# Green Roof Concept- Need of Hour for Healthy Environment

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***Abstract:*** **As forests, agricultural fields, and suburban and urban lands replaced with impervious surfaces resulting from development, the necessity to recover green space is becoming increasingly critical to maintain environmental quality. Vegetated or green roofs are one potential remedy for this problem. Establishing plant material on rooftops provides numerous ecological and economic benefits, including energy conservation, mitigation of the urban heat island effect, and increased longevity of roofing membranes, as well as providing a more aesthetically pleasing environment in which to work and live. The aim of providing the green roof concept is to minimize the temperature of building and to decrease the effect of global warming. The Method of research include local and international case studies, which will provide the data regarding the comparative temperature with those buildings without green roof, survey of nurseries and material shop in order to collect data regarding the cost estimation & a deeper approach towards its installment on roofs. This paper is a review of current knowledge regarding the benefits of green roofs, plant selection and culture, and barriers to their acceptance in Hyderabad. This paper will help in providing the practical approach and concluding the valuable effect of green roof on environment and internal temperature of house & will conclude how the proposed concept help in challenging the effect of global warming within our structures through reducing the direct exposure of building roof towards sun.**

***Keywords:*** **Global warming, Green roof, Green space, Temperature reduction.**

## I. INTRODUCTION:

Green roof is the roof contain green parts & vegetation, Green roofs and roof gardens date back to thousands of years. Not only existence evidences are recorded but some of the physical evidences also has recorded & survived [1] History reveals that the aim of green roofs was diverse, which include the insulating qualities, and an escape from the stress of urban environment. Evidence of roof gardens in history coded the Augustus and Hadrian mausoleums & Romans planted green roof on several institutional buildings [2]. Norwegians from 16$^{th}$ to 18$^{th}$ century used soil on roofs as insulation [3]. The birthplace for modern-day green roof systems is supposed to be Germany. In late 18$^{th}$ century, Germany practiced rapid urbanization & industrialization. a roofer H. Koch aimed to reduce the fire hazard & he add a sand and gravel substrate [4] It's a combination of biotic and abiotic components, engineered to function as a green space in a harsh environment. [5], Green roof act as a (swms) storm water management system [6]. Green roof lain in these layers: I. Vegetation stratum, II. growing medium or soil layer, III. irrigation layer, IV. filter fabric layer, V. drainage layer, VI. waterproofing membrane layer, VII. the roof deck [7], [8]. Green roofs are expensive than the traditional roof but has effective benefits on the long run which will counter the initial cost of installation [7]. Hyderabad is the 2$^{nd}$ largest city in Sindh and the 8$^{th}$ most populated city of Pakistan, with a total area of 123 sq. mile, with a huge population of 1,732,693 (2017 census). Due to growth in population major part of the city is now covered with residential and commercial areas, ratio of park is quite low. Due to which the temperature and the environment remain high specially in summer season, and increasing temperature due to lack of desired number of trees the environment is becoming quite dangerous for human beings and other creatures. Being a populated city, now it is nearly impossible to build a huge number of parks or green spaces to overcome this situation the solution which author recommend is to utilize the roof top of every building as a green space. Most of the areas are now begin to be residential or commercial other vacant spaces are not sufficient for plantation, the noise & air pollution is also harming the environment, which means the need of plantation is high because of high temperature, in summer season the internal temperature of buildings are quite harmful for the dwellers & due to the direct exposure of building to the sun the building poses high M & R cost and dwellers tend to have health and physical issues. The performance of RCC as a building material has low drought and solar radiation to leant which result in decreasing the age of building and its performance which directly or indirectly effect the performances of dwellers. Main objectives of proposed study include introducing the concept of green roof in Hyderabad by reviewing current knowledge regarding the benefits of green roofs, plant selection and culture, and barriers to their acceptance in Hyderabad the proposed study aims to provide the practical approach of selection of plants, its installing techniques, including initial and running cost.

## II. TYPES OF GREEN ROOF

According to Mentes and his team depth of substrate layer in green roof divide it into two categories which are intensive and extensive green roof [9].

### *A: Intensive Green Roof*

The type of roof which contains types of vegetation ranges from grasses, shrubs to small trees. It can be a roof garden and may include pathways, benches, tables, and fountain on the roof. Depth must be greater than 150mm. It is heavy in weight hence require high maintenance [10]. It slopes should be less than $10^0$ [11]

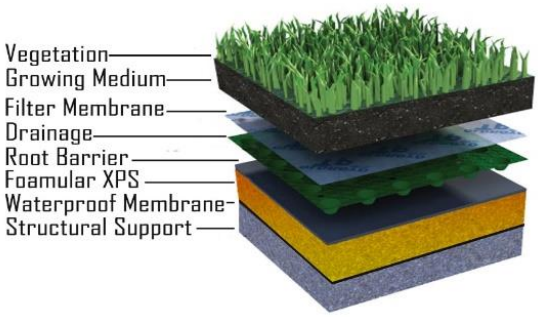


Fig. 1. Intensive roof's installation pattern

weigh of these roofs' ranges from 171 – 391kg/$m^2$ [12] Fig. 1. Shows intensive green roof installation pattern [10]

*B. Extensive Green Roof*

This is simpler as compare to intensive green roof because of its lightweight and it requires low-maintenance as compare to that intensive type. Extensive roof use drought resistant plants majorly sedum species. Its thickness is 150 mm. According to Breuning extensive green roof can weigh from 73kg/$m^2$ to 122 kg/$m^2$ [12]. It is considered as more sustainable than intensive type green roof. [13] It is considered to be semi intensive green roof when the elements of both intensive & extensive roof are used. [14]. Figure # 2 shows the installation pattern of an extensive roof [12].

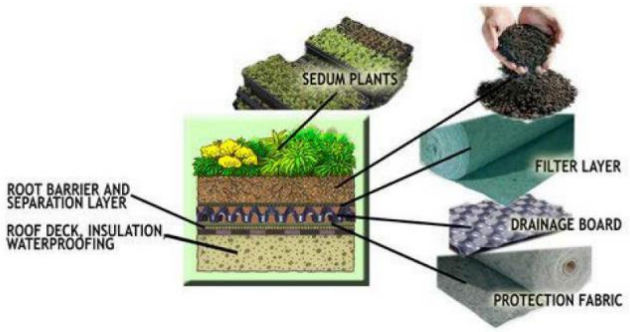


Fig. 2. Extensive roof's installation pattern

## III. LITERATURE REVIEW:

One of the greatest environmental benefit that green roofs provide is the reduction of total amounts of stormwater runoff, much of the precipitation is captured in vegetation and will eventually evaporate from soil surface soil or will be the part of atmosphere by transpiration. Kolb reported that 45% of rainfall can be recycled through green roof [11]. It can reduce runoff by 60% to 100%, which depend on the type of green roof system [15]-[19]. Plant protect roof membranes from solar & ultraviolet radiation that can damage it. These materials also reduce day/night temperature fluctuations at the membrane, which reduces the stress of daily expansions and contractions. Green roofs provide shade and insulation, resulting in energy savings and mitigation of the urban heat island effect. [20]. Every decrease in internal building air temperature of 0.5 _C may reduce electricity use for air-conditioning up to 8% [21]. Green roofs can provide habitat. world's largest green roofs are in Dearborn, on top of a Ford Motor Company. It covers an area of 42,900 m2, consists of a mix of 13 Sedum species planted, within 2 years of initial plant establishment, 29 insect, 7 spider, & 2 bird species were identified [22] Plants can filter out gaseous pollutants & particulate matter in the air. [23] It is beneficial for health to view green plants and nature such as reducing stress, lowering blood pressure, releasing muscle tension, and increasing positive feelings [24]. Solid roofs are responsible for high energy value, high internal temperature & resource consumption. [25, 26]. Today, green roofs are chosen both as a technological device that has potential to decrease energy and pollution based environmental problems and as a construction application that can minimize the lack of green fields in urban areas in many countries around the world [27, 28] It also decreases the temperature of roof membrane [29], It also improve air quality by absorbing carbon dioxide from air and releasing hydrogen in the air. [30], It give rise to several habitat and biodiversity [31], It also provide mitigation of urban heat island effect [32], Noise reduction and aesthetic view are important benefits which green roof provide. [33], It also create recreational areas [34]. They have not attracted the required attention of clients due to high initial and maintenance costs, but in some of the countries like Germany and Japan, green roof applications are mandatory [35, 36]. Thus, in order to encourage investors for green roofs in practice, it seems to be necessary to present their economic advantages in the long term through the analysis of their lifecycle costs besides environmental benefits.

## IV. MATERIAL & METHOD:

Materials and method adopted by author for research include case studies, which are briefly described under:

### *A. Case Studies:*

According to existence of green roof in building, case studies are further divided into 2 parts i.e. With green roof & without green roof.

#### *A.1 Buildings with Green Roof*

Two sites, one living example and one international example were focused which are discussed in context of our project.

##### *A.1a CASE STUDY # 1: Saeed Akhtar Studio, Johar Town, Lahore (Physical case study)*

The building is located at Johar Town, Lahore, Pakistan, it is served as an artist studio, belong to the famous Artist of Pakistan "SAEED AKHTAR". It is a three storey building, it was initially designed as eco-friendly bulding, it is serving as an art gallery of "SAEED AKHTAR" & as an architectural firm. The terrace is also covered with green grass, serving as a green roof, and the roof top is also served as a green roof, according to "Umer saeed", who is the architect and designer of this art gallery: "according to my research in coming years, it will become essential for every single resident to install green roof in order to cope with alarming high temperature". The green roof serves as open air art gallery for the Artist, the green roof is also complimented with a barbeque area, which help in making the environment more peaceful in case of et togethers. Umer saeed also said "in my all the proposed designed throughout Pakistan I propose the green roof and most of their clients because of their brief description implemented that & are quite satisfied with their decision".

##### *A.1b CASE STUDY # 2: Casa Vallarta (International case study online)*

It is residential building, close Pacific Ocean, Mexico, considered as exceptionally eco-accommodating consequently it contains both green rooftop and green divider. Cynthia Villalba planned this green divider and green rooftop and was worked in 2012. It's a concentrated green rooftop, measures 711 square meters with an incline of 10. The north-east façade of building contains green mass of around 287 square meters. Tall bushes and grasses were planted on rooftop and the planner endeavored to have some sort of development thinking about his outline using bends in the scene following example. Consonant hues add excellence to the green rooftop. Plants extending from grasses, agaves and perennials were planted on the green rooftop while short grasses and greeneries were planted on the green divider. The tempest and inundated water on rooftop are being caught and reused and utilized for further water system. For giving high warmth protection they join green rooftop and green divider there by lessening the expense of cooling. They utilize perennials and agaves is so it can fill in as a garden where individuals can go and appreciate the indigenous habitat. It additionally gives warm protection to the building. High support and care are required here in light of high thickness and distinctive assortments of plants. It is at some degree being private building supplement our proposed venture, and because of immense assortment of temperature at that locale it was contemplated, it demonstrates that it requires high support however the consequences of green rooftop are very viable.

#### *A.2 Without Green Roof*

2 residential buildings were picked up by author, which lack green roof and the description of all those 3 case studies are given below:

##### *A.2a CASE STUDY # 1:*

House # 221 block A, Kohsar housing scheme phase 1 airport road Hyderabad, it covers an area of 150 sq. Yds, A well planned house which is constructed while considering the wind and light orientation, having 3 floors, ground floor consists of 3 rooms, with attach baths and a properly ventilated kitchen and well orientated lounge. First floor consisted of same 3 rooms with a slightly difference in dimensions of lounge and a master bedroom. 2nd floor consist of a room with attach bath and a store room and washing area. Each space gathers proper sunlight and wind, balconies facilitates the rooms and an open lane facilitate lounge and kitchen with natural light. The roof is without any sort of plantation, as house have quite proper ventilation but in summer season due to hot and dry wind the overall ambiance of house become dry and hot for that the solution might take time to be considered but will help in making the internal temperature of house cool in summer season, is green roof.

##### *A.2c CASE STUDY # 2:*

House # 73 block D unit # 12 Latifabad, Hyderabad, area of house is 150 sq.yds. it is a 3-story house. Ground floor consist of 3 rooms with attach baths, a lounge, 2 kitchens, small verandah, courtyard and a back side open lane. 1st floor consist of 3 rooms with attach baths a kitchen and courtyard, 2nd floor is basically roof, with a room attach bath and washing area. All parts

of house catch proper light due to courtyard but wind catching capacity of house is low due to high construction of neighboring house. The roof lack plantation, as the house have quite proper light but not ventilation and in summer season due to hot and dry wind the internal environment of house become dry and hot for that the solution that should be considered is green roof.

*B. Interview with Expertise:*

An unstructured interview with landscape designers, Architects and other expertise which include the name of Architect Umer saeed, Architect Khalid yar khan.

*C. Survey of Nurseries & Material shop:*

Nurseries & material shop were surveyed in order to estimate the cost of each material used in installation of green roof, Table # 1. provide all the material list along with their cost in order to estimate the financial amount, needed for green roof:

Table 1. Material list for green roof

| SERIAL # | MATERIAL | COST |
|---|---|---|
| 1 | Plant | Vary |
| 2 | Soil medium | 50 Rs/kg |
| 3 | Filter fabric | 180 Rs sq. /m |
| 4 | Drainage & storage layer | 120 Rs sq. /m |
| 5 | Insulating (membrane) | 500 Rs sq. /m |
| 6 | Water proof membrane | 250 Rs sq. /m |
| 7 | Protection board | 150 Rs sq. /m |
| 8 | Roof deck | 1200 Rs sq. /m |

*D. Cost Estimation of Extensive Green Roof:*

As finance is the major key for any sort of project, in this regard author go through several researcher's work on cost estimation, life span of green roof and the methods for implementation of green roof. Several authors from different regions contributed their research about unit cost along with the brief regarding installation techniques and life span of green roof. The green roof is classified into 2 types, Table 2 & Table 3, shows all the data of all the 2 types of green roof:

Table 2. Cost estimation of Extensive roof

| Authors | Country | Unit cost ($/m) | Lifespan (Yr.) | Methods |
|---|---|---|---|---|
| Porsche & Kohler [38] | Germany | 85-90 | 90 | NPV |
| Zhang et al. [39] | Germany | 31.72 | 40 | NPV |
| Clark et al. [27] | USA | 232 | 40 | NPV |
| Carter & Keeler [28] | USA | 158.82 | 40 | NPV |
| Blackhurst et al. [32] | USA | 97.04 | 30 | BCR |
| Niu et al. [40] | USA | 306 | 40 | NPV |
| Wu & Smith [41] | USA | 107.64 | 40 | PBP-NPV |
| Bianchini & Hewage [42] | USA | 130-165 | 40-55 | NPV-PBP |
| Mullen et al. [43] | USA | 158-306 | 40 | NPV |
| Sproul et al. [44] | USA | 172 | 50 | NPV |

| | | | | |
|---|---|---|---|---|
| Jokismovic & Alam [45] | Canada | 236.45 | 50 | NPV |
| Peri et al. [46] | Italy | 75.05 | 40 | NPV |
| Angelakoglu et al. [47] | Greece | 90-180 | 25 | PBP |
| Claus & Rousseau [35] | Belgium | 141.9 | 50 | NPV |
| Tsang & Jim [48] | Hong Kong | 150 | 40 | NPV |
| Chan & Chow [49] | Hong Kong | 68 | 25 | NPV-PBP |
| Peng & Jim [50] | Hong Kong | 64 | 40 | BCR-PBP |
| Lee at el. [51] | South Korea | 134.5 | 2-100 | - |
| Shin & Kim [52] | South Korea | 23.32 | 20 | BCR |
| Liu & Hong [37] | China | 241.2 | 40 | BCR-NVR |
| Wong et al. [53] | Singapore | 89.86 | 40 | AIRP-PBP |

*E. Cost Estimation of Intensive Green Roof:*

Following table shows the same data for intensive green roof:

Table 3. Cost estimation of Intensive roof

| **Authors** | **Country** | **Unit cost ($/m)** | **Lifespan (Yr.)** | **Methods** |
|---|---|---|---|---|
| Porsche & Kohler [38] | Germany | 340-380 | 90 | NPV |
| Chui et al. [56] | Hong-Kong | 153-273 | 30 | NPV |
| Bianchini & Hewage [42] | USA | 165-540 | 40-55 | NPV-PBP |
| Liu et al. [54] | USA | 168.34 | 20 | NPV |
| Langston [55] | Australia | - | 25-100 | BEP |
| Peng & Jim [50] | Hong Kong | 256 | 40 | NPV- |
| Wong et al. [53] | Singapore | 178.93-197.16 | 40 | AIRP-PBP |

## V. RESULT & DISCUSSION:

Case studies and interviews with expertise open up to author that we go through the maps worldwide or Pakistan we can see a vulnerable change of green area into large urban growing areas, which is the end of environment friendly trees and plants, due to urbanization major part of our land is now covered with residential and commercial area, and it is now near impossible to retreat these areas as landscaping or green areas. Therefore, the solution is to provide green areas within these urban spaces, which will help in retaining the environment up to valuable amount as it was 20 years before. Expertise also told that it is the fortune of Pakistan that where ever we just drop a seed within days, the growing took place and no extra or special care is needed to grow the green medium, the only lacking is awareness and implementation of small step of growing plants, green belts within the vicinity of their house and on roof top, making the environment pleasing.

## VI. BENEFITS OF GREEN ROOF:

Authors from different countries also contributed in listing the benefits, which we get through green roof, these benefits divided into 3 categories which are economic, environmental & social benefits, Table # 4 shows the benefits of green roof according to different authors:

Table 4. Benefits of Green Roof

| | ECONOMICAL BENEFITS | | | ENVIRONMENTAL BENEFITS | | | | | SOCIAL BENEFITS | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AUTHORS | Energy saving | Longer Roof Life | Increased Property value | Storm | Water Management | Air Quality | Urban Heat Island | Biodiversity | Fire Protection | Thermal Insulation | Noise Reduction | Aesthetical View |
| Porsche & Kohler [38] | | | x | | | | | | | x | | |
| Zhang. [39] | x | | | | | | | | | | | |
| Clark. [27] | x | | | | X | | | | | | | |
| Carter & Keeler [28] | x | x | | | X | x | | | x | | | |
| Blackhurst et al. [32] | x | | | | | x | | | x | | | |
| Niu et al. [40] | x | | | | X | | | | | | | |
| Wu & Smith [41] | x | x | | | X | | | | | | | |
| Bianchini & Hewage [42] | x | x | x | | X | x | x | | x | | x | |
| Mullen et al. [43] | x | | | | X | | | | | | | |
| Sproul et al. [44] | x | x | | | X | x | | | | | | |
| Angelakoglu et al. [47] | x | | | | | | | | | | | |
| Claus & Rousseau [35] | x | x | x | | X | x | x | x | | | x | |
| Tsang & Jim [48] | x | | | | | | | | x | | | |
| Chan & Chow [49] | x | | | | | | | | | | | |
| Peng & Jim [50] | | | | | X | x | | | | | | |
| Langston [55] | x | x | | | X | | | | | | | |
| Shin & Kim [52] | x | | | | X | x | | | | | | |
| Liu & Hong [37] | x | X | | | | | | | | | | |
| Wong et al. [53] | x | x | | | | | | | | | | |

## VII. BARRIERS IN ACCEPTING IN HYDERABAD:

For a wider approach towards barrier of "Green Roof Acceptance" in Hyderabad, author conducted a questionnaire survey which include 10 questions, and 65 questionnaires were distributed among public of different areas, and the factors are discussed below

### *A. Finance:*

Being under developing city, Hyderabad still lack several basic necessities which keep the public far from important things, as far as the finance is concern due to rapid increase in utility charges and other daily basis needs, the people of Hyderabad are far from such these sorts of solutions which need a valuable amount of finance for make it happen. The finance and monthly income of majority of Hyderabad population did not permit them to adopt green roof concept for their residence.

### *B. Water Scarcity:*

Being in other critical situations, water scarcity is another hot issue which effected our lives very much, the green roof need an estimate bale amount of water which is not available, the issue which public raise while conducting survey was that they were lacking water for drinking so how they can use a bulk amount of water only for green roof, without considering the ultimate result of roof top gardens they consider it irrelevant.

### *C. LACK OF AWARENESS:*

Majority of Hyderabad public is considered as middle class family who lives in a joint family system or due to rapid growth in population, a bulk number of families are shifting towards flats and residential plaza, so their main focus remains on daily basis necessities which include utility bills, rents and educational and sustenance needs, there is lack of awareness as most of them even don't know about the green roof concept and how much it can be beneficial for their residence and for the environment too.

### *D. PUBLIC UNWILLINGNESS:*

Public of Hyderabad lack interest in green roof or other green building concepts as they are very far from the benefits of green roof, according to the survey they were not willing about the green roof concept as they feel it un-practical and un-workable.

### *E. MAINTENANCE & REPAIR:*

The maintenance and repair of green roof is not as much as they are considered but need a bit of willingness towards its regulation, it is supposed to be one-time investment as the initial cost is high but the running cost is affordable for a middle-class family. Due to high initial cost most of the people were unwilling to adopt this strategy.

### *F. UN AVAILABILITY OF NURSERY EXPERTISE:*

To choose the right plant for different types of roof, different areas of Hyderabad and different orientation of each residence is the duty of a nursery expertise, which are unavailable at this time in Hyderabad, the need of hour is to set the trend of green roof in order to minimize the environmental pollution.

## VIII. CONCLUSION:

Green rooftops are one compelling technique to check the decimation of characteristic living spaces as we assist our manufactured condition. Today, we have distinguished that green rooftop can function as tempest water maintenance, storm water spillover deferral and rate decrease, increment material layer life, shading and protection advantages, biodiversity and environment, control of clamor and air contamination. These commonly unused spaces can turn into an approach to recover territory that was lost because of industrialization while additionally supporting in the security of our condition through more manageable practices. Green rooftops can give monetary advantages to the green business. Nurseries that are developing ground spreads, perennials, or grasses will have the most to pick up. In Pakistan, many scene temporary workers may have development, upkeep, and green rooftop divisions, and others may represent considerable authority in green rooftops alone. In numerous zones of Pakistan, the idea of green rooftops is a few seconds ago being presented and will probably turn out to be more typical later on. They speak to an altogether new market for nursery stock and scene contractual workers, and the potential market comprises of all current and future rooftops in the nation. Hyderabad is inadequate with regards to these sorts of offices so the need of hour is to set the pattern of rooftop top gardens uniquely for neighborhoods to diminish the warmth engrossing limit of the building and improving the earth.

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