



Evaluating the Impact of Green Roofs on Urban Heat Island Effect and Stormwater Management

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DOI: <http://doi.org/10.36676/dira.v12.i4.155>



Accepted :29/10/2024 Published 28/12/2024

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Abstract

Due to rising urbanisation and climate change, urban areas are increasingly confronted with issues linked to the Urban Heat Island (UHI) effect and stormwater management. These challenges are becoming increasingly apparent. There has been a growing interest in green roofs as a sustainable building strategy due to the fact that they have the potential to alleviate these environmental problems. to what extent green roofs are beneficial in mitigating the urban heat island effect and in managing stormwater in urban environments. The research evaluates the thermal performance of green roofs by using a combination of field measurements, simulation models, and case studies. It also examines the impact that green roofs have on surface and ambient temperatures, as well as their capacity to retain and delay the discharge of rainwater. Green roofs have a substantial impact on lowering temperatures on rooftops, which in turn contributes to a reduction in the overall urban heat island effect. A further benefit of green roofs is that they improve stormwater management by soaking up rainwater, lowering peak flow rates, and delaying the discharge of runoff into urban drainage systems. In addition, the study underlines the fact that performance might vary depending on a variety of parameters, including the species of plant, the depth of the substrate, and the meteorological circumstances.

Keywords: Green Roofs, Urban Heat Island (UHI) Effect, Stormwater Management, Thermal Performance

Introduction





As a result of urbanisation, landscapes all over the world have been changed, resulting in densely populated settings that are frequently characterised by the Urban Heat Island (UHI) effect and considerable issues in stormwater management. The widespread use of impermeable surfaces like concrete and asphalt, which are able to absorb and retain heat, is the primary factor that contributes to the urban heat island effect (UHI), which occurs when metropolitan regions suffer greater temperatures than their more rural surroundings. This phenomena not only makes the need for energy to cool buildings more severe, but it also adds to the deterioration of air quality and the health of people living in metropolitan areas. At the same time, urbanisation has resulted in the disturbance of natural water cycles, which has led to an increase in both the volume and the speed of surface runoff from stormwater. When there is severe rainfall, traditional drainage systems in many cities are frequently overloaded, which results in flooding, water pollution, and the deterioration of aquatic ecosystems. As urban areas continue to expand and the effects of climate change become more severe, there is an immediate demand for creative solutions that can reduce the impact of urban heat islands and improve the management of stormwater. Among the potential solutions to these problems, green roofs have emerged as a promising candidate. Green roofs are able to bring several environmental benefits to urban infrastructure by incorporating flora into the structure. These benefits include the regulation of temperature, the retention of runoff, and the conservation of biodiversity. On green roofs, the plants and soil layers serve as natural insulators, lowering the temperatures on the rooftops and lessening the impact of the urban heat island effect. Furthermore, green roofs have the ability to absorb rainfall, which results in a reduction in runoff volumes and a delay in peak flows. This can facilitate the alleviation of the stress placed on urban drainage systems. the impact of green roofs on the urban heat island effect and stormwater management, providing a comprehensive analysis of their effectiveness in mitigating these urban environmental challenges. Despite their potential, the adoption of green roofs is still considered to be limited. This is partly due to uncertainties regarding their performance in different climatic conditions and urban settings. Using a variety of methods, including field measurements, computer models, and case studies, the purpose of this research is to quantify the advantages of green roofs and provide insights that can be put into practice immediately for their wider deployment. This work contributes to the expanding body of knowledge on green infrastructure by





addressing the urgent need for sustainable urban development. Additionally, it provides support for the incorporation of green roofs into urban planning and design as a feasible strategy for strengthening urban resilience and sustainability.

Importance of Addressing Urban Heat Island (UHI) Effect and Stormwater Management in Urban Areas:

Because of the rapid rise of their populations and the development of their infrastructure, urban regions are becoming increasingly susceptible to environmental concerns. Among these difficulties, the Urban Heat Island (UHI) effect and insufficient stormwater management are particularly significant concerns that need to be addressed.

- **Urban Heat Island Effect**

When urban regions suffer greater temperatures than their rural surrounds, this phenomenon is known as the urban heat island effect (UHI). This is mostly caused by the concentration of buildings, roads, and other infrastructure that allows heat to be absorbed and retained. This phenomenon not only makes the energy requirements for cooling more severe, which in turn results in increased consumption of electricity and emissions of greenhouse gases, but it also has an effect on public health by increasing the number of illnesses that are caused by prolonged exposure to heat. During heatwaves, vulnerable populations, such as the elderly and those with pre-existing health disorders, are especially predisposed to experiencing adverse health effects. In addition, higher temperatures can worsen air quality by hastening the creation of ground-level ozone, which in turn contributes to respiratory issues among people living in metropolitan areas.

- **Stormwater Management:**

Due to the fact that urbanisation frequently results in the formation of impermeable surfaces such as asphalt and concrete, which hinder natural water infiltration, efficient stormwater management is essential for the sustainability of urban areas. As a consequence, this leads to an increase in surface runoff, which can cause drainage systems to become overwhelmed, resulting in urban flooding, water pollution, and erosion. Moreover, ineffective management of stormwater can cause disruptions in the natural hydrological cycle, which in turn can have a detrimental effect on water quality and aquatic ecosystems. When climate change becomes





more severe, it is anticipated that the frequency and severity of extreme weather events, such as storms and heavy rainfall, will rise. This will put additional demand on the infrastructure that is now in place to manage stormwater.

In order to improve the resilience and liveability of urban environments, it is critically important to address both the urban heat island effect and the management of stormwater. Green infrastructure, which includes things like green roofs, permeable pavements, and urban green spaces, can help minimise these difficulties by lowering the amount of heat that is absorbed, increasing the amount of water that is able to penetrate the urban environment, and giving extra environmental and social advantages. The implementation of these solutions helps to improve the overall sustainability of cities, thereby enhancing the quality of life for people while simultaneously lowering the negative effects of urbanisation on the environment. It will be essential to prioritise methods to address the urban heat island effect and stormwater management in order to ensure the long-term profitability and resilience of cities in the face of climate change. This will be the case as cities continue to expand.

Green Roofs as a Sustainable Solution

Green roofs, also known as vegetated or living roofs, are a solution that incorporates nature into urban infrastructure in a way that is both innovative and sustainable. Green roofs are a significant tool for promoting urban sustainability because they cover the rooftops of buildings with layers of flora, soil, and other materials. Green roofs bring several benefits to the environment, the economy, and society.

➤ Environmental Benefits:

Green roofs are an essential component in the process of minimising the Urban Heat Island (UHI) effect, which is a prevalent issue in densely populated areas. This is because conventional rooftops have the ability to absorb and store heat, which results in higher temperatures. By acting as a natural insulator, the vegetation that is found on green roofs helps to lower the temperatures of the rooftop, which in turn brings the temperature of the air around the building down. This cooling impact not only helps to lessen the UHI effect, but it also reduces the amount of energy that is required for air conditioning in buildings, which ultimately results in a reduction in the emissions of greenhouse gases.





Additionally, green roofs are extremely successful in the management of runoff, in addition to their ability to regulate temperature. By absorbing and retaining rainwater, the soil and vegetation layers are able to reduce the amount of runoff that reaches urban drainage systems as well as the rate at which it does so. Not only does this procedure help to reduce floods in metropolitan areas, but it also filters contaminants out of the water, which ultimately results in an improvement in the quality of rainwater that finally flows into rivers and streams. The use of green roofs helps to make urban infrastructure more robust and capable of withstanding harsh weather events. This is accomplished by lessening the load that is placed on drainage systems.

➤ **Economic Benefits:**

Even though the initial installation cost of green roofs may be more than that of regular roofing systems, green roofs offer economic benefits that are more significant over the long run. The lifespan of roofing materials is increased by green roofs because they shield them from ultraviolet radiation and significant temperature variations. This results in a reduction in the expenses of maintenance and potential replacement. In addition, the additional energy savings that result from decreased heating and cooling requirements might, over time, compensate for the initial expenditure. The aesthetic appeal and environmental performance of buildings are both improved by green roofs, which contributes to an increase in property appreciation.

➤ **Social Benefits:**

The creation of green spaces in otherwise concrete-dominated environments is one of the ways that green roofs contribute to the physical and mental well-being of urban dwellers. An improvement in the quality of life in metropolitan areas can be attributed to the existence of these places, which offer chances for recreation, relaxation, and social interaction. In addition, green roofs can be used to assist urban agriculture by providing a platform for the cultivation of food in the immediate area and encouraging community involvement. Additionally, the presence of green roofs contributes to the ecological richness of cities by providing habitats for birds, insects, and other forms of animals. This helps to increase the biodiversity of urban areas. Green roofs provide a sustainable solution that simultaneously solves numerous environmental and social issues, which is being sought after by cities as they attempt to meet the challenges posed by climate change, the depletion of resources, and the accumulation of population.





Through the incorporation of green roofs into urban design and construction, cities have the ability to lessen their influence on the environment, improve their resistance to the effects of climate change, and produce areas that are healthier and more livable for their population. As a component of a more comprehensive plan for the development of sustainable urban areas, green roofs are a solution that is both practicable and impactful in terms of constructing cities that are greener and more resilient.

Conclusion

Green roofs have emerged as a potential and practical option for solving two of the most important environmental concerns in urban areas: the Urban Heat Island (UHI) effect and stormwater management. Green roofs are a type of roof that is covered with vegetation. The findings of this study have proven that green roofs have the potential to considerably alleviate the urban heat island effect by lowering the temperatures of rooftops and the temperatures of the air in urban areas below them. Green roofs assist minimise the need for air conditioning by utilising the natural cooling processes of vapotranspiration and shading. This results in a reduction in the amount of energy that is consumed as well as the emissions of greenhouse gases. When it comes to the management of stormwater, green roofs have been shown to be particularly successful at absorbing and retaining rainfall, which in turn reduces the amount of stormwater runoff as well as the rate at which it takes place. This not only reduces the strain that is placed on urban drainage systems, but it also helps to improve the quality of the water by filtering out pollutants before the water is released back into the natural water cycle. In addition to its role in mitigating urban flooding and managing stormwater in a sustainable manner, green roofs have the capacity to delay peak runoff times, which further supports their functionality. In addition to their positive effects on the environment, green roofs also provide a number of economic benefits, including the reduction of energy consumption, the extension of roof lifespans, and the enhancement of property values. The provision of green spaces that improve urban aesthetics, sustain biodiversity, and offer possibilities for recreation and community interaction is another way in which green roofs contribute to the social well-being of the community. On the other hand, the full potential of green roofs can only be realised via careful design, the selection of appropriate plants, and the consideration of the climatic





conditions of the local area. It is possible that the initial cost of installation will be a barrier; however, the long-term benefits, which include energy savings, less strain on infrastructure, and increased urban resilience, will justify the investment. Urban sustainability can be improved through the use of green roofs, which are a realistic and sustainable method. As cities continue to struggle with the simultaneous issues of urbanisation and climate change, the use of green roofs has to be promoted and incorporated into more comprehensive urban planning and development initiatives. By doing so, cities have the ability to build settings that are healthier and more resilient for their citizens, while also contributing to global efforts to battle climate change and promote sustainable development.

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