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Sustainable Living: Green Screen Strategies for Enhanced Indoor Thermal Performance in Dhaka's Mid-Rise Residential Buildings

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ABSTRACT

This study investigates sustainable living strategies, focusing on the application of green screens to enhance indoor thermal performance in mid-rise residential buildings in Dhaka, Bangladesh. Dhaka's subtropical monsoon climate poses challenges such as high temperatures and humidity, necessitating innovative solutions for improved indoor comfort and sustainability. The research employs a case study based methodology, using mid-rise residential buildings in Dhaka as the primary subjects. Green screens, which integrate vegetation into the building design as passive shading devices, are the central intervention. Data collection involves comparing results with real-world measurements of indoor thermal performance and resident feedback. Preliminary findings indicate significant improvements in indoor thermal conditions due to green screens, which act as effective shading elements, reducing heat gain and promoting a more sustainable indoor environment also reveal potential reductions in reliance on mechanical cooling systems, supporting the principles of sustainable living. Resident feedback further provides insights into the social acceptance and perceived benefits of green screen interventions, highlighting the importance of user satisfaction in sustainable design. In conclusion, this research underscores the importance of integrating green screen strategies into sustainable living practices for mid-rise residential buildings in Dhaka. The findings offer valuable insights for architects, urban planners, and policymakers aiming to implement effective sustainable solutions in densely populated urban settings.

Keywords: Energy Efficiency, Green Screens, Indoor Thermal Performance, Shading Devices, Sustainable Living, Urban Sustainability.

INTRODUCTION

A vegetation cover on the rooftop provides a cooler interior environment and a milder microclimate under the urban canyon [1]. Land scarcity and dense population has caused the residential buildings to evolve into high rise, which limits the effectiveness of roof gardens as an urban greening measure. Most of the rooftops are occupied by mechanical devices such as water tanks, elevator machinery and solar panels, resulting in very little space for vegetation. Various passive cooling techniques including cool roof coatings reveals the effectiveness of reflective materials in reducing indoor temperatures and enhancing energy efficiency in slum houses aimed at improving thermal comfort in urban settings, particularly in Dhaka [2]. This work serves as a foundation for understanding how similar strategies, such as green screens or vertical gardens, could be applied to mid-rise residential buildings. By integrating nature-based solutions, such as green facades, the paper suggests further potential to address heat gain, improve air quality, and support sustainable living in rapidly urbanizing cities like Dhaka. The popularity of vertical greenery is increasing in the context of urban landscaping because of the smaller footprint of rooftops. Green screening on wall facades is certainly an alternative to roof greenery which has high wall to roof ratio, and consequently large potential surface area for greening. Moreover, facade walls, unlike rooftops, usually have no insulation layer against solar heat and incorporation of green screens can also act as passive shading devices.

Like other forms of green infrastructure, green screens are increasingly being considered as a design feature to control internal thermal performance of buildings, thus reducing energy consumption and facilitating urban sustainability in a warming climate. By placing vegetation within the built space of the urban fabric, raised urban temperatures can decrease within the human habitats themselves and not only in the detached spaces of parks. Urban surfaces which are not used, such as the building envelope (walls and roofs), could easily be covered with vegetation and alter the microclimate of the built environment, as well as the local climate of the city. The magnitude of temperature decreases due to this transformation depends on the climatic characteristics, the amount of vegetation and urban geometry [3]. In cities all over the world, infill development and urban sprawl are leading to extensive and rapid depletion of vegetation. As the shading and evapotranspirative cooling benefits provided by plants are progressively lost, the urban heat island effect intensifies. Localized temperature increases associated with the urban heat island effect already exceed those predicted by climate change models over coming decades [4].

This paper presents the results of a quantitative research on how the provision of green screens have an effect on the indoor thermal temperature by covering the envelope of urban mid-rise residential buildings with vegetation. The aim of this research has been to assess the potential of mitigating raised urban temperatures through vegetation, for different urban geometries and climates. Empirical data on the thermal performance of green walls are scarce, though emerging [5]. The community will thus benefit if a vegetated cladding on building facades can exhibit the efficacy of a green screen.

BACKGROUND

Introduction of vegetation on residential buildings can have an impact on the microclimate of buildings. With buildings, some vegetative climatic effects could be made by combining green cover on walls, roofs and open spaces in the vicinity of buildings [6]. Research has shown the thermal performance of a double skin façade covered with plants, a simulation model was developed to analyze the influence of plants on the performance of the double skin façade. Further simulations of the entire building proved that plants can contribute to a comfortable indoor climate and energy savings [7].

Vegetation can dramatically reduce the maximum temperatures of a building by shading walls from the sun, with daily temperature fluctuation being reduced by as much as 50% [8]. A building façade fully covered by greenery is protected from intense solar radiation in summer and can reflect or absorb in its leaf cover between 40% and 80% of the received radiation, depending on the amount and type of greenery.[9] The insulation effect of vegetation and temperature fluctuations at the wall surface can be reduced from between 10 C and 60 C to between 5 C and 30 C [9]. In addition, vertical greenery systems can reduce air-conditioning load by shading walls and windows from incoming solar energy as a 5.5 C reduction in the temperature immediately outside of a building can reduce the amount of energy needed for air-conditioning by 50% to 70% [10]. In another study, the shading effect of vertical greenery systems reduces the energy used for cooling by approximately 23% and the energy used by fans by 20%, resulting in an 8% reduction in annual energy consumption[11]. Therefore, vertical greenery systems applied on the exterior would be effective by reducing incoming solar energy into the interior through shading and reducing heat flow into the building through evaporative cooling, both translating into energy savings.

GREEN SCREEN AS A RESPONSE TO THERMAL COMFORT

As cities grow hotter, demand for building space cooling is increasing. Once considered a luxury, the use of air-conditioners and evaporative coolers has been growing rapidly. The strategic use of green infrastructure (including shade trees, green roofs and green walls and green facades) may mitigate these problems [12] Green facades have potential benefits in dense inner-urban areas where the walls of high-rise buildings comprise a large proportion of total surface area and ground area for planting with shade trees is limited [13]. However, studies have shown introducing vegetation on wall facades can dramatically reduce the maximum temperatures of a building by shading walls from the sun, with daily temperature fluctuation being reduced by as much as 50% [8]. Research showed that the humid climates can achieve substantial benefits of a maximum temperature decrease of 8.4 C with vertical greenery systems in an urban canyon [3]. Green facades have potential benefits in dense inner-urban areas where the walls of high-rise buildings comprise a large proportion of total surface area and ground area for planting with

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shade trees is limited [13]. In addition, vertical greenery systems can reduce air-conditioning load by shading walls and windows from incoming solar energy as a 5.5 C reduction in the temperature immediately outside of a building can reduce the amount of energy needed for air-conditioning by 50% to 70% [10]. Areas with vertical vegetation are cooler than light-coloured bricks, walls and black surfaces that are typically found in urban areas. Therefore, together with the insulation effect of vegetation, temperature fluctuations at the wall surface can be reduced from between 10 C and 60 C to between 5 C and 30 C [10]. Moreover, through evapotranspiration, large amounts of solar radiation can be converted into latent heat which does not cause temperature to rise.

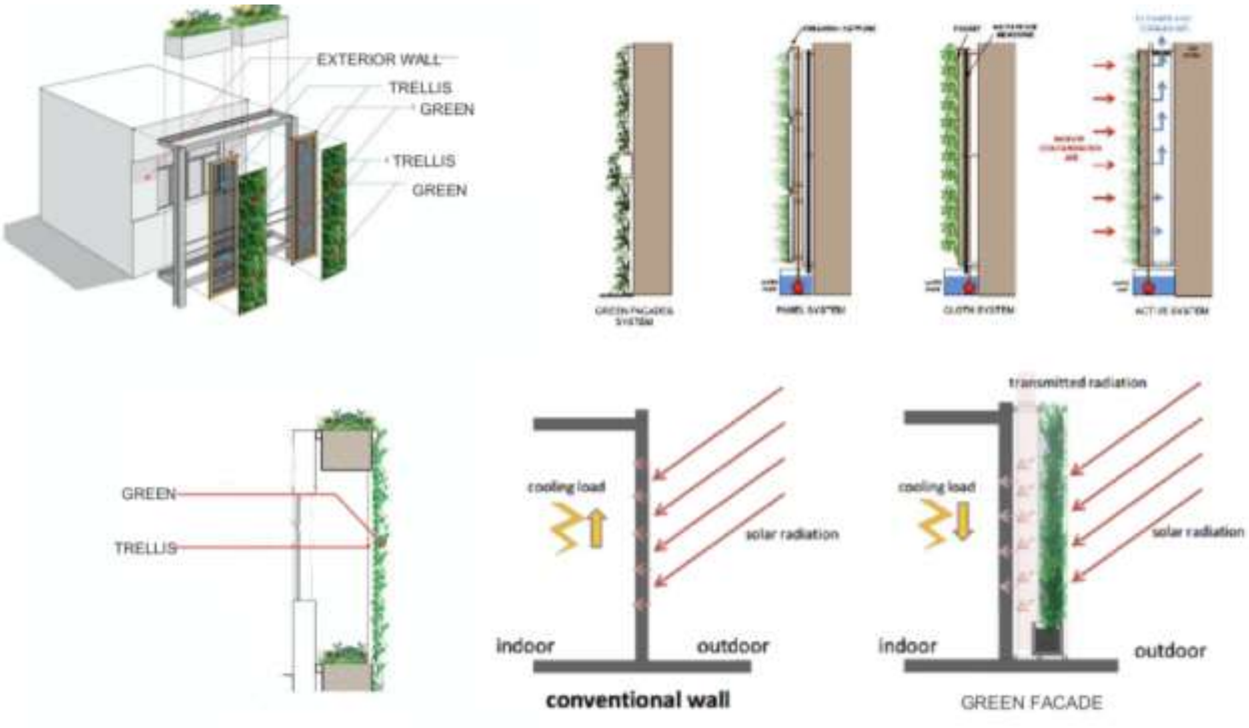

Figure 1: Advantages of implementing green screen strategies (Source: Students, 2024)

OBJECTIVE

This study investigates sustainable living strategies, specifically focusing on the application of green screens to enhance indoor thermal performance in mid-rise residential buildings in Dhaka, Bangladesh. The research aims to address the challenges posed by Dhaka's subtropical monsoon climate, characterized by high temperatures and humidity, by exploring innovative solutions to improve indoor comfort while promoting sustainability. By adopting a case study approach, the study selects mid-rise residential buildings in Dhaka as its primary subjects and evaluates the effectiveness of green screens—vegetation integrated into building design as passive shading devices.

METHODOLOGY

This study adopts a case study approach to evaluate the effectiveness of green screens in improving indoor thermal performance in mid-rise residential buildings in Dhaka, Bangladesh. The selected buildings serve as primary subjects for the research, where green screens, comprising vegetation integrated into the building design, are implemented as passive shading devices. Data collection involves measuring indoor temperature variations by using mobile apps and thermometers and using energy meters to measure electricity consumption, particularly focusing on cooling energy requirements. Additionally, resident feedback is gathered through surveys and structured interviews to capture qualitative data on their perceptions of thermal comfort, aesthetic appeal, and changes in air conditioning usage. The quantitative data on indoor temperatures and energy consumption are analyzed statistically to assess the impact of green screens, while thematic analysis is conducted on resident feedback to identify common sentiments and themes regarding the intervention. Comparative analysis between buildings with and without green screens further

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elucidates the performance differences. The results are then interpreted within the context of sustainable living practices and Dhaka's climatic conditions, providing a comprehensive evaluation of green screens' benefits and offering insights for architects, urban planners, and policymakers aiming to enhance sustainability in urban residential environments.

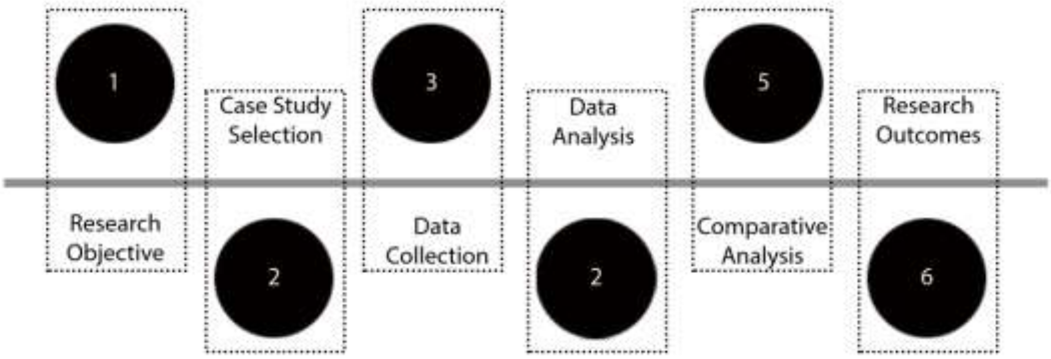

Figure 2. Research Framework. (Source: Author, 2025)

SITE LOCATION

The study is conducted in Dhaka, the capital city of Bangladesh, with a specific focus on mid-rise residential buildings located in the neighborhoods of Azimpur, Khilji Road, and Mohammadpur. These areas represent typical urban residential settings within Dhaka, characterized by their dense population and the city's subtropical monsoon climate, which brings high temperatures and humidity.

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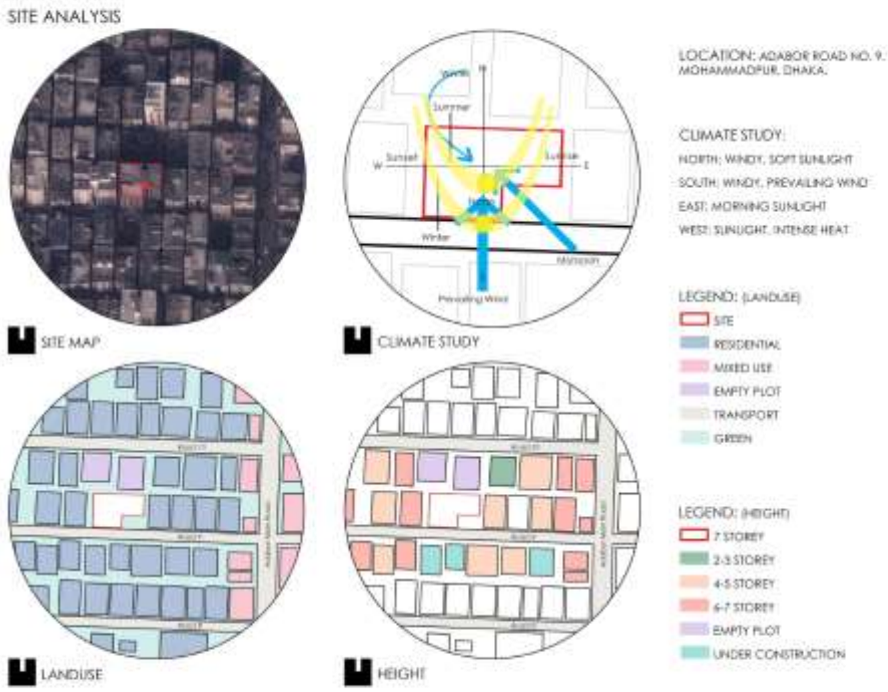

Figure 3. Site location. (Source: Author, 2024)

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Figure 4. Plan and sections of case study 1.(Source: Author, 2024)

Figure 5. Plan of case study 2. (Source: Author, 2024)

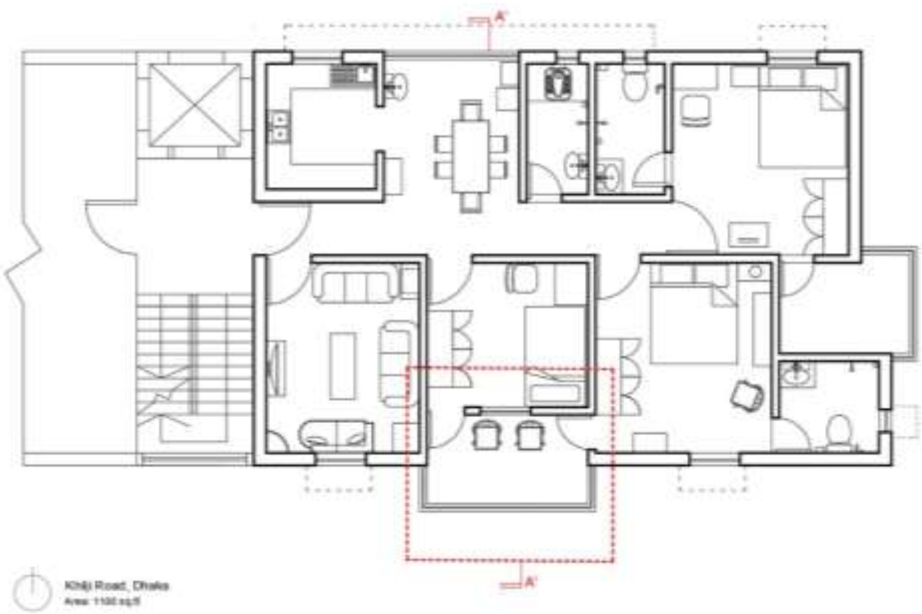

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Figure 6. Plan of Case Study 3. (Source: Author, 2024)

Figure 4,5 & 6 shows the site location at Azimpur, Khilji Road, and Mohammadpur which are selected for their diverse architectural styles and the variety of residential buildings they encompass, providing a comprehensive understanding of how green screens can enhance indoor thermal performance across different building types. This location selection is pertinent due to the rapid urbanization and the urgent need for sustainable living solutions in Dhaka, making it an ideal context for evaluating the effectiveness of green screens in improving indoor comfort and energy efficiency.

DATA COLLECTION

Data collection for this study involves measuring indoor thermal conditions before and after the installation of green screens. Temperature and humidity sensors are placed within the buildings to track changes in indoor climate. Additionally, resident feedback is gathered through surveys and interviews to understand their perception of indoor comfort and the social acceptance of green screen interventions. Figure 7, 8 & 9 are included for showing the temperature recordings of each case study, recorded at different hours of the day. The temperature readings were taken before implementation of the green screen and again the temperatures were recorded after implementation of green screen at the respective hours of the day.

Date	Time	Temperature (Before)	Date	Time	Temperature (After)
18 August	10:00	32.3	22 August	10:00	27
18 August	12:00	34.7	22 August	12:00	26.75
18 August	17:00	31.9	22 August	17:00	25.8
18 August	20:00	34.6	22 August	20:00	25.75

Figure 7. Before and after change in temp. of case 01. (Source: Author, 2024)

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Date	Time	Temperature (Before)
18 August	10:00	28
18 August	12:00	34
18 August	17:00	32
18 August	20:00	30

Date	Time	Temperature (After)
22 August	10:00	26
22 August	12:00	28
22 August	17:00	30
22 August	20:00	27

Figure 8. Before and after change in temp. of case 02. (Source: Author, 2024)

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Date	Time	Temperature (Before)		Date	Time	Temperature (After)
11 August	10:00	33		29 August	10:00	32
11 August	12:00	30		29 August	12:00	29
11 August	17:00	29		29 August	17:00	29
11 August	20:00	27		29 August	20:00	27

Figure 9. Before and after change in temp. of case 03. (Source: Author, 2024)

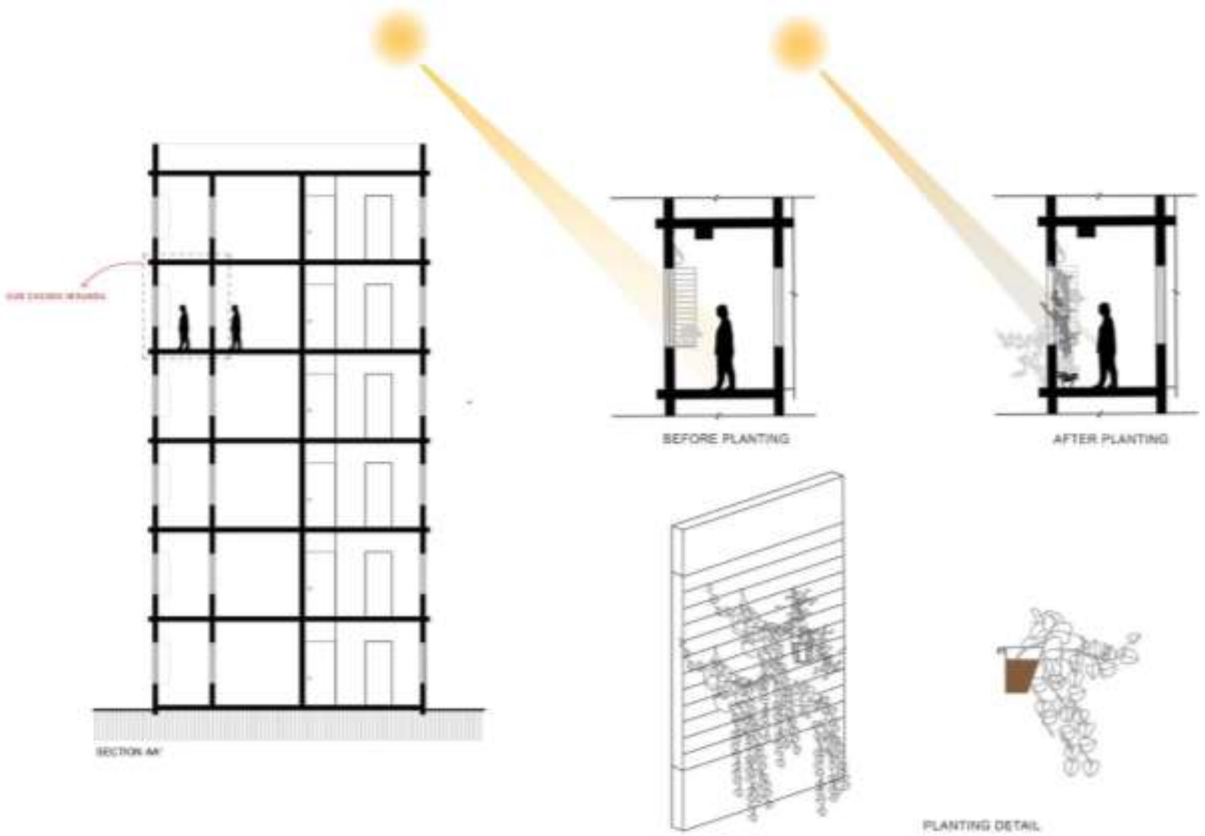
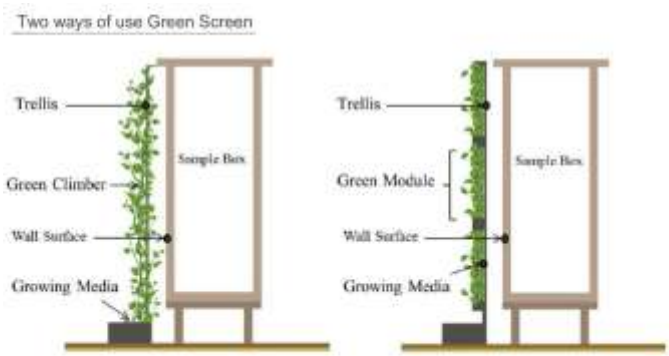


Figure 10. Section of veranda, before and after green screen implementation on case studies. (Source: Author, 2024)



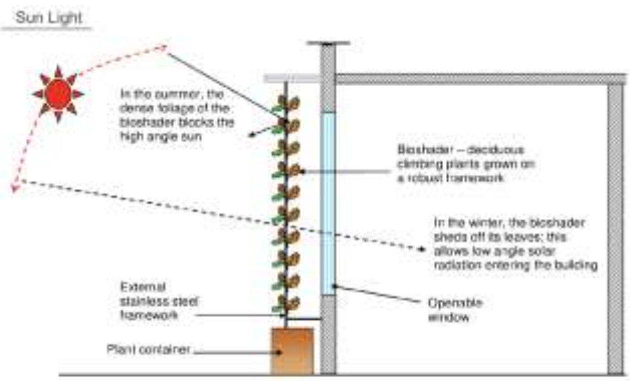


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Figure 11: Two ways of implementing green screen strategies. (Source: Author, 2024)

Preliminary findings suggest that green screens significantly improve thermal conditions by reducing indoor temperatures and humidity. Moreover, they offer a sustainable alternative to mechanical cooling systems, which can lower energy consumption.

DATA ANALYSIS AND OUTCOME

The study's findings reveal that the incorporation of green screens significantly improves indoor thermal performance in mid-rise residential buildings in Dhaka, Bangladesh. From the graphical trends of Figure 12, 13 & 14, the data indicate a noticeable reduction of 1-3°C in indoor temperatures, attributed to the shading and cooling effects of the vegetation and plantation.

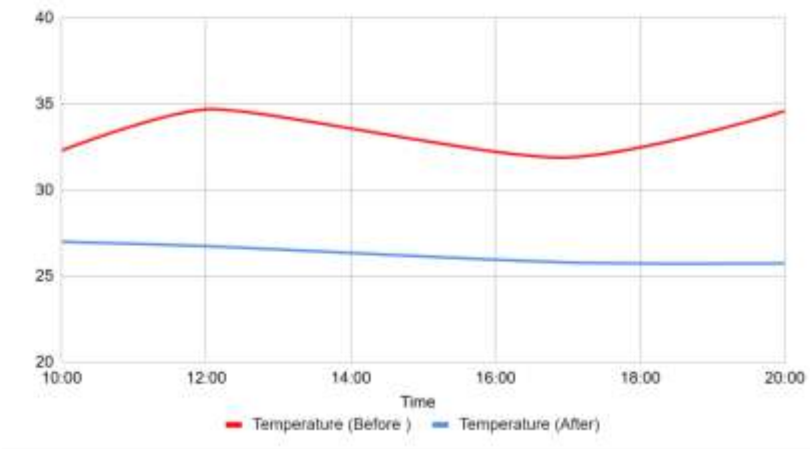

Figure 12. Before and after result of case study 01

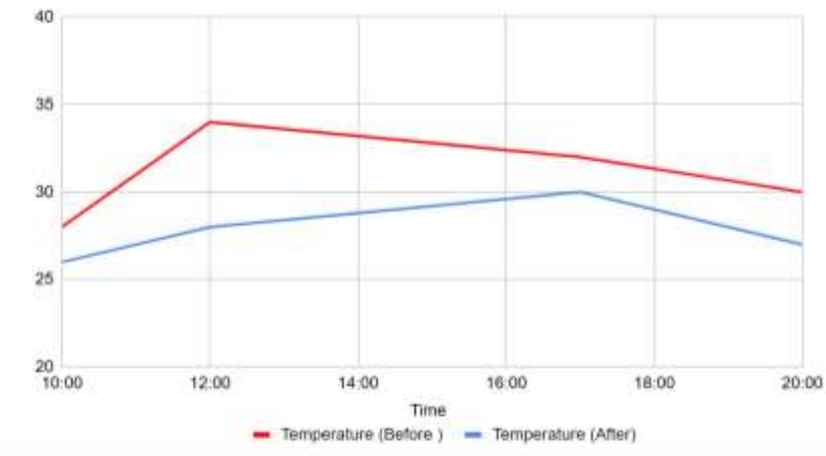

Figure 13. Before and after result of case study 02

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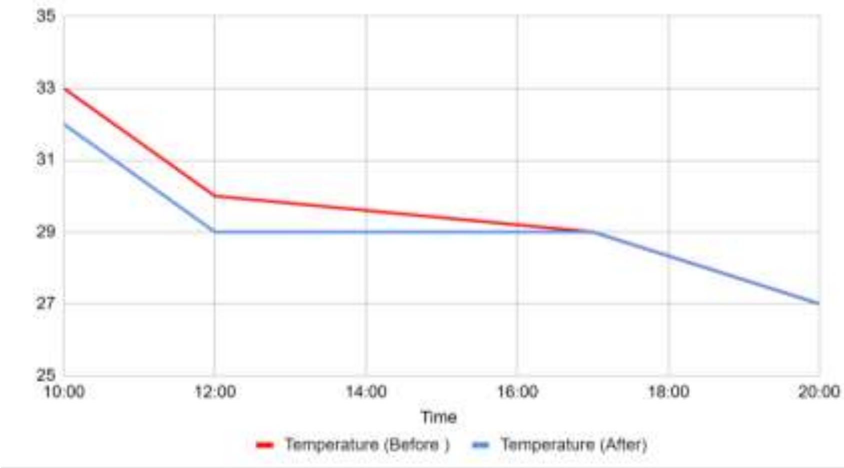

Figure 14. Before and after result of case study 03

This decrease in temperature leads to a reduced reliance on mechanical cooling systems, subsequently lowering energy consumption. Resident feedback supports these findings, with many reporting enhanced thermal comfort and satisfaction with the aesthetic benefits of the green screens. The qualitative analysis highlights a positive social acceptance of the green screen intervention, emphasizing its dual role in improving comfort and contributing to sustainable living practices.

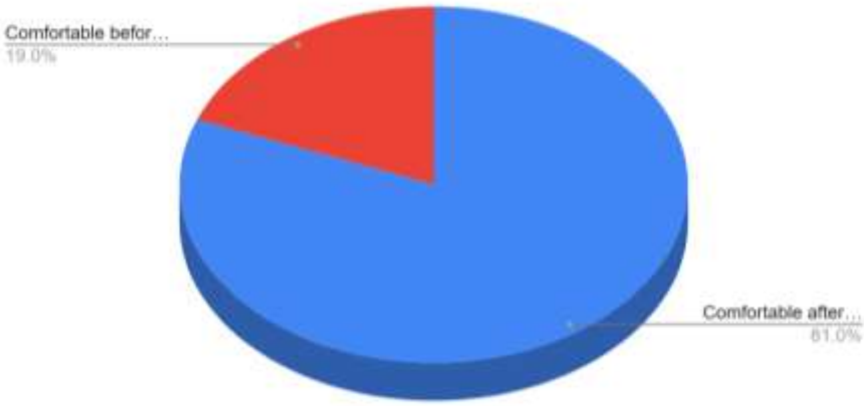

Figure 15. Survey of 'Feel-Like' Data Before and After Application

The survey data revealed significant improvements in thermal comfort following the application of the green screen in the verandah. Prior to the installation, a large portion of participants reported feeling discomfort due to elevated temperatures. However, after the green screen was applied, 81% of participants expressed feeling more comfortable, with temperatures perceived as more bearable. In contrast, figure 15 shows only 19% of the participants reported feeling similar to the temperature they experienced before the application, indicating that the green screen significantly enhanced their thermal comfort. This suggests that the green screen effectively mitigated heat and improved overall comfort in the space.

Overall, the study underscores the effectiveness of green screens as a natural, energy-efficient solution for mitigating the heat challenges in Dhaka's subtropical monsoon climate, offering valuable insights for sustainable urban development.

RECOMMENDATION

Further research should explore the long-term impacts of green screens on building performance and resident well-being in various climatic conditions. In fact, it is not yet possible to make valid comparisons about green facade thermal performance within, and between, climatic regions because the number of published studies is still limited. It would be beneficial to conduct similar studies in different urban settings, comparing results across diverse environmental and socio-economic contexts to validate the generalizability of the findings. Additionally, future studies should examine the maintenance requirements and cost-effectiveness of green screens over time, assessing their durability and financial viability. Investigating the integration of other sustainable technologies, such as solar panels and rainwater harvesting systems, in conjunction with green screens could provide a holistic approach to enhancing building sustainability. Moreover, expanding the scope to include high-rise buildings and commercial structures could offer broader insights into the applicability and benefits of green screens in different architectural contexts. Collaboration with urban planners, architects, and policymakers will be crucial to developing comprehensive guidelines and policies for implementing green screens as a standard practice in urban design, promoting resilient and sustainable cities globally.

DISCUSSION AND CONCLUSION

The goal of this thermal performance research was to determine a comparative assessment of thermal performance on green screens as long as building dimensions, design and material thermal properties are kept constant. The effects of a green screen on wall surface temperature, heat transfer through the wall, internal air temperature and building cooling load were estimated from these basic measurements. Green screens have potential benefits on thermal comfort however it is unlikely to regulate internal temperatures in every climate, on all building aspects, every building construction type, and at all heights above ground. Therefore, research designs must be improved through better experimental replication and the validation of modeling studies. Green screens are already being incorporated into new building designs for aesthetic reasons. To make meaningful comparisons among studies, it is crucial that we standardize our approach to the measurement of green screens' microclimatic parameters and build a more comprehensive knowledge of the climbing plant layer, so that plant morphological and physiological parameters essential to green facade thermal performance can be identified. Much work is needed to quantify the potential energy savings. Increased uptake will occur when their effectiveness in regulating building internal temperatures has been quantified for specific climatic regions and building aspects, optimal designs for green facade components have been developed, and key plant traits contributing to thermal performance have been identified.

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