Spectrum of Engineering Sciences
ISSN (e) 3007-3138 (p) 3007-312X
Volume 3, Issue 7, 2025

ASSESSMENT OF THERMAL EFFICIENCY IN BUILDINGS WITH GREEN VS CONVENTIONAL ROOFS: A CASE STUDY OF HYDERABAD

Asma Qayoom[*1], **Sarah Hafeez**[2]

[*1]*Department of Architecture and planning, Dawood university of engineering and technology Karachi*
[2]*Department of Architecture and Planning NED UET*

[*1]asma.qayoom@duet.edu.pk, [2]sarahhafeez@neduet.edu.pk

DOI: https://doi.org/10.5281/zenodo.16791818

Keywords
urban heat island, passive therm energy, green roof

Article History
Received: 01 May, 2025
Accepted: 16 June, 2025
Published: 31 July, 2025

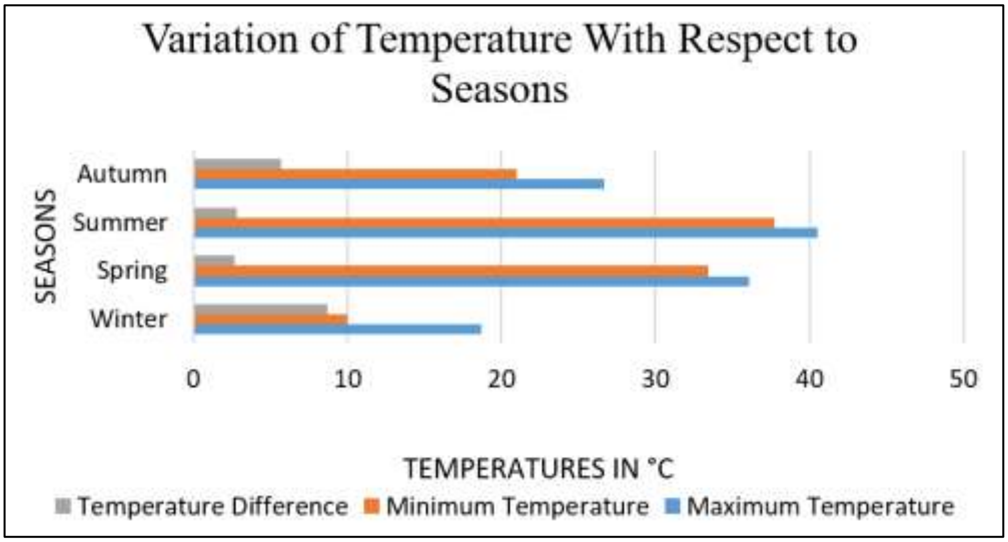
Corresponding Author: *
Asma Qayoom

Abstract

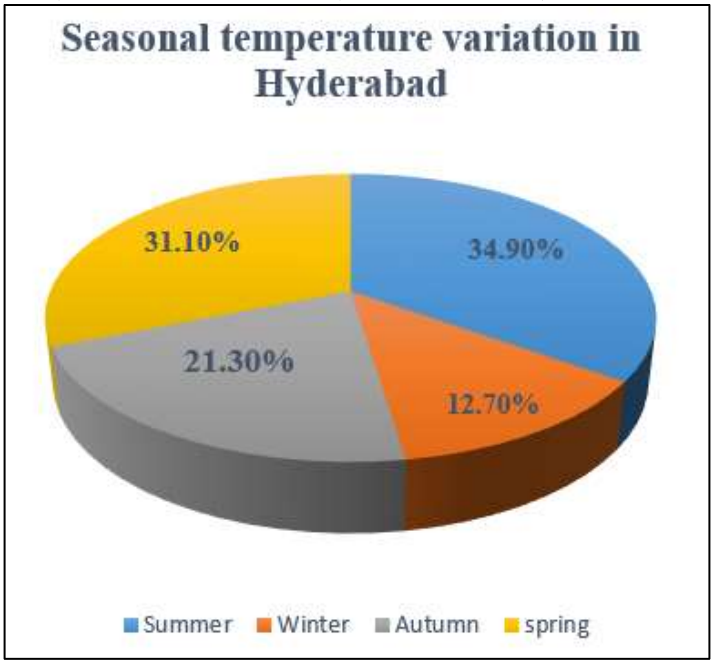
A number of reasons make contributions to global warming, which includes gasol intake, urbanization, much less open area, and vehicle emissions. Hyderabad, a city the Sindh province of Pakistan, is a high instance of the terrible results environmental trade. Its scorching, dry weather is made worse via the scarcity inexperienced areas. This have a look at examines how beginner roofs may be able alleviate these problems through evaluating their thermal behavior to the ones conventional roofs. The examination focused on Hyderabad's hot summers that m attain 40°C, and its chilly, windy evenings.
Results from 3 months of statistics collection (July to September) revealed tl inexperienced roofs substantially lessen both indoor and out of doors temperatures. T common indoor temperature distinction turned into 4.08°C, at the same time as outdoor temperature difference became 2.75°C. These consequences reveal how u green roofs reduce warmth float, offer insulation at night time, and maintain stec temperature and humidity levels, mainly because the rainy season strategies.
Ultimately, inexperienced roofs enhance occupant consolation and strength economy means of acting as passive thermal modifiers. In warm, dry areas like Hyderabac they provide a sustainable way to reduce the outcomes of urban warmness islands regulating temperatures and lowering direct daylight hours exposure on rooftop slabs.

INTRODUCTION

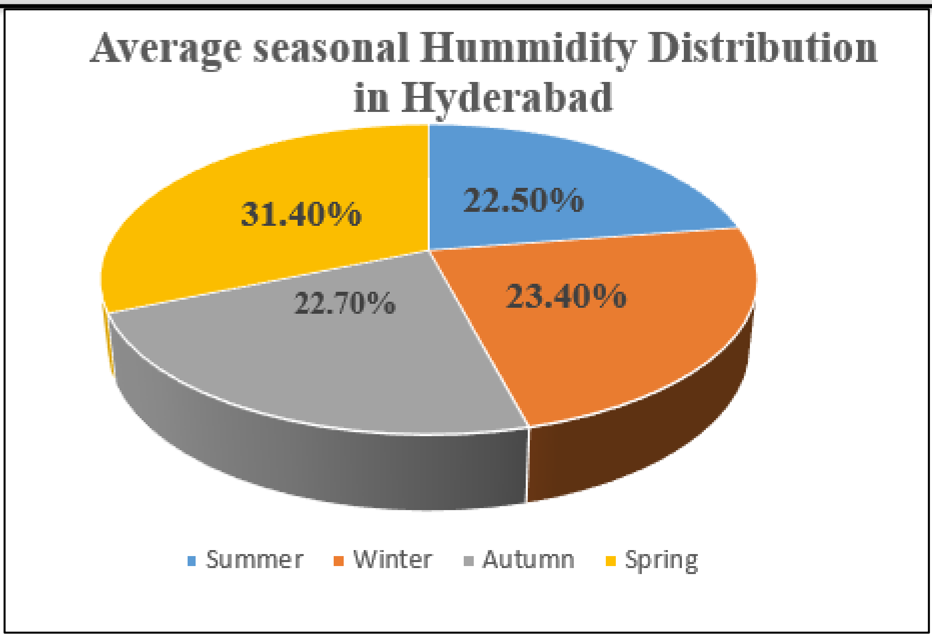
The primary root causes of global warming are a variety of factors, including the burning of industrial fuels, vehicle exhaust, diminished natural cover, shrinking water bodies, and the fast growth of the built environment. Hyderabad, a major Pakistani city, has faced significant environmental issues, especially the shift to a hotter and drier climate. The loss of green areas in the urban setting is the main cause of this change. In these climates, green roofs have great advantages since they reduce heat accumulation and improve the thermal performance of the construction and the surroundings. Vegetated rooftops naturally insulate and support the ecology, so lessening the effects of global warming (Sheng et al., 2011). Generally speaking, the province of Sindh—where Hyderabad is located—is divided into two climatic zones: the lower Sindh region, which is defined by humid coastal conditions, and the upper Sindh region, which is defined by arid and dry conditions. Well-known are Hyderabad's cool, windy evenings and stifling summer days. It sits in the upper, hot-dry zone. Green rooftops offer several advantages in these contexts, including extending the lifetime of roofing materials, lower energy consumption, and winter heating and summer cooling. Green rooftops are now generally accepted as a good way to save energy worldwide. By keeping warm in the winter and avoiding heat accumulation in the summer, they improve thermal comfort all year long and give metropolitan areas ecological and landscape value. Particularly in May and June, Hyderabad suffers a hot and dry climate with daytime highs of over 40°C. Local wind patterns, though, cause the city to have cooler evenings. Dusty winds and cyclones are frequent during the summer, particularly in May and June. June through September is typically when the southeast monsoon season occurs. August is typically the wettest month, with an average rainfall of 60.8 mm, while January is the driest, with frequently very little precipitation. Pie charts 1.1 and 1.2 provide a summary of the stark contrast between summer heat and winter temperatures, which can fall as low as 11.1°C as shown in graph 1.1.



Graph 1.1 Variation of temperature with respect to seasons



Pie chart 1.1: variation of seasonal temperature



Pie chart 1.2: Average seasonal humidity

PROBLEM ANALYSIS

Among the warmest and driest places in the Sindh province of Pakistan, Hyderabad is Mostly due to its inadequate green cover, the city has several problems related with global warming and climate change. These climate issues aggravate the architectural and environmental discomfort experienced by people. In this regard, two main problems found are:

- Higher energy consumption and related costs resulting from increased cooling demand.
- The Urban Heat Island (UHI) phenomenon's aggravation brought on by poorly vegetative surroundings and heavily built structures

LIMITS OF THE RESEARCH

This study mostly assesses the thermal efficiency of large green roofs, which are defined by low-maintenance vegetation including grasses and small bushes in installation. The parameters of this study exclude alternative forms of green roofing systems.

EXPECTED RESULTS

This study on the thermal efficiency of green rooftops in Hyderabad's hot and arid environment expects:

- Improved residential building energy efficiency.
- Control of inner temperature: warmer winters and cooler summers.
- Enhanced urban surroundings and roof visual appeal.
- Solving of the Urban Heat Island phenomena.
- Reducing greenhouse gas emissions and helping to fight world warming.

SCOPE

By shielding building rooftops from adverse weather conditions including sunlight, wind, and precipitation, green roofs significantly increase their durability (Sheng et al., 2011). Two to three times the lifespan of a roof can be extended from well-maintaining green roofs. Moreover, they improve urban biodiversity by providing homes for species of plants and animals (Ana et al., 2014).

By absorbing heat instead of drawing it, green rooftops help to reduce cooling needs, so saving costs. As a natural insulator, they offer environmentally friendly heating options particularly suitable for hot and dry climates. The less demand on air conditioning in summer and more insulation in winter show how well green roofs work as a sustainable design element.

METHODOLOGY OF RESEARCH

This work offers a complete knowledge of the thermal performance of green roofs by using both qualitative and quantitative approaches. The methods consist:

- Review of existing studies on green roof systems for current projects.
- Surveys sent among residents and interested parties.
- Making on-site observations and gathering environmental data.
- Comparative case studies of buildings with green ceilings against those without them.

LITERATURE REVIEW:

Gains and Benefits of Green Roof In Different Climatic RegionMary Semaan and Annie Pearce presented the research paper "Gains and Benefits of Green Roof in Different Climatic Regions" at the International Conference on Sustainable Design, Engineering, and Construction in 2016. They elucidated the advantages of green roof technology and its impact across various climatic regions, including stormwater management, urban heat island mitigation, summer cooling and winter heating, roof membrane durability, noise reduction, provision of wildlife habitat, enhancement of natural biodiversity, and aesthetic appeal, which were focal points of their research. (Semaan and Pearce (2016)

Functions of Green Roof Technology

In 2012, Gaffin, Khanbilvardi, and Rosensweig conducted research on "Green Roof Technology" and provided an explanation of the various types of construction, the function of green roof technology, and their management. They also provided an example of Chicago's green roof sustainability and the benefits of green roofs in New York City, which are based on the temperature difference between rural and urban areas.(S Gaffin, R Khanbilvardi, and C. Rosensweig, 2012) Additionally, an estimation has been conducted to determine the purpose and outcome of numerous studies that have been conducted on green roofs in conjunction with similar climatic approaches worldwide. The subsequent investigations have been assessed by the researchers: a) The United States, Canada, and Sweden have a humid and frigid climate. b) Greece and France are regions that are mild and humid. c) Brazil and Singapore have an equilateral climate. In contrast to analogous climatic differences with a minor change, they have obtained a positive result from this research. The comparison of GDP results demonstrates the existence of formal policies that encourage the use of green roof technology. The implementation of green innovations and the development of policies to facilitate their adoption have been influenced by a variety of factors.frese, 2016

Green Roof Concepts as A Passive Cooling

In the research paper "Green Roof Concepts as a Passive Cooling Approach in Tropical Climate," Noorazlina Kamarulzamana, Siti Zubaidah Hashim, Hassan Hashim, and Alia Abdullah Saleh elucidated the primary causes and factors contributing to the escalation of global warming and climate change. The heat island effect is emerging as the most dominant phenomenon of climate change.('LifeMedGreenRoof Project Green Roof Thermal Performance', no date) Several studies have analysed the fact that the maximal consumption of energy for cooling is a result of the high urban temperature, which in turn increases the demand for electricity.(Mohamed, Lee, and Chang, 2016) A green roof is a roof that is planted and contains a growing medium.

Green Roof Technology

Bradley Rowe's 2011 research on the "Implementation of Green Roof" explains that green roofs can be classified into two types: extensive green roofs, which are light and covered with a thin coating, and intensive green roof systems, which are heavier and adorned with tiny shrubs and trees. Green roof technology offers numerous advantages, including the increase of urban biodiversity, energy conservation, storm water management, aesthetic and practical benefits, reduction of air and noise pollution, and an enhanced return on investment when contrasted with traditional roofs. (D. Bradley Rowe, 2011)

Implementation of Green Roof Technology

In their 2013 research paper "Green Roof Concepts as a Passive Cooling Approach in Tropical Climate," Noorazlina Kamarulzamana, Siti Zubaidah Hashim, Hassan Hashim, and Alia Abdullah Saleh posit that the green roof is a system that necessitates basic roofing requirements to function as a passive cooling technology. It enhances thermal performance and offers a sustainable solution for an environment by utilising a significant vegetation surface.(2013, Lin et al.) The implementation of green roof technology has been acknowledged by researchers as one of the factors that contributes to the reduction of global warming and heat transfer into a building.Ana et al. (2014) The energy benefits of a green roof are contingent upon the local climate and, more importantly, the specific characteristics of the building. (D. Bradley Rowe, 2011)

Effects of Green Roof

The 71st conference organised by the Italian Thermal Machines Engineering Association was conducted in Tunis, Italy, in September 2016. The research paper "Green Roof Effects in a Case Study of Rome (Italy)" was presented by Gabrele Battista, Eleanora M. Pastore, Luca Mauri, and Carmine Basiheata. The paper elucidates that global warming is the primary cause of urban heat island intensity.2014 (Pedersen) The UHI is associated with the temperature disparity between urban and rural regions.(Battista et al., 2016) Green roofs have evolved into a vegetable garden, which has become a benefit to local food production. The objective of this investigation was to evaluate the thermal impacts of the implementation of verdant roofing in a Roman district. The case study was conducted in the Flamingo district of Rome, an urban city. The structures have all been equipped with verdant roofs. The result was determined through the use of various software simulations, model validation, the estimation of the vertical air and temperature profile, and the estimation of the variation in building performance. The findings have demonstrated that the green roof effect diminishes significantly as solar radiation increases due to the decrease in water content. (Battista et al., 2016)

Variation In The Performance Of Building

The performance of a building is subject to variation as a result of the various implementation of a green roof. Based on the analysis conducted by researchers, the green roof reduces the energy consumption by approximately 2%, which is equivalent to 2.6 kwh per day.(2016, Roslan et al.) It has been determined that the green roof will not exhibit any air temperature difference at approximately 2 p.m. when solar radiation is at its peak. This is a result of the evapotranspiration phenomenon and the decrease in water content. Also, the energy efficacy of the building is reduced by the vegetative roof.(Battista et al., 2016)

Thermal Insulation And Cost Effectiveness Of Green- Roof Systems

The well-known authors Panel Vivian W.Y. Tam, Jiayuan Wang, and Khoa N.Le published a study in 2016 titled "Thermal Insulation And Cost Effectiveness Of Green-Roof Systems: An Empirical Study In Hong Kong." The study explains that the presence of a green roof system can reduce the indoor temperature of a structure by up to 3.4 °C. The utilisation of green roofs enhances the thermal efficiency of any structure and minimises expenses. (Khoa, Wang, Panel, 2016)

Performance Evaluation Of Green Roof

Rakesh Kumar and S.C. Kaushik's 2005 research on the subject of Performance Evaluation of Green Roof and Shading for Thermal Protection of Buildings indicates that the thermal performance of green roofs is beneficial. The green roof's cooling efficacy is sufficient to maintain an average air temperature of 25.7 °C in any room, with a LAI of 4.5, requiring 3.02 kWh per day. (Rakesh Kumar, S.C. Kaushik 2005)

Green Roofs In Buildings: Thermal And Environmental Behaviour

The 2009 research by Theodoros Theodosiou on Green Roofs in Buildings: Thermal and Environmental Behaviour reveals that the temperature of traditional roofs and green roofs decreases from 38°C to 26°C. The room with a green roof demonstrates a thermal comfort efficiency of around 2°C, with the air temperature decreasing from 4.5°C to 4.22°C due to the green roof (Theodoros2009)

RESEARCH AREA

The study is conducted in Hyderabad, a highly populated metropolitan center in Sindh marked by a

ISSN (e) 3007-3138 (p) 3007-312X Volume 3, Issue 7, 2025

hot and dry environment. Though there are few green areas in the city, some homes there have made use of green roof systems. Two houses have been selected for comparison study to evaluate how well green roofs reduce energy consumption and indoor temperatures.

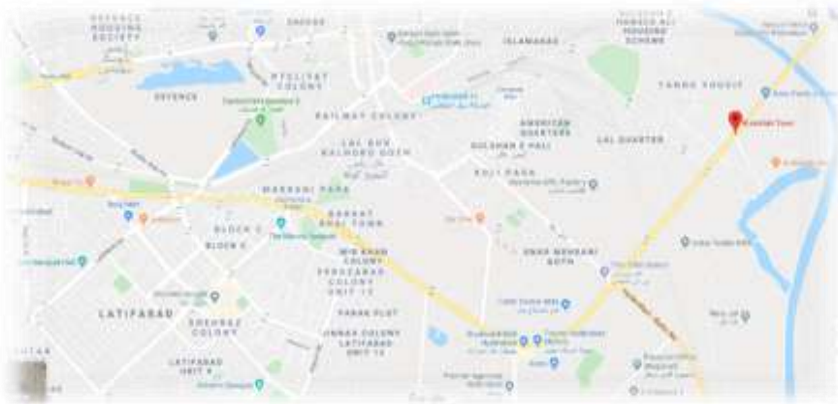


Figure 1.1: Location Plan of Site

QUESTIONNAIRE SURVEY

To gather information and understanding on public knowledge and attitudes of green roof technology, a questionnaire survey was sent to a diverse population. The findings show growing concern about climate change, which emphasizes right away the need of effective mitigating strategies. Because of their environmental benefits and ability to increase the visual appeal of buildings, green rooftops have grown to be a practical alternative.

Participants said that for building occupants, green rooftops significantly improve internal thermal comfort. These technologies make the built environment and the surrounding ecology more sustainable, which makes them a convincing choice for urban development.

METHODS OF DATA ANALYSIS

This study compares two residential buildings in the same climatic zone of Hyderabad. The study intends to evaluate in arid and high-temperature environments the thermal efficiency of green roofs.

The study mostly focused on a house with a roughly 210 square yard roof at Bungalow No. B-16, Fateh Chowk. For inspection two similar-sized homes in Bismillah Town, Hyderabad were selected. Whereas the second house kept a conventional naked roof, one house included a green roof system made of plants and vegetation on one of its rooms.

Both homes followed same architectural guidelines and orientation to preserve homogeneity. Over a three-month period under varying weather, indoor and outdoor temperatures were recorded. Reliable instruments designed especially to evaluate thermal fluctuations both inside and outside were used to get temperature readings. This methodical approach made it possible to exactly compare conventional and green roof systems in terms of thermal efficiency.

Photograph 1.1: Extensive Green roof at Hyderabad

Photograph 1.2: Lawn arrangement at green roof at Hyderabad.

Photograph 1.3: Plantation at green roof at Hyderabad

Photograph 1.4: Device used to measure indoor and outdoor temperature

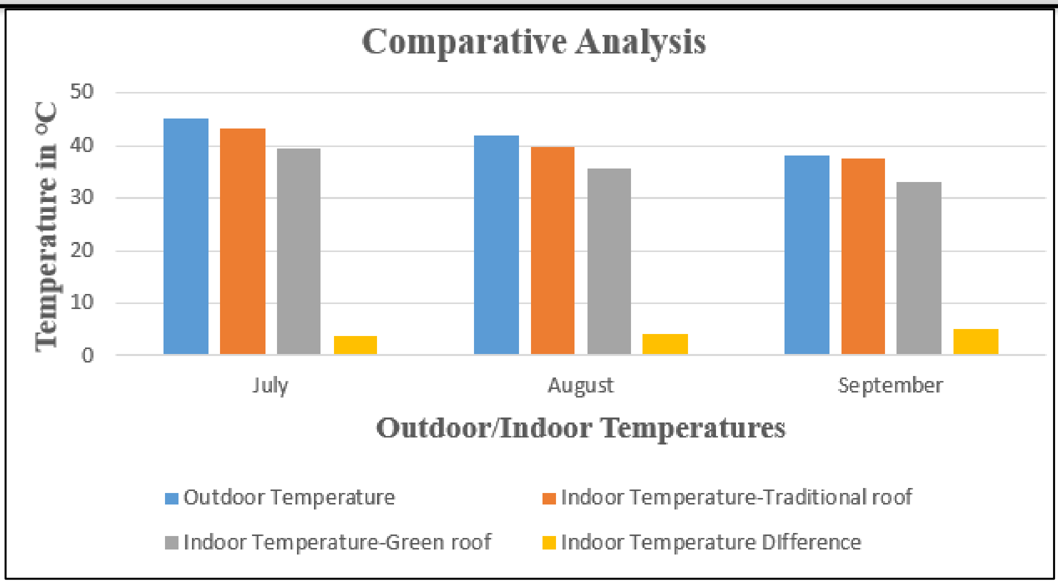
INSTALLATION COST OF GREEN ROOF

Geographic location and material availability determine how expensive it is to install a green roof. Generally speaking, the basic system—excluding soil and vegetation—costs about PKR 400 per square foot. The total cost is much increased by auxiliary expenses for labor, plants, and soil.

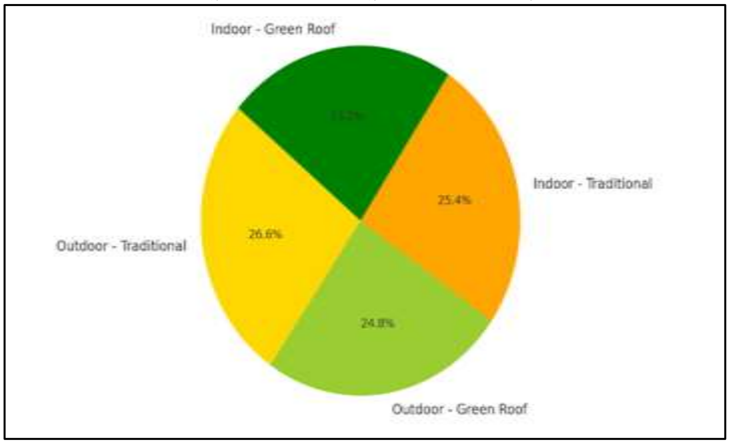
With all required components—including waterproof membranes, root barriers, drainage layers, and protective sheets—a standard completed roof runs between PKR 250 and PKR 350 per square foot. A flat slab with a 2% to 5% slope will suffice for green roof building to generate enough water runof. The estimated overall cost of installing a green roof in the assigned residential case study area comes out to be PKR 335,000.

TEMPERATURE MEASUREMENTS

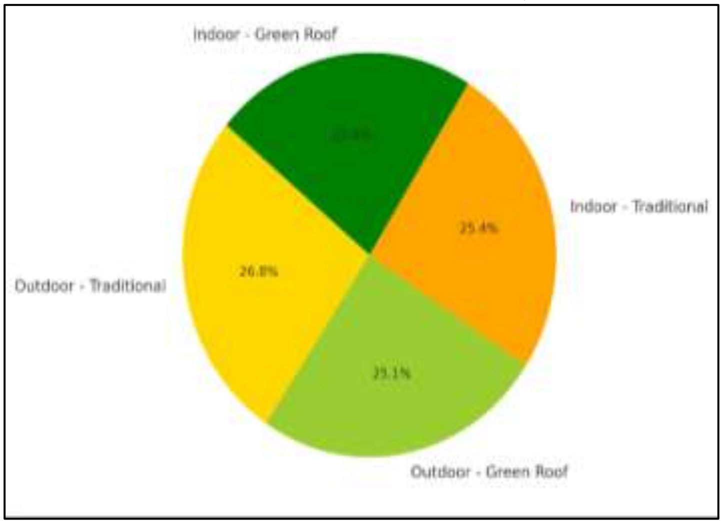
Under same environmental conditions, temperature readings were recorded for a green and a conventional roof. Under varying weather, these simultaneous measurements at 2:30 PM evaluate and compare the thermal efficiency of every roofing system.



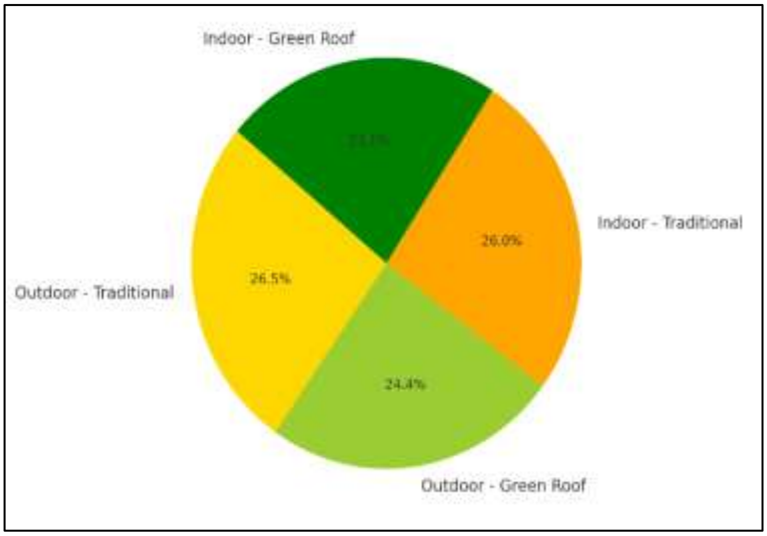
Graph. 1.2: Comparative Analysis



Pie chart. 1.3: Green roof v/s Traditional roof: Temperature Variation in July



Pie chart. 1.4: Green roof v/s Traditional roof: Temperature Variation in August



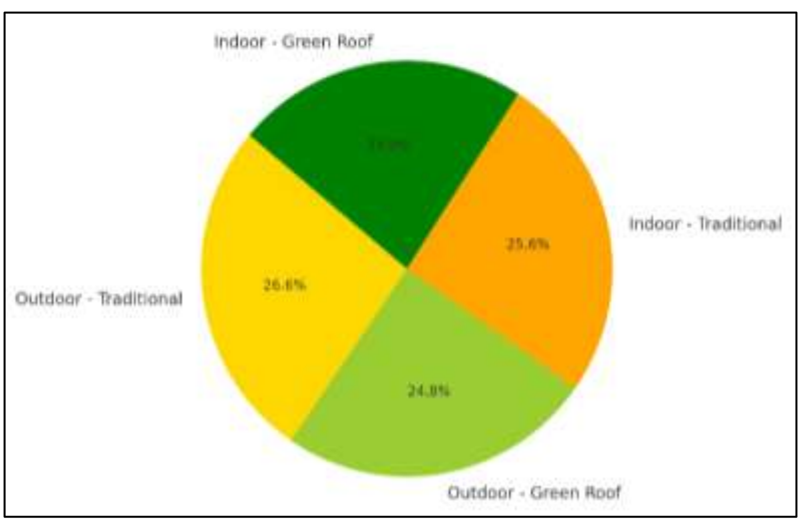
Pie chart. 1.5: Green roof v/s Traditional roof: Temperature Variation in September

ANALYSIS OF AVERAGE TEMPERATURE

By contrast, buildings with green roofs had an average outdoor temperature of 38.85°C, while those with conventional roofs had an average outdoor temperature of 41.6°C. In the same line, the average indoor temperature of buildings with traditional roofing was 40.1°C, while it was 36.02°C for those with lush roofs.

RESULTS

Apart from their visual and environmental advantages, green rooftops significantly help to control heat inside a building, as seen by a comparison of indoor and outdoor temperatures for different types of roofing. The data shows that green rooftops have a moderating effect on outdoor environmental conditions as well as help to lower interior temperatures in sweltering seasons. Temperature readings taken over a three-month period—including the milder September conditions and the high summer month of July—have produced these findings. Whereas the average outdoor temperature difference was 2.75°C, the average indoor temperature difference between traditional and green roofs was 4.08°C. This shows the possibility of green roofing systems to improve building thermal comfort and energy economy.



Pie chart. 1.5: Thermal efficiency of Green Roof

CONCLUSION

The primary goal of this study was to evaluate, in comparison to conventional roofing systems, the thermal efficiency of buildings featuring green roofs. By reducing heat flow into the building, green roofs clearly act as passive thermal regulators. Moreover, green roofs provide good insulation at night by lowering outside temperatures, so lowering the demand for indoor cooling systems.

For both types of roofing, the data unequivocally shows significant temperature differences between indoor and outdoor environments. The ability of the green roof to lower direct solar radiation on the roof slab greatly improved the afternoon cooling effects. Green rooftops also maintained constant interior temperature and humidity levels during precipitation, so enhancing occupant comfort.

REFERENCES

Sheng, L. X. *et al.* (2011) 'Assessing The Green Roof Technology In Green Building Rating Systems', (June), pp. 50–56.

Semaan, M. and Pearce, A. (2016) 'Assessment of the Gains and Benefits of Green Roofs in Different Climates', *Procedia Engineering*. Elsevier B.V., 145, pp. 333–339. doi: 10.1016/j.proeng.2016.04.083

Ghaedi, A., Ghaedi, Hojat and Ghaedi, Hamed (2012) 'The Role of Roof Shapes in Design of Green Building Systems (Case Study: Iran, BandarAbbas)', *APCBEE Procedia*, 1(January), pp.335–340. doi:10.1016/j.apcbee.2012.03.055.

Frese, Z. (2016) 'Green Roofs : Analyzing the Potential for Mitigating the Effects of Urbanization'.

Pedersen, K. L. (2014) 'Green roofs for sustainable urban development : The Oslo case study'.

Conference, I., Built, O. N. and Countries, E. (2008) 'Using Green Roof Concept As A Passive Design Technology TO', (Icbedc), pp. 588–598.

Mohamed, H. I., Lee, J. and Chang, J. D. (2016) 'The Effect of Exterior and Interior Roof Thermal Radiation on Buildings Cooling Energy', *Procedia Engineering*. Elsevier B.V., 145, pp. 987–994. doi: 10.1016/j.proeng.2016.04.128.

Lin, B. *et al.* (2013) 'Impact of climatic conditions on the thermal effectiveness of an extensive green roof', *Building and Environment*. Elsevier Ltd, 67, pp. 26–33. doi: 10.1016/j.buildenv.2013.04.026.

Ana, P. *et al.* (2014) 'Green roofs - construction and functional requirements for four buildings on the IST campus Morvarid Mobasheri Thesis to obtain the Master of Science Degree in Architecture Supervisors : Examination Committee President : Supervisor : October 2014', (October).

Ganguly, A., Chowdhury, D. and Neogi, S. (2016) 'Performance of Building Roofs on Energy Efficiency- A Review', *Energy Procedia*. Elsevier B.V., 90(December 2015), pp. 200–208. doi: 10.1016/j.egypro.2016.11.186.

Roslan, Q. *et al.* (2016) 'A literature review on the improvement strategies of passive design for the roo fi ng system of the modern house in a hot and humid climate region', *Frontiers of Architectural Research*. Elsevier, 5(1), pp. 126–133. doi: 10.1016/j.foar.2015.10.002.

Battista, G., Pastore, E.M., Mauri, L. and Basilicata, C. (2016). Green Roof Effects in a Case Study of Rome (Italy). *Energy Procedia*, 101, pp.1058–1063.Doi:https://doi.org/10.1016/j.egypro.2016.11.134.

Kamarulzaman, N., Hashim, S.Z., Hashim, H. and Saleh, A.A. (2014). Green Roof Concepts as a Passive Cooling Approach in Tropical Climate- An Overview. *E3S Web of Conferences*, 3, p.01028. doi:https://doi.org/10.1051/e3sconf/20140301028.

Kumar, R. and Kaushik , S.C. (2006). 06/01301 Performance evaluation of green roof and shading for thermal protection of buildings. *Fuel and Energy Abstracts*, 47(3), p.194. doi:https://doi.org/10.1016/s0140-6701(06)81305-6.

Tam, V.W.Y., Wang, J. and Le, K.N. (2016). Thermal insulation and cost effectiveness of green-roof systems: An empirical study in Hong Kong. *Building and Environment*, 110, pp.46–54. doi:https://doi.org/10.1016/j.buildenv.2016.09.032.

Rowe, D.B., 2011. Green roofs as a means of pollution abatement. Environmental Pollution, 159(8–9), pp.2100–2110 https://doi.org/10.1016/j.envpol.2010.10.029

.