These conditions often intensify urban heat islands and increase surface-water runoff, making urban areas particularly vulnerable to climate-change impacts (Echeta *et al*., 2023; Mohamed *et al*., 2024). Aronson *et al*. (2014) further noted that compact built environments, urban expansion, and poor management of green infrastructure often result in varying levels of biodiversity deterioration. Nigerian evidence also shows that land-cover change, vegetation loss, and urban encroachment are fast becoming environmental concerns with measurable climate-risk issues (Akanwa *et al*., 2026; Komolafe *et al*., 2026). Urban activities are also major sources of air, land, and water pollution.

Several urban areas around the world have experimented with green walls and green roofs and have documented useful lessons. However, this information remains context-specific and may not easily inform NbS implementation in buildings across all regions. Although the need for more NbS applications to improve the resilience of buildings in cities is globally recognised, cross-benefit mapping of the current state of the art remains limited (Kandel & Frantzeskaki, 2024). A synthesis of the literature on building-level NbS can clarify their performance requirements and add to the existing body of knowledge on NbS in urban areas. Such a synthesis can also provide insights into how building stock can contribute to urban cooling, climate adaptation, and biodiversity. In Southeast Nigeria, related studies have argued that biophilic and landscape-based design should be treated as strategies for thermal comfort, environmental quality, user well-being, and long-term sustainability (Umeora *et al*., 2025).

By protecting habitats and restoring degraded ecosystems in urban areas, NbS can improve environmental resilience, decrease urban heat stress, reduce flood risks, improve air quality, and enhance water purification (Ruangpan *et al.* 2020). These outcomes can improve well-being and reduce infrastructure maintenance costs within urban areas and buildings. According to United Nations estimates, Africa has a population of about 1.4 billion people, representing 16.72% of the world population, of which 43.8% reside in urban areas (UN-HABITAT, 2020). Furthermore, according to the United Nations report on urbanisation, Africa has 15 rapidly growing cities and is projected to have a rapid urban growth rate (UN, DESA, & PD., 2015). Furthermore, the United Nations report on urbanisation indicates that Africa has 15 rapidly growing cities and is projected to experience rapid urban growth (UN, DESA, & PD, 2015). Much of this urban growth is occurring in small and medium-sized towns, with an estimated additional 950 million people expected to live in African urban areas by 2050. Accelerated urbanisation has been identified as one of the major environmental threats that lead to visible consequences, such as deforestation and land degradation (Spyrou *et al*., 2021). Buildings in urban areas create an ecological footprint that affects natural resources and surrounding ecosystem services. This situation affects public health because of the reduction in ecosystem services. Consequently, some sustainable development goals may not be achieved in Africa without significant changes to urban master plans and development-management strategies. Calliari, Staccione, and Mysiak (2018) posited that building urban resilience through NbS is essential for reducing socioeconomic losses and promoting sustainable urbanisation. NbS also have the potential to support climate mitigation at a relatively low cost while providing additional benefits for people and the environment.

Against this backdrop, this study examines nature-based solutions as a combined approach to societal challenges that can reduce trade-offs and encourage synergies among the SDGs. Since existing building stock poses challenges for urban cooling and climate adaptation, a synthesis of the literature can provide insights into identifiable knowledge gaps. The aim of the study is to offer insights, through a scoping literature review, into NbS on buildings as opportunities for enhancing climate resilience. The objectives are to identify the design characteristics of building-level NbS that provide multiple benefits and to explore the benefits of NbS for buildings and their surrounding environments.

2. METHODOLOGY

The methodology was based on the review of scientific articles and ebooks. Literature searches were conducted in April 2026 using Google Scholar as the primary search platform, supported by citation tracking from relevant articles and selected institutional or policy documents. ResearchGate was used as a supplementary route for locating full-text versions of already identified publications. Search terms included combinations of the following keywords "nature-based solutions", "building-level nature-based solutions", "green roofs", "living walls", "vertical greening systems", "urban greening", "blue-green infrastructure", "urban heat", "stormwater management", "climate resilience", "climate change mitigation", "Nigeria" and "Africa".

The review prioritised peer-reviewed articles and high-quality policy or institutional sources that addressed NbS in relation to buildings, urban greening, heat mitigation, stormwater management, biodiversity, ecosystem services, governance or African urban climate resilience. Literature was included where it helped explain the benefits, constraints or implementation conditions of NbS at the building or neighbourhood scale. Studies were excluded where NbS was mentioned only tangentially or where the intervention was unrelated to the built environment. The selected literature was synthesised thematically to address three concerns: opportunities for Nigerian cities, evidence on building-level performance, and implementation constraints.

3. RESULT AND DISCUSSION

3.1 Opportunities for Nature-Based Solutions in Nigeria

Globally, NbS are known to enhance environmental-development actions that address social and economic challenges. Their implementation contributes to the sustainable resilience of societies and is increasingly perceived as a serious tool for responding to the climate-change crisis (Kiribou *et al*., 2024). Some opportunities for climate-change mitigation are outlined below:

Pervious Surfaces & Rain Gardens: According to Ajijola *et al*. (2021), shifting away from the conventional concrete landscapes to incorporating greenery and rain gardens will help cities in Nigeria manage extreme precipitation, mitigate flash floods, and replenish groundwater. These interventions are most effective when linked to site grading, maintenance plans and wider catchment-level drainage strategies rather than installed as isolated landscape features.

Vertical Greening Systems (VGS) & Green Walls: Some pilot projects in cities in tropical climates (like Lagos) revealed that installing green walls and facades with native plants can reduce indoor air temperatures by an average of 2.3°C, reducing reliance on air conditioning, thereby curbing greenhouse gas emissions.

Food Security: Integrating edible crops and medicinal plants into urban green infrastructure directly will benefit local neighbourhoods, simultaneously aiding adaptation and socioeconomic resilience.

Urban Forestry: Planned tree-planting campaigns, green belts, and mangrove restoration, especially in the Niger Delta and coastal areas, can support carbon sequestration while creating microclimates that support agriculture and protect against flooding.

3.2 Nature-Based Solutions for Climate Change Mitigation at Urban and Building-level

Kandel and Frantzeskaki (2024) noted that most studies on this subject were conducted in Australia, China, Europe, and North America; a few were conducted in Asia and South America, while very few were conducted in Africa. The benefits of nature-based solutions for buildings and the built environment are discussed as follows. The implementation of NbS on buildings affects the thermal behaviour of buildings. Piro *et al*. (2018) noted that, during hot seasons, building-level NbS can reduce temperature. External surface temperatures decrease across climates and across different infrastructures considered in the review. Compared with a concrete roof, a green roof can reduce outdoor surface temperature. Indoor surface temperature can also be reduced; the temperature reduction of the internal surface can reach 20 °C for a green roof compared with that of a conventional roof (CR) (Hao *et al*., 2022). The temperature reduction achieved through green walls and living walls is influenced by climatic conditions. The highest temperature reduction is observed during sunny and hot days because of higher solar radiation. During rainfall, indoor cooling effectiveness may decrease (Lin *et al*., 2013; Nagdeve *et al*., 2023).

The implementation of NbS on buildings also affects the built environment by reducing the temperature of exterior air and influencing the microclimate. A maximum temperature reduction of 6.4 °C has been observed for the air between a building and vegetation (Juras, 2022). Building-level NbS absorb less heat and evapotranspiration, thereby reducing the temperature of the surrounding environment. Because of the cooling effect of green roofs in their surrounding environments, they can serve as cooling buffers on roofs and can support other installations, such as renewable-energy systems (Alonso-Marroquin & Qadir, 2023). For instance, Alonso-Marroquin and Qadir (2023) found that the integration of photovoltaic PV installations with a green roof causes the underlying vegetation to serve as a continuous cooling buffer to the renewable energy system. This system is known as a Photovoltaic-Green Roof (PV-GR) or bio-solar roof.

Water management: The installation of green roofs on buildings helps to improve water-retention capacity. Kiribou *et al*. (2024) observed a sevenfold greater reduction in runoff with a green roof than with a conventional roof. Installing NbS on buildings and in their surrounding environments can contribute to flood reduction, as greenery on ground surfaces and roofs reduces runoff rates. The duration of rainfall also affects the environment. If a rainfall event is prolonged, it can affect the hydrological performance of the green roof (Almaaitah & Joksimovic, 2022).

Vegetation: The water management is akin to the management of the vegetation of the green walls, green roofs, and the environment: the soil is affected and then follows the vegetation. The stability of the soil is delicate and should be well-maintained to allow the adequate growth of the vegetation. Irrigation of the NBS is important to sustain biodiversity enhancement. The organic matter of the soil is vital as the plants cannot grow without it. On buildings, gardening infrastructures such as living walls, contribute to food production, and home gardening can potentially meet 46.4% of the residents' need for vegetables (Kiribou, *et al*, 2024). The surroundings of a building with NBS influence the exposure to solar radiation due to a shading effect (du Toit *et al*, 2018).

3.3 Challenges of Nature-Based Solutions applications in Nigeria

NbS in urban environments have the potential to (re)establish connections of people with nature and in this way may also contribute to pro-environmental behaviour and increased awareness of the significance of sustainability in everyday urban life (Soga & Gaston 2020). Engaging in pro-environmental behaviour through environmental stewardship practices may also be related to human well-being, social cohesion and happiness, which in turn may lead to increased nature interaction and positive conservation attitudes. However, several challenges inhibit NbS implementation in Nigeria.

Awareness and Technical Knowledge: There is presently low public awareness regarding building-level NbS, such as living roofs or modular living walls. Professionals in the built environment often require specialised training to integrate these tropical designs effectively.

Rapid Urbanisation and Land Use Pressures: High-density developments often prioritise housing and commercial space over green infrastructure. Major cities in Nigeria, like Abuja, Port Harcourt and Lagos are experiencing rapid, unstructured population growth.

Financial Constraints: Implementing urban NbS requires upfront capital and ongoing, resource-intensive maintenance. Local governments struggle to secure funding, relying heavily on international grants and external partnerships.

Policy and Regulatory Gaps: Although Nigeria has national climate policies, they are often poorly implemented. Fragmented institutional mandates and weak enforcement mean that developers frequently bypass building codes that require green spaces.

4. CONCLUSION AND RECOMMENDATIONS

NbS implementation is a key alternative that could contribute to the achievement of the SDGs, particularly SDG 11. Buildings should be seen as a new frontier for mainstreaming nature-based solutions to foster climate resilience in Nigerian cities. Given the benefits associated with green roofs, green walls, and living walls, these interventions are feasible solutions to consider for older buildings, especially those without structural insulation. To scale up NbS in Nigeria, cities must bridge the gap between policy and practice. This requires introducing tax incentives for property developers who integrate green roofs and walls, partnering with academic institutions to gather data on tropical plant performance, and mainstreaming NbS into local land-use and urban-renewal master plans.

NbS can integrate development, climate, and nature into comprehensive interventions that reinforce the short-term resilience of the physical and natural capital of cities. NbS implementation requires local community engagement and the establishment of institutional arrangements that integrate sustainable development into urban transformation. Given their environmental and social benefits, NbS provide an opportunity to support urban transformative change and the achievement of sustainable development goals in Nigerian cities. This calls on local and national governments, NGOs, researchers, and other decision-making institutions to advocate for urban NbS implementation in Nigeria. This can be done by involving the private sector and a wide range of stakeholders; leveraging innovation and technological development to unlock the full potential of NbS in cities; strengthening the capacity of city leaders and policymakers at local, national, and regional levels to address equity and sustainability in cities through NbS; and creating a national NbS framework for urban climate resilience by monitoring and assessing sustainable urban transformation.

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