

Opinion

Analysing the Benefits and Challenges of Integrating Green Roofs and Vertical Gardens into Urban Infrastructure

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Abstract: Green roofs and vertical gardens may be adopted into urban infrastructure to address contemporary challenges in the environment, the economy, and the society. Some of the benefits that green roofs and vertical gardens offer are: improved air quality, enhanced energy efficiency, reduced urban heat island effect and increased biodiversity. They also help manage storm water runoff by absorbing rainwater which helps to reduce runoff and flooding hazards. These eco-friendly systems increase the life span of building materials as well as reduce costs for heating and cooling due to their natural insulation. However, there are several problems associated with the installation of green roofs and vertical gardens. Issues related to initial costs, maintenance needs and structural load limitations can hinder large-scale uptake. Since sustainable urban design is not yet standardized and there is a lack of expertise, it makes it difficult for these green roofs and vertical gardens to be implemented in practice. These abstract sheds light on the pros and cons of using green roofs as well as vertical gardens when developing an urban area. It provides strategies for effective implementation of these methods to improve resilience in cities.

Keywords: Green roof, urban infrastructure, Nigeria

Introduction

Global Urbanization is a universal concept that has led to notable changes in the physical environment, giving rise to several ecological problems. The growth of cities necessitates sustainable urban infrastructure and the use of green roofs and vertical gardens is one way of tackling some of the detrimental impacts that urbanization has brought. Such ecological assets are beneficial in three ways, namely; environmental, economic, as well as societal benefits. However, they have some issues that require resolution for their complete integration into the city landscape. This study aims to explore the benefits and challenges associated with the installation of green roofs and vertical landscapes into urban infrastructure.

Benefits of Green Roofs and Vertical Gardens

Environmental Benefits

Urban Heat Island Mitigation: The reduction of the urban heat island (UHI) effect is a major role played by green roofs and vertical gardens in which cities are hotter than rural areas due to human activities and large surfaces with high absorption rates. The vegetation on green roofs and vertical gardens performs evapotranspiration and provides shading which ultimately lowers air temperatures, thereby reducing ambient temperature (Sailor, 2008). Studies show that during summer, green roofs can reduce rooftop temperatures by up to 40°C thus effectively mitigating the UHI effect in cities (Akbari, 2005).

Improved Air Quality: Green roofs and vertical gardens can take up airborne particles, including pollutants and particulate matter; hence cleaning up the city air. Plants absorb gaseous pollutants through stomata and they also capture airborne particles on their leaves (Yang et al., 2008). This can have significant health benefits and is very important for people living in cities prone to air pollution.

Stormwater Management: In urban areas, stormwater management is a major concern and this can be effectively managed by green roofs and vertical gardens. Runoff and flooding are normally associated with little to no infiltration of water through traditional impenetrable surfaces like concrete and asphalt. The extent of runoff could be lessened as well as its rate by absorbing it into the ground using green roofs and vertical gardens (Mentens et al., 2006). This not only eases the burden of urban drainage systems but also reduces the likelihood of floods.

Biodiversity Enhancement: Implementing urban areas with green roofs and vertical gardens provides habitats for various plant species and animals thereby increasing biodiversity. These green spaces support diverse flora and fauna such as birds, insects and small mammals that add to urban biodiversity (Madre et al., 2013). Green roofs and vertical gardens create ecological niches in otherwise barren cityscapes where they help preserve indigenous wildlife while maintaining natural harmony.

Economic Benefits

Energy Savings: Significant energy savings can be realized in the buildings that house the green roofs and vertical gardens. The layer of vegetation also serves as insulation which reduces the need for heating during the cold season and cooling during summer, thus reducing energy consumption and costs (Liu & Baskaran, 2003). It has been found that for certain climates green roofs reduce the energy used by air conditioning by nearly 75% (Getter & Rowe, 2006). This will not only help reduce operational expenses for building owners but also decrease greenhouse gas emissions associated with power generation.

Increased Property Value: The aesthetics of green roofs and vertical gardens increase property prices. Green infrastructure in a building creates a perception that it is more attractive and eco-sensitive than its non-green counterparts thereby boosting its market value (Ichihara & Cohen, 2011). Moreover,

they generally make urban areas look more aesthetically pleasing thus making them good places to live in or work from.

Extended Roof Lifespan: Green roofs help to protect the underlying roofing materials in buildings from harmful effects of UV radiation and extreme temperature fluctuations thereby, prolonging the life span of the roof. Green roofs have been found to double or triple the life expectancy of a roof compared with other roofing materials (Oberndorfer et al., 2007), which in turn helps reduce maintenance and replacement costs for building owners.

Social Benefits

Enhanced Aesthetic and Recreational Value: Urban aesthetics can be significantly improved through green roofs as well as vertical gardens. These green spaces provide visual relief in dense urban areas thereby contributing to a more pleasant and attractive cityscape. Accessible green roofs can act as recreation areas for residents, that is they provide places where people can relax, interact among themselves and even practice urban agriculture (Dunnett & Kingsbury, 2008).

Improved Mental and Health Well-being: There is a correlation between green space access and better mental health. Green roofs and vertical gardens also give urban dwellers the chance to reconnect with nature, which in turn relieves them of stress, improves their mood and can provide overall good mental health (Bratman et al., 2012). Additionally, greenery can create a strong sense of community and social cohesion in urban centres.

Educational Opportunities: Green roofs or vertical gardens may become educational tools, where they help teach about sustainable practices employed in urban ecology and horticulture. Institutions like universities and schools, or other social groups in the society can utilize these green spaces to carry out educational programs and other activities that aim at making the people aware of the environment (Berardi et al., 2014).

Challenges of Green Roofs and Vertical Gardens

Technical Challenges

Structural Load and Building Design: One of the main technical difficulties involved in constructing green roofs and vertical gardens is their impact on the structural load capacity of buildings. Soil, plants, fertilizers and so on are heavy, resulting into the need for suitable buildings to support this weight (Kosareo & Ries, 2007). There are moments when changing current structures to fit in these green roofs might necessitate landscape changes that are both expensive and complicated.

Water Management and Irrigation: For the success of green roofs and vertical gardens, it is important to have an effective water management system. They need a dependable supply of water so as to keep the plants healthy, especially during dry season. Sometimes it might be hard to make efficient irrigation systems that would minimize the amount of water used but at the same time ensure there is enough

moisture to the plants (Williams et al., 2010). Also, excess water should be allowed to drain off from such facilities in order to avoid water-logging and damage on structure.

Plant Selection and Maintenance: Choosing right plant species for green roofs and vertical gardens is very crucial for their prosperity. They must be able to withstand specific site conditions such as sunlight, wind, various levels of humidity among others (Butler & Orians, 2011). Maintenance also plays a big role in this case, thus green roofs and vertical gardens need regular watering, trimming and pest control. This continuous supporting may involve too much man power and money.

Economic Challenges:

High Initial Costs: To install green roofs and vertical gardens can be expensive with initial costs including design, materials, installation as well as structural changes. Such costs are a significant deterrent for owners or developers especially in areas where there are little financial incentives or support for green infrastructures (Bianchini & Hewage, 2012).

Funding and Incentives: Securing funds for projects on green roofs and vertical gardens could be a difficult task, especially in places where government incentives and subsidies are limited. There are cities that provide financial assistance towards green infrastructure but many do not which makes property owners to bear the full costs. Green roofs and vertical gardens will require developing solid funding mechanisms and incentives that will encourage their uptake (Clark et al., 2008).

Social and Cultural Challenges

Public Awareness and Perception: The perception and knowledge of the public concerning green roofs as well as vertical gardens can determine their acceptance and success. Sometimes, people may not understand or appreciate such benefits offered by these green infrastructures thereby leading to resistance or indifference from property owners, developers and the general public (White & Gatersleben, 2011). Education and outreach should be an essential part of increasing awareness about green infrastructure as well as developing positive attitudes.

Policy and Regulatory Barriers: Certain policies or regulations may hinder the integration of green roofs and vertical gardens into urban structures. In some instances, zoning laws, building codes among other legislations may not be in line with going green (Banting et al., 2005). Policymakers have a role to play in ensuring that supportive rules are formulated for easy adoption of green roofs as well as vertical gardens within urban centres.

Conclusion and Recommendations

Green roofs and vertical gardens have significant impacts on the various aspects of a city's landscape, including environmental sustainability, economic savings, and social well-being. These advanced vegetative infrastructures can alleviate urban heat island impact, enhance air purity, manage stormwater, and enhance biodiversity. They bear other economic gains like energy cost savings,

property appreciation as well as increasing the life of a roof. Inclusion of green roofs and vertical gardens in cities also improves urban beauty, mental health, and educates residents. Despite these beneficial aspects of green roofs and vertical gardens for cities, some challenges hinder their integration into urban infrastructure. Structural load, water management, and plant selection are important technical issues which must be solved for the successful implementation and maintenance of these systems. There may be economic constraints such as high initial costs or lack of funds to introduce them widely. Similarly, green infrastructure has cultural barriers which include public awareness or regulatory factors that may affect its viability. This shows that integrating green roofs with vertical gardens is not an easy task as seen from case studies conducted in cities such as Toronto, Singapore and Lagos. These examples highlight the importance of supportive policies, financial incentives, and public awareness in promoting the adoption of green infrastructure.

Recommendations

Develop Comprehensive Policies and Regulations: Governments should create well-rounded policies and rules that either command or give people a reason to integrate green roofs and vertical gardens in the urbanized areas. Policies should provide detailed recommendations on how it should be designed, installed, and maintained so as to make sure that greening projects would meet the highest standards of sustainability and performance.

Update Building Codes and Zoning Laws: The building codes and zoning laws that support the existence of green roof and vertical gardens should be improved. This includes allowing for necessary structural modifications as well as providing flexibility in design standards to accommodate the green infrastructure. Additionally, regulatory frameworks need to streamline the approval process for green projects.

Introduce Financial Incentives: Property owners and developers could be motivated into investing into green roofs through financial incentives such as tax allowances, grants, subsidies etc. Governments should also establish financial plans aimed at reducing initial costs while providing support towards maintenance and operation.

Implement Performance-Based Standards: Performance-based standards focus more on what is achieved through the use of green infrastructure than telling how these achievements can be met from one point to another. By imbuing these standards into the system, innovation becomes a necessity whereby applications of advanced technologies become a common practice.

Research and Development Support: The private sector, governments and colleges, should make investments in research and development that improve the methods and technologies of the green roofs and vertical gardens. The focus should be on finding new materials or improving on existing ones, better water management systems and plants that would thrive in urban areas.

Technology Transfer Promotion: Accelerating the adoption of green infrastructure can be done by transferring technological advancements and ideas across different regions or even sectors. The

countries, cities as well as industries ought to cooperate for sharing best practices, innovations, and successful models.

Encouraging Public-Private Partnerships: Public-private partnerships can make the most of their strengths to promote green infrastructure. Governments can provide regulatory support and incentives while on the other hand, private corporations may bring their know-how, technology as well as investment. These alliances result into enhanced efficiency as well as environmentally sustainable green projects.

Cultivate Innovation Culture: To ensure the success of a sustainable green infrastructure in future years to come, it would be necessary to create a culture of innovation within construction industry and urban planning. This implies that people need to be encouraged to experiment with new technologies while engaging in a continuous learning process aimed at improving learning.

Stakeholder Engagement in Policy Development: Property owners, developers, architects, engineers, investors, other stakeholders and the public need to be engaged by the policy makers in the development of the regulations for the green infrastructure. This ensures that all sectors are carried along, different perspectives are considered, and the policies are widely supported and accepted.

Promote Community Involvement: Community leaders and residents should be informed and actively involved in the planning, implementation and maintenance of the green roofs and vertical gardens in their community. This fosters a sense of ownership of the project.

Enhance Interdepartmental Coordination: Establishing collaboration among different government agencies like urban planning, environmental protection, public works and housing ensures that green projects are integrated in broader urban plans.

Capacity building and training: Trainings and workshops should be provided for the professionals on the green projects. These trainings should include design, installation and maintenance of the green roofs and vertical gardens. This ensures that those involved have the proper knowledge to carry out the project.

Conclusion

Green roofs and vertical gardens in the urban infrastructure provide an effective solution to address many of the environmental, economic, and social challenges caused by urbanization. Although the implementation of green infrastructure has many benefits, it is imperative to address the technical, economic, and social challenges which may hinder its success. Good policies should be well developed by the governments, building codes updated, and financial incentives provided. Innovations should be encouraged through research and development, technology transfer and public-private partnerships as this will aid the advancement of green infrastructures in urban areas. Community development and stakeholder collaboration are important for the successful adoption of green roofs and vertical gardens in cities. Addressing such areas would greatly assist cities in providing more sustainable, resilient, and

better places to live in. The integration of green roofs and vertical gardens will not only contribute to environmental sustainability but also improve the quality of life of residents in the urban setting, hence these cities will be more aesthetically pleasant and healthier places to live and work.

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