Vol. 2 No. 4 (2024)
Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

Journal of Social Signs Review

Roof Gardens: Meaning, Historical Development, Progression, and Role

Ar. Nida Jawad
Associate Professor, Department of Architecture, Comsats University Islamabad, Islamabad Campus. Email: jawad.nida@gmail.com
Dr. Amna Jahangir
Assistant Professor, School of Architecture, University of Lahore.

Abstract

Buildings in metropolitan settings frequently include sizable spaces that are not used, especially on the walls and roofs. Usually, heat-reflective materials like brick, glass, and concrete are used to create outside surfaces. Many social, economic, and environmental issues could be resolved by covering these outdoor areas with green vegetation, especially in urban areas. Research examined and documented the connection between vegetation features and their impacts on building thermal performance, air and water pollution, and building energy efficiency was reviewed. Definitions based on various roof types and their combinations, historical progression throughout time, and observations about the functions of green systems were also analysed in a number of published studies. The purpose of these studies is to give academics a general understanding of the conventional approaches used to comprehend one of the passive cooling techniques used in both warm and cold areas. The methods contribute significantly to environmentally friendly building and raise awareness of the continuous developments in green roofing. This traditional, uncomplicated green roof still contributes significantly to indoor thermal comfort even in the face of innovative green system designs.

Keywords: Green Roof, Thermal Performance, Environment, Eco-Roof, Energy Comsumption

Introduction

Building development always advances in tandem with economic expansion. 43 megacities with populations of 10 million or more are predicted to exist by 2030[1]. Approximately 40% of the world's energy consumption in the building sector is attributed to human activity, and the growth of the construction industry has been directly connected to a 3% increase in greenhouse gas emissions between 2000 and 2010[2]. Both the public and private sectors must implement mitigation techniques in light of residential areas' susceptibility, especially in places that significantly rely on the usage of fossil fuels[3]. Given that building roofs make up 20–25% of urban areas, they can significantly lower air and surface temperatures in urban areas. In a biological system that functions horizontally, a green roof helps to solve a number of environmental issues. The terms "green roof, living roof, eco-roof, vegetated roof, and rooftop garden" refer to two types of green roofs: intensive and extensive, with or without cultivated plants[4]. David et al describes a green roof as a structure that has been human-engineered and placed on top of a building, including the construction of a framework that has the required mechanical integrity[5]. A green roof is defined by Vijayaraghavan as the top of a building that is entirely or partially covered with vegetation and a growth medium. The growth media can be flat or sloped, and it is intended to support plants while serving as a functional roof. The components of a green roof include vegetation, a drainage layer to control excess water, a water system to assist root growth, and a substrate to supply nutrients. A green roof often produces an environment that is conducive to plant growth[6].

Table 1 demonstrates the categorization and comparison of three distinct kinds of green roofs, which are frequently placed on building rooftops, according to their intended application and budget[7]. There are differences in structural

Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

components, kinds of plants, availability, and installation costs. For these kinds of green roofs, the ultimate cost may vary depending on the country and the green roof installation.

	Extensive Vegetated Roof	Semi-intensive Vegetated Roof	Intensive Vegetated Roof
Soil Depth:	3-6 in.	6-10 in.	10 in. and more
Weight:	13-30 PSF	24-40 PSF	35- 100+ PSF (up to 150 PSF)
Type of Plants:	Mosses, sedums, and grasses	Grasses, herbs, and shrubs	Lawn, perennials, shrub, and small trees.
Cost:	Low initial cost $10-$20/SF	Medium to High initial cost $15-$20/SF	Hight initial cost $15-$25/SF
Maintenance:	Low	Periodically	Regularly
Irrigation	No	Periodically	Regularly
Function:	-Ecological protection layer -More suitable for large area -More suitable for retrofit projects	-Designed green roof -More suitable for plant diversity -More suitable for design-oriented layout	-Park-like garden -Best insulation properties and water runoff/retention. -Suitable for accessible rooftop -Larger range of plant diversity

Table 1: Comparison of various green roofs

Background

Twenty-First-Century Green Roofs

The notion of the green roof was widely adopted in many different locations and civilizations during the early modern age, and it was maintained by several continents. The concept of a living roof was introduced by new technology in the middle of the 1880s and was first demonstrated at the 1867 World Expo in Paris[8]. The first design of an enormous green roof was taken into consideration when the model depicted a green roof with drainage and waterproofing[9]. In the 20th century, modern architects Le Corbusier, Alvar Aalto, and Frank Lloyd started integrating green roofs and walls into their plans in an attempt to blend architecture and nature[10]. This strategy is demonstrated in their well-known

Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

designs, such as Villa Mairea, Millard House, and Villa Shodhan. Famous buildings with green roofs are shown in Figure 1, 2 and 3[11,12,13].

Fig 1: Villa Mairea by Alvar Alto

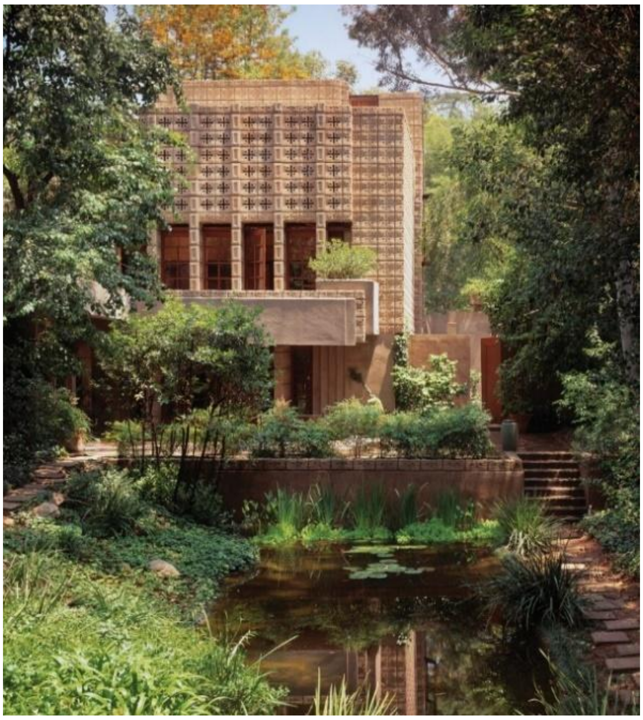

Fig 2: Frank Lloyd Wright - Millard House

Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

Fig 3: Villa Shodhan by Le Corbusier

A Green Roof in a Hot Environment

Steppe, tropical, Mediterranean, and hot climates are all included in this section's description of a hot climate. Both vernacular and monumental architecture have included green roofs as a component of their construction in Asia, Africa, Eurasia, America, and Australia. Ziggurat, Mesopotamia, was the first place to witness a green roof between the fourth millennium and 600 BC. Trees and plants were planted on terraces created by a gran-stepped pyramid that served as the courtyard temples' green roof. While the most well-known example of a roof garden was built around 500 BC and is called "The Hanging Garden of Babylon," which is regarded as the world's first botanic garden. The green roof, a green area in the centre of the city, was a feature of Pompeian buildings throughout the Mediterranean region. In addition to public areas, residential buildings' roofs also have the appearance of an atrium-shaped green garden. According to Osmundson, the intensive roof garden at Pompeii is evident in the Villa Dei Misteri. The façade is a sort of hanging garden, and the entrance to the home is a strong indication of the roof garden. These roofs can be utilised as a leisure space, to alleviate the effects of the hot weather, or to convey the owner's social standing. The idea of a "green roof" in massive buildings is not far from the idea of a "dry roof" in

Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

vernacular architecture, which refers to the usage of bamboo, grass, leaves and reeds as building materials in many places, eras and civilizations[14].

A Green Roof in a Frigid Region

A shortage of water is typically not a problem in cold climates, where there are many green roofs. As a result, green roofs are utilised as a kind of insulation to reduce heat loss from the interior to the exterior[15]. Since ancient times, dry grass has been utilised as building material throughout Europe; in Germany, Poland, France, the Scandinavian countries, Ireland, and Britain[16]. The burial site is beneath a hill covered in grass and vegetation, and it features a bathway leading to chambers. The green roof is visible in the construction of the tomb. The arrangement of the grave could be single, twin, triple, modest, or huge[17]. The prehistoric nation was able to leave its mark on the landscape design because of these straightforward arrangements. Many ethnic groups, like the Vikings, Celts, Pagan Saxons, and ethical communities from central Europe, also used man-made tombs[18]. The Scandinavian groups' estimated time frame was between 1500 and 800 B.C., whereas the Southern French ethics groups' estimated time frame was between 1400 and 1200 B.C.. This period continued into the Christian era[19]. In response to the green roof that has been seen in tombs from 1500 BC, reed roofs are typically seen in places of worship, such as churches during the Christian era and mosques in Africa. Additionally, the roofs of the Vidmyri Church and the Sifrastadir Church in Northern Iceland, constructed in 1842, were also planned with green living. Not only are thatched roofs utilised to cover building decks in cold climate vernacular architecture, but dense roofs are also utilized. Depending on the weather, the grass could grow naturally [20]. The hatching and living roof techniques were common from prehistoric times until the 19th century in numerous regions of central Europe, France, the British Isles, and Russia. This method demonstrated that brown and green roofs were widely used in a variety of buildings, including homes, churches, and temporary sheltering enterprises. The idea of green foliage is still present on huts and buildings even after humans turned to agriculture and villages began to form in 3900–3600 BC[21].

Green Roof Adaptation As A Solution To Environmental Issues

The late 20th century appears to have seen a rise in support for the idea of green roofs in urban areas for environmental reasons. People start to pay more attention to environmental issues. One strategy for improving the urban environment was the installation of green roofs on buildings in certain locations[22]. The benefits of horizontal green systems in terms of the environment, society, and economy are as follows:

Environmental

- To remove dust and purify the air, green roofs act as natural air filters[23].
- Photosynthesis, a process that plants use to absorb CO2 emissions and release oxygen, purifies the air and lowers CO2 emissions[24].
- The green roof could be trapped up to 4% of heavy metal city dust[25].
- Green roofs have the capacity to regulate and lessen sound reflection[26].
- In addition to controlling storm floods, green roofs function as porous surfaces. The original roof could be 4 °C warmer than a green roof or pavement[27].

Economic:

- Green roofs can reduce energy consumption by increasing thermal mass, evapotranspiration, insulation, and shade[28].
- Because lateral plants can lower temperatures, they are an effective way to improve energy efficiency and reduce cooling energy demand[29].
- Along with protecting against acid rain and UV rays, a green roof reduces the contraction and expansion of building materials caused by temperature changes[30].
- Plants have a significant influence on systems that lessen urban heat islands, a significant problem in cities and metropolitan areas, due to their capacity to absorb shortwave radiation and cool the surroundings.

Journal of Social Signs Review
Print ISSN: 3006-4651
Online ISSN: 3006-466X

- As a means of reducing urban heat islands, green roofs can reduce ambient temperatures by 0.3 to 3 degrees Celsius.
- By shielding the building's roof from heat, UV, and stress variations throughout the day, a green roof extends its lifespan[31].

Social:

- The green roof provides areas for recreation and rest[32].
- Green roofs demonstrated that being in nature has a positive psychological effect and improves people's health and happiness[33].
- Being near green spaces helped plants reduce stress and weight[34].
- Positive effects on those who work or live nearby are seen in plants. According to a study, worker productivity is higher in buildings with greenery than in those with less livable conditions[35].
- More individuals are drawn to urban and building-compound plants than to garden plants[36].
- Roofs can provide extremely important habitats for rare or endangered animals[37].

Discussion

This research demonstrated that green roofs are not just a 20th-century scientific idea for enhancing urban life and social interactions. The grass and dry or living plants on building walls and roofs has been used as a construction element in many climates, as well as a mitigation strategy to insulate building envelopes from cold weather or to reduce excessive temperatures in hot climes. In certain societies, a green roof represented the social standing of the home's owner, or it was a place for socialising or enjoying an outdoor terrace garden. In other cultures, the idea can even be considered offensive to those who are less fortunate. From prehistoric times until the turn of the century, thatched roofs were used in both permanent and temporary structures, regardless of whether they were used to represent a social status or to lessen the effects of the climate. Visionaries have been looking for ways to make urban inhabitants' lives better since the early 20th century. Vegetation is a vital component of the residents' well-being, regardless of their approach and societal values. The environment itself was less of a concern at the start of the 20th century than people and society.

Conclusion

The evaluation of green roofs, which began with their definition, system components, historical development, and the effects of their performance, is concluded in this study. The study, which focusses on the green system in the building envelope, includes this document. To demonstrate the degree of comprehension of these systems' impact on the building surroundings, including passive strategies that aid in lowering energy consumption and improving thermal envelope performance and insulation materials in hot, humid climates.

References

1. Siegel, F. R. (2018). Cities and mega-cities: problems and solution strategies. Springer.
2. Huang, L., Krigsvoll, G., Johansen, F., Liu, Y., & Zhang, X. (2018). Carbon emission of global construction sector. Renewable and sustainable energy reviews, 81, 1906-1916.
3. Romero-Lankao, P. (2016). Governing carbon and climate in the cities: An overview of policy and planning challenges and options. Climate change and sustainable cities, 7-26.
4. Besir, A. B., & Cuce, E. (2018). Green roofs and facades: A comprehensive review. Renewable and Sustainable Energy Reviews, 82, 915-939.
5. Johnston, D. R., & Master, K. (2004). Green Remodeling: Changing the World One Room at a Time (Vol. 9). New Society Publishers.
6. Vijayaraghavan, K. (2016). Green roofs: A critical review on the role of components, benefits, limitations and trends. Renewable and sustainable energy reviews, 57, 740-752.

7. www.phdesigns.us
8. Abass, F., Ismail, L. H., Wahab, I. A., & Elgadi, A. A. (2020). A review of green roof: definition, history, evolution and functions. In IOP Conference Series: Materials Science and Engineering (Vol. 713, No. 1, p. 012048). IOP Publishing.
9. Basu, A. S., Pilla, F., Sannigrahi, S., Gengembre, R., Guilland, A., & Basu, B. (2021). Theoretical framework to assess green roof performance in mitigating urban flooding as a potential nature-based solution. Sustainability, 13(23), 13231.
10. Sharp, D. (2002). Twentieth century architecture: A visual history. Images Publishing.
11. https://www.archdaily.com/85390/ad-classics-villa-mairea-alvar-aalto/5037e77028ba0d599b00039f-ad-classics-villa-mairea-alvar-aalto-photo
12. www.pinterest.com
13. https://dome.mit.edu/handle/1721.3/43317
14. Osmundson T1999 Roof Gardens: History, Design, and Construction (New York: W.W. Norton)
15. Saadatian, O., Sopian, K., Salleh, E., Lim, C. H., Riffat, S., Saadatian, E., ... & Sulaiman, M. Y. (2013). A review of energy aspects of green roofs. Renewable and sustainable energy reviews, 23, 155-168.
16. Veen, P., Jefferson, R., De Smidt, J., & Van der Straaten, J. (2014). Grasslands in Europe: Of high nature value. BRILL.
17. Blythe, R. W. (2001). Abraham Lincoln Birthplace National Historic Site. Cultural Resources Stewardship, Southeast Regional Office, National Park Service, US Department of the Interior.
18. Laidoner, T. (2020). Ancestor worship and the elite in Late Iron Age Scandinavia: A grave matter. Routledge.

19. Price, T. D. (2015). Ancient Scandinavia: an archaeological history from the first humans to the Vikings. Oxford University Press, USA.
20. Abass, F., Ismail, L. H., Wahab, I. A., & Elgadi, A. A. (2020). A review of green roof: definition, history, evolution and functions. In IOP Conference Series: Materials Science and Engineering (Vol. 713, No. 1, p. 012048). IOP Publishing.
21. Artursson, M., Earle, T., & Brown, J. (2016). The construction of monumental landscapes in low-density societies: New evidence from the Early Neolithic of Southern Scandinavia (4000–3300 BC) in comparative perspective (November 5, 2015). Journal of Anthropological Archaeology, 41, 1-18.
22. Saadatian, O., Sopian, K., Salleh, E., Lim, C. H., Riffat, S., Saadatian, E., ... & Sulaiman, M. Y. (2013). A review of energy aspects of green roofs. Renewable and sustainable energy reviews, 23, 155-168.
23. Arbid, Y. (2021). Impact of green roof plants on the removal of air pollutants (NO2/O3) and on the photochemical fate of pesticides (Doctoral dissertation, Université Clermont Auvergne).
24. Tayeb, H., & Farahi, M. H. (2024). How to Control Carbon Dioxide Gas in the Earth's Atmosphere to Reduce Global Warming. Nangarhar University International Journal of Biosciences, 553-556.
25. Shehzad, M., Younis, A., Asif, M., & Hameed, M. (2023). Prospects of green roof technology as a sustainable solution to urban pollution index. Journal of Agriculture and Food Research, 14, 100751.
26. Veisten, K., Smyrnova, Y., Klæboe, R., Hornikx, M., Mosslemi, M., & Kang, J. (2012). Valuation of green walls and green roofs as soundscape measures: Including monetised amenity values together with noise-attenuation values in a cost-benefit analysis of a green wall affecting courtyards. International journal of environmental research and public health, 9(11), 3770-3788.

27. Mora-Melià, D., López-Aburto, C. S., Ballesteros-Pérez, P., & Muñoz-Velasco, P. (2018). Viability of green roofs as a flood mitigation element in the central region of Chile. Sustainability, 10(4), 1130.
28. Cascone, S., Coma, J., Gagliano, A., & Pérez, G. (2019). The evapotranspiration process in green roofs: A review. Building and environment, 147, 337-355.
29. Pérez, G., Coma, J., Martorell, I., & Cabeza, L. F. (2014). Vertical Greenery Systems (VGS) for energy saving in buildings: A review. Renewable and sustainable energy reviews, 39, 139-165.
30. Rowe, D. B. (2011). Green roofs as a means of pollution abatement. Environmental pollution, 159(8-9), 2100-2110.
31. Akbari, H., & Kolokotsa, D. (2016). Three decades of urban heat islands and mitigation technologies research. Energy and buildings, 133, 834-842.
32. Sattler, S., Zluwa, I., & Österreicher, D. (2020). The "PV rooftop garden": providing recreational green roofs and renewable energy as a multifunctional system within one surface area. Applied Sciences, 10(5), 1791.
33. Ozturk Sari, S. (2023). Green Roof Exposure and Office Workers' Mental Health: Work-related Distress, Mental Fatigue, and Perceived Restoration.
34. World Health Organization. (2016). Urban green spaces and health (No. WHO/EURO: 2016-3352-43111-60341). World Health Organization. Regional Office for Europe.
35. Gray, T., & Birrell, C. (2014). Are biophilic-designed site office buildings linked to health benefits and high performing occupants?. International journal of environmental research and public health, 11(12), 12204-12222.
36. Stenros, A. (2023). The Nature Smart City—Defining the Next Urban Vision. In Urban and Transit Planning: City Planning: Urbanization and Circular Development (pp. 171-183). Cham: Springer International Publishing.

37. Ishimatsu, K., & Ito, K. (2013). Brown/biodiverse roofs: a conservation action for threatened brownfields to support urban biodiversity. Landscape and ecological engineering, 9, 299-304.