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GREEN ROOF BENEFITS, OPPORTUNITIES AND CHALLENGES

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Abstract: **Over the last two decades, major research have been made about green roofs, this article tries to raise more awareness on green roof components and its many benefits (environmental, social and economic) that are related with the green roof technology. This article also places emphasis on how green roofs works in different areas, their overall performance in reducing storm water and energy costs, and improving air and ecological performance. The benefits of green roof shows that it plays an important role in making cities more secure, sustainable and resilient to local climate change. However, huge construction costs, excessive renovation costs and roof leakages are the primary challenges associated with the application of green roofs. These challenges can be overcome with new cost effective green roof layout that can work successfully and efficiently in any area. Advanced amendments and traits of green roof application are also covered in this article.**

Keywords: **Green roof, Components, Benefits, Promotional policies, Advanced modification.**

1. INTRODUCTION

Climate change and urbanization are matters of modern interest. Due to speedy financial growth, urbanization is growing in many countries which degrade the natural landscape as well as the close environment. These problems can be solved by making use of green infrastructure strategies. The introduction of new urban development techniques such as rain gardens, green roofs, and green partitions can help reduce the direct effects of urbanization and improve the environment of an area. Green roofs are basically roofs that are planted with a distinct form of vegetation/plants on the top of a growth medium (soil). The idea is to encourage the implementation of vegetation on the top of buildings to get multiple social, economic and environmental benefits. A green roof commonly consists of several components, including vegetation, substrate, filter layer, drainage material, insulation, root barrier and water proofing membranes. The placement of each component of the green roof is very essential in order to get the best outcomes from the green roofs. Each component is equally important and performs a very important role for the better overall performance of green roofs in an area. Due to multiple benefits, green roofs are being applied in many countries. Research on the green roofs indicates several social, environmental and economic benefits. Significant evidence indicates that green roofs can supply more than one benefits, such as storm water management, depletion of heat in urban context, increase in urban plant life, small increase in wildlife habitats, improvements with regards to the air and water quality and quality of life in an urban context, decreased energy consumptions costs of buildings, decreased noise pollution, encourages recreational activities and increase in aesthetic value in an urban environment. As a result of water quality enhancement, green roofs decrease the workload of the water cure amenities in an area. Due to the above advantages, many countries begun to design green roofs on their buildings. As the result of this more and more green roofs are established and designed day by day around the globe.

2. LITERATURE REVIEW

Planted roofs can improve the thermal environment in cities with the aid of decreasing solar absorption, Daily thermal variation and annual thermal fluctuations. By providing large vegetated surfaces, they contribute to the improvement of

thermal performance of the building (Eumorfopoulou and Aravantinos, 1998). Niachou A et al (2001) which observed that the indoor temperature values in buildings with green roof are lower during the day, in order to support this finding, they measured the roof temperatures of non-insulated buildings, with and without green roof. The end results shows that the roof temperature of non-insulated building without green roof varies from 42 to 48 degrees Celsius whilst the temperatures of the green roof upon non-insulated building are lower and ranging from 28 to 40 degrees Celsius. They also concluded that the existence of large temperature variations due to the installation of green roof could lead to energy saving potential.

A research to inspect the outcomes of rooftop garden on energy consumption of a five-storey commercial building has been carried out in Singapore. The study was performed on three different types of roof which are exposed roof, typical flat roof and rooftop garden with different stages of vegetation (low vegetation, medium vegetation and high vegetation). The results of the study showed that the installation of rooftop garden on five storey commercial building can result in a saving of 1 to 15% of annual energy consumption, 17-79% in space cooling load and 17-79% in the peak space load and shrubs were found to be the most effective energy consumption in building

(Wong et al., 2003b).

Many research has established that different kinds of vegetation could provide unique thermal reduction measurements. Large foliage development with mainly horizontal leaf distribution could give excellent thermal reduction (Barrio, 1998). Those finding were supported by Wong et al. (2007) which indicated that the temperatures measured underneath extensive greenery coverage were considerably lower than that measured underneath the groundcover with tiny leaves. Lower temperatures were obtained under thick greenery while higher temperatures were obtained beneath sparse vegetation or only soil, and green plants irradiated and reflected less solar heat (Wong et al., 2003).

Wong et al. (2003b) also conducted a simulation study to learn about the strength of energy consumption for different types of roofs on a five-storey commercial building in Singapore. The comparison between rooftops that are without vegetation, rooftops that are totally covered with turfing, shrubs and trees was carried out on that building. The result revealed that shrubs were the most effective vegetation in reducing energy consumption in buildings while turfing has the least reduction.

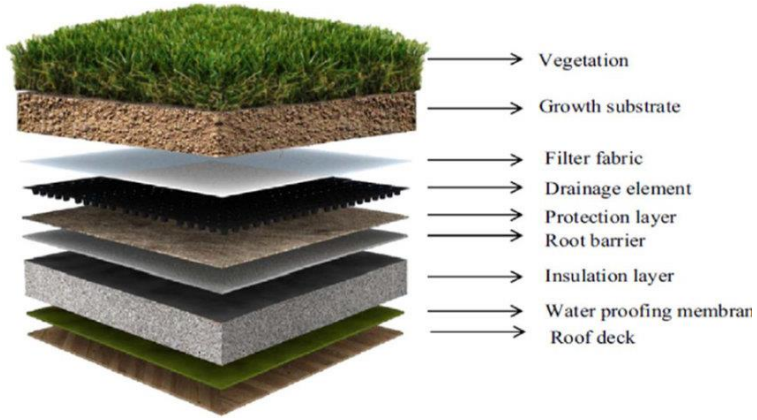
3. METHODOLOGY

This article provides an overview of green roof technology and suggests how they have considerably contributed to supply more than one benefits (social, environmental and economic) in urban areas. This paper reviewed global literature from distinctive sources, i.e. peer reviews, research articles, books, case studies, conferences, technical reports, design guidelines, project summaries and group discussions. A search of a number of different keywords for the green roof that includes green roof technology, green roof components, green roof benefits, green roof policies, and a new combination of green roof for a number of benefits. This assessment is giving an insightful overview of the green roof to the common user to recognize the green roof technology. This overview additionally explains the components of the green roof and their benefits in details. Many research has been stated to show the green roof benefits for storm water management and improving the environmental performance in unique areas.

This paper gives an overview of green roof technology and shows how they have significantly contributed supply many advantages (social, environmental and economical) in urban areas. This review paper differs from the previous review works on the green roofs in phrases of quite a number of aspects. First of all, the idea of green roof is explored in a holistic way in this review paper. The review initiates with a historical overview of the green roof technology with the aid of theoretical basics and clear explanations. Each component of green roof is comprehensively described with their benefits. Each benefit of green roof with the life cycle assessment is described in details, green roof promotional policies of different countries as well as the research gap, the problems and technical difficulties that are associated with green roofs are also described in details.

4. FINDINGS AND DISCUSSIONS

There are various kinds of green roof model established by way of research. Each model consists of simple aspects of green roof which are plant layer, growing medium and drainage layer. For lengthy term environmental benefits, the choice of each layer according to the region and climatic benefits is very important. Every aspect of green roofs is very important and should be selected appropriately to achieve the most advantageous results.



Typical components of a green roof.

A. The most crucial and exciting part of the development of green roof is the selection of **plant layer**, which maximize the green roof life. The fulfilment of green roofs depends on plant's health. With regards to the selection of plant, we have to consider the geographic vicinity, rainfall intensity, humidity, wind and sun exposure. Depth of growth can additionally determine the plant species we can use for green roofs.

Plants usually use for green roofs all around the globe.

Green roofs are the best storm water management practices in urban areas due to the fact that plant life and substrate layers have capabilities to store a huge amount of water. As a result of this, the possibilities of flash flooding decreases in city region.

Vegetation/plants of green roofs, enhance the runoff water quality, air quality and decrease the heat waves in an area. However, it must pointed out that the rooftop is not the ideal space for natural plant growth. Water is always a limiting factor for rooftop environments. Similarly, building regulations restrict the soil depth. The soil additionally needs essential nutrients to maintain overall performance of plant life. After thinking about most of these restrictions at rooftops, the ideal plants/flowers to be considered for rooftops should have the following characteristics.

- Capability to withstand drought and excessive climate conditions.
- They should be easily available and economically friendly.
- They shouldn't need frequent irrigations.
- They should have short and tender roots.
- They should have the ability to continue to exist under minimum nutrients conditions.
- They should require less maintenance.
- More evapotranspiration.
- Can lessen the heat island phenomena

It is very difficult that plants can have all of the above favourable characteristics, but significant progress have been made for the selection of suitable vegetation for green roofs.

B. The **growth medium** layer may be known as the crucial layer because it directly affects the plant's growth and the success of a green roof. Consequently, the standard choice of this growth medium (soil) should be necessary for the success of a green roof. Most of the green roof benefits are directly correlated with the substrate of green roofs which includes water quality enhancement, runoff reduction, peak flow reduction and thermal advantages. The growth medium must have specific properties, i.e. mild weight and the high ratio of natural minerals that help for plant increase, but it isn't always sensible that a substrate may have all preferred properties. Consequently, the general exercise is to mix the different additives in growth substrate.

Green roofs growth mediums should have a low bulk density, because if it has a high bulk density it may collapse the structure, especially in old buildings because the load restriction cannot allow the additional heavy weight to substrate. Hence it is continually attempted to keep the weight of the green roof as little as possible. This can be achieved by adding lower density inorganic material within the substrate.

The green roof water proofing membrane material should have high water holding capacity (WHC) because it helps to minimize the peak runoff flow and helps to allow the plants survive under drought conditions. WHC can be increased by increasing the substrate volume and depth.

Growing media of green roof should have high air filled porosity (AFP) because it helps the continuity of water under rainy events and prevents the leakage of a green roof. An optimum substrate should stable and support the wide ranges of the plant/vegetation. It should also be light weight and help plants to be able to withstand extreme climatic conditions.

C. A **filter layer** of green roofs is used to split the growth medium from the drainage layer, and stop smaller particles like soil fines and plant debris from getting into and clogging the drainage layer. This is also called, geotextiles and are used to provide higher continuity for water in the drainage layer. These filter fabrics have high tensile strengths and high water permeability to flow water into the drainage layer.

D. An **insulation layer** isn't always an obligatory layer on any roof. This sediment prevents water stored in the green roof system from extracting heat in the winter or cool air in the summer. More insulation is usually required when green roofs are applied on existing roofs in restoration or retrofitting projects. Depending on the design and type of the roof it should be provided. However, it is placed above the waterproofing, as it further protects the membrane from condensation and physical damage.

The biggest challenges for the drainage layer is the cost and disposal of drainage layer is a big issue for the drainage layer. Hence, further research is needed for the selection of better cost effective and environment-friendly drainage layer.

E. The **drainage layer** could be very crucial for green roofs because it lets in the removal of excess water from the substrate. In this manner, it reduces the weight on the building and possibilities of a collapse of building structure additionally decrease. It also protects the water-resistant membrane and improves the electricity efficiency of the building [80].

F. The **waterproofing membrane** is vital for the green roof to avoid the leakage of water on the roofs. Within the green roof, because the moist soil and high moisture content increases the chances of leakages of green roofs. Therefore, a waterproofing membrane is very essential for green roofs and care has to be taken while the selection of waterproofing membranes

B. Reduction of **surface temperature and thermal comfort** are the two crucial capabilities of the green roof in an urban context. Green roofs add thermal resistance to the building this causes the cooling of the building in summer and additionally reduces the electricity expenses. Green roof vegetation and substrate absorbs fewer solar radiation than the alternative types of roofs, hence also saving the money use for cooling

C. Green roof **has potential to capture the harmful fine dirt particles** from the air that could help to comfort for human in highly developed urban areas. In urban areas, the air typically contains fine dust particles that make the urban environment bad and uncomfortable.

D. Another benefit of the green roof is the **reduction of the noise** level. A green roof can act as a kind of sound insulation. Closing off some level of noise from outdoors.

E. Green roofs additionally **beautify the aesthetic of an area** in addition to the natural world. Peng and Jim confirmed that the green roofs play a crucial role to enhance the urban ecology, however it is difficult to measure in urban areas. Numerous studies shows that green roofs are very helpful to reduce the habitat loss in the urban context. Green roofs also promote the leisure activities in city areas. It promotes the wildlife by allowing them to be available in green areas. It attempts to make impervious surface areas into natural green areas that can also add environmental benefits in urban areas.

5. CHALLENGES AND TECHNICAL DIFFICULTIES OF GREEN ROOF

Despite the fact that green roofs are considered as a potential opportunity for pollution control and an attempt to retrieve the natural hydrology in urban areas, the demanding situations which restrict their use still stay. despite the fact that many study results show that the green roofs are the best management practices because of multiple social, environmental and economic benefits, but many factors which includes (high initial cost, unawareness the green roofs construction mechanics and maintenance costs and so forth.) still hinder the green roofs in underdeveloped nations. An ideal green roof design that can apply to the all places and weather circumstance is also one of the biggest challenges. As most of the researches have been carried out in cold areas, therefore the selection of the green roof plant needs extra attention. On the contrary, in hot regions, there's a need to pick the right plant for the higher overall performance of green roof within the summer season. These research challenges and issues associated with green roof research, we think, are connected to each other and need to be researched further for the successful implementation of green roofs everywhere.

Also, it is important to consider multiple factors like initial high construction cost, reduction of use of polymer material and their disposal, high maintenance costs, limited local research, roof leakage problems, and lack of cooperation between different fields that hinder us from solving challenges that will benefit the use of green roofs in an urban context.

6. TECHNICAL DIFFICULTIES

The main technical difficulties regarding the application of green roofs, which are needed to be considered are listed below:

- It is very hard to estimate the air quality, ecological improvement, temperature and noise reduction costs for life cycle cost analysis of green roofs, so it is needed to carry out more studies with regards to the life cycle cost analysis that includes the benefits listed above.

- More effort is needed in order to find a better local substrate for the green roof, which can reduce the water quality problems that green roofs struggle with.

- Air, water quality and thermal performance of green roofs should be advertised to attract stakeholders for the application of green roofs.
- Polymer materials that are used in green roof components should eliminate and find the Eco friendly that can enhance the environment.
- A huger effort is needed for the co-operation and collaboration between different fields for the application and management of green roofs.

7. CONCLUSION

Research work on green roofs has been challenging and provides opportunities for researchers to focus on future research. This paper, reviews literature regarding green roof properties, environmental, social and monetary benefits, challenges, opportunities, and potential applications of green roofs. Although significant features have been reported, there are many challenges such as high construction costs and management problems that should also be considered for the potential applications around the world. In this paper, an effort was made to demonstrate how green roofing can help mimic the natural hydrology as well as help prevent global warming which has become a major issue in both our political and natural surroundings. There is also need to develop cost effective green roof practices for the many benefits (environmental, social etc.) of green roof. Nonetheless, in order to make more progress. a more in-depth real experimental work on each component of the green roof is required, and multidisciplinary research collaboration in dealing the challenges is gravely needed.

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