De Silva, S.B.N.S.W., Sridarran, P. and Maddakandage, M.N.U., 2026. A conceptual biomimicry-inspired model for enhancing energy efficiency in high-rise buildings in Sri Lanka.. In: Waidyasekara, K.G.A.S., Jayasena, H.S., Chandanie, H. and Tennakoon, G.A. (eds). *Proceedings of the 14th World Construction Symposium*, 10-11 July 2026, Sri Lanka. pp. 16-29. DOI: https://doi.org/10.31705/WCS.2026.2. Available from: https://ciobwcs.com/papers/

A CONCEPTUAL BIOMIMICRY-INSPIRED MODEL FOR ENHANCING ENERGY EFFICIENCY IN HIGH-RISE BUILDINGS IN SRI LANKA.

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ABSTRACT

Rapid urbanization in Sri Lanka has led to increased energy consumption in high-rise buildings, particularly due to cooling demands in tropical climates. Conventional buildings with extensive glazed facades contribute to excessive solar heat gain and high reliance on mechanical systems. This study evaluates the potential of biomimicry-inspired strategies to improve energy efficiency in high-rise buildings. Two models, a conventional building and a biomimicry-inspired model, were developed and simulated using energy analysis tools in Revit under Colombo climatic conditions. The biomimicry-inspired model incorporates envelope strategies such as external shading, textured facade surfaces, and reflective roof coatings. The results indicate a reduction of approximately 25% in cooling energy consumption in the biomimicry-inspired model, along with decreases in lighting and equipment energy use. The study concludes that biomimicry-inspired envelope strategies can effectively enhance energy efficiency in tropical high-rise buildings.

Keywords: *Biomimicry; Energy Efficiency; High-Rise Buildings; Tropical Climate.*

1. INTRODUCTION

Rapid urbanization and population growth have significantly transformed the urban landscape of Sri Lanka, particularly in Colombo, where limited land availability has accelerated the development of high-rise buildings. While vertical expansion offers an effective solution to urban land scarcity, it also contributes to increasing energy demand within the built environment (Jayasinghe et al., 2021). Globally, buildings account for nearly 40% of total energy consumption and a substantial proportion of greenhouse gas emissions (Christopher et al., 2023). In Sri Lanka, the building sector represents almost 60% of national electricity consumption, with a large share attributed to mechanical cooling systems used to maintain indoor thermal comfort in the tropical climate (Weerasinghe et al., 2022).

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In addition, the increasing use of glazed facades in contemporary commercial buildings intensifies solar heat gain, thereby increasing cooling loads and operational energy consumption (Qahtan, 2024). Consequently, conventional building design approaches have become increasingly inadequate in addressing the combined challenges of energy efficiency, environmental sustainability, and occupant thermal comfort.

In response to these challenges, biomimicry has emerged as a promising approach in sustainable architectural design (Vasanthanathan et al., 2020). Biomimicry involves studying and emulating strategies found in natural systems to solve complex human design problems (Dash, 2018). Many organisms have evolved efficient mechanisms to regulate temperature, airflow, and energy exchange within their environments. For instance, termite mounds maintain stable internal temperatures through natural ventilation systems, while plants such as cactus reduce heat gain through adaptive surface structures (Adarsh & Thomas, 2024). Translating such biological strategies into architectural applications presents an opportunity to develop innovative passive cooling solutions that reduce dependence on mechanical systems. Thus, this study investigates:

How can biomimicry-inspired cooling strategies improve energy efficiency and indoor thermal comfort in high-rise buildings under tropical climatic conditions in Sri Lanka?

Therefore, the aim of this study is to develop a biomimicry-inspired model for improving energy efficiency in high-rise buildings under tropical climatic conditions in Sri Lanka. Although biomimicry-inspired design strategies have been increasingly explored internationally, limited research has investigated their application for improving energy efficiency in high-rise buildings within the Sri Lankan tropical context. There are limited simulation-based studies evaluating biomimicry-inspired envelope strategies for commercial high-rise buildings in Sri Lanka. To address this gap, the study first reviews biomimicry principles applicable to tropical climates and suitable for architectural integration. Based on this, a conceptual biomimicry-inspired design model is developed by applying selected biomimicry strategies to an existing conventional building. Furthermore, both the conventional and biomimicry-inspired building models are simulated using energy simulation software to evaluate and compare their energy performance.

2. LITERATURE REVIEW

This section reviews the existing literature related to energy consumption in high-rise buildings, the role of building envelopes on energy efficiency and the use of biomimicry in sustainable building design. It also reviews the cooling strategies inspired by nature and their possible role in achieving better energy efficiency in tropical high-rise buildings.

2.1 ENERGY CONSUMPTION IN HIGH-RISE BUILDINGS

The building sector is one of the largest consumers of energy worldwide and plays a significant role in global greenhouse gas emissions. Studies indicate that buildings account for nearly 40% of global energy consumption and approximately one-third of total carbon emissions (Harputlugil & De Wilde, 2021; Omer, 2020). In rapidly urbanizing cities, the development of high-rise buildings has increased significantly due to limited land availability and growing population demands (Mostafavi et al., 2021). However, these buildings typically require higher energy consumption compared to low-rise structures due to their dependence on mechanical systems for cooling, ventilation, lighting, and vertical transportation (Ge et al., 2023).

Among building systems, Heating, Ventilation, and Air Conditioning (HVAC) systems represent the largest share of energy consumption, accounting for more than 50% of total building energy use in many cases (Anarene, 2024). In tropical countries such as Sri Lanka, the demand for cooling energy is particularly high due to elevated temperatures and humidity levels. As urban areas such as Colombo continue to experience rapid vertical development, energy consumption in the building sector has increased considerably. Buildings in Sri Lanka consume a substantial portion of national electricity, with commercial high-rise buildings identified as major contributors due to their intensive cooling requirements. Total energy consumption in commercial buildings can generally be categorized in Figure 1.

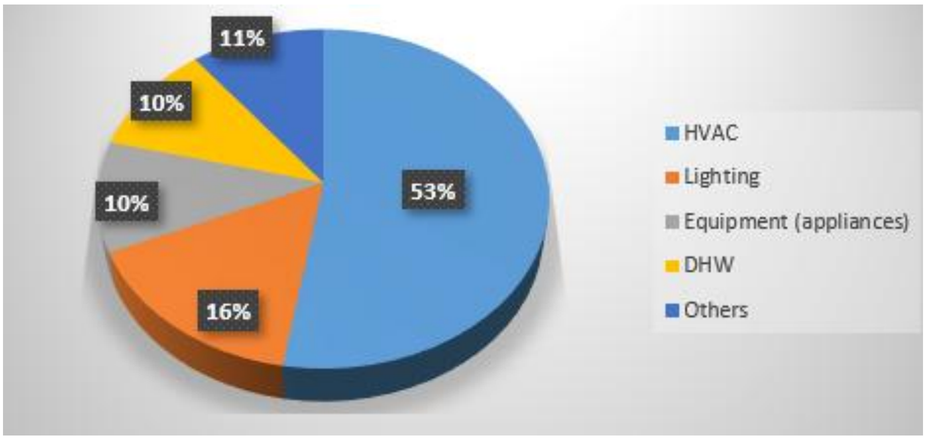

Figure 1: Total energy consumption in commercial building
Source:(Gajaba & Dissanayake, 2025)

2.2 ROLE OF BUILDING ENVELOPE IN ENERGY EFFICIENCY

The building envelope plays a crucial role in determining the energy performance of buildings by controlling the interaction between indoor spaces and external environmental conditions (Azima et al., 2022). Key components of the building envelope include external walls, roofs, glazing systems, shading devices, and ventilation openings. These elements collectively determine the building's ability to minimize heat gain and maintain comfortable indoor conditions. In tropical climates, poorly designed envelopes allow excessive solar radiation and heat penetration, which increases indoor temperatures and leads to higher cooling loads. Modern high-rise buildings frequently incorporate extensive glazed facades to improve daylighting and architectural aesthetics. However, large glazing areas can significantly increase solar heat gain if not properly designed, resulting in greater dependence on mechanical cooling systems such as air-conditioning (Dutta & Samanta, 2020). According to (Abdou & Reffat, 2025) the building envelope in high-rise buildings comprises physical form and orientation, external walls, roofs, glazing systems, shading devices, and ventilation elements, all of which play a critical role in controlling solar heat gain, indoor thermal comfort, and overall energy consumption in hot humid climates.

2.3 THE CONCEPT OF BIOMIMICRY

The concept of biomimicry involves studying natural systems, organisms, and processes to inspire solutions for human challenges. By emulating nature's strategies for adaptation, efficiency and resilience, biomimicry provides opportunities for developing environmentally responsive and energy-efficient design solutions (Araque et al., 2021). Furthermore, the approach of biomimicry, that examines and emulates the principles and mechanisms of nature to address human design challenges, with a strong emphasis on achieving sustainability (Mayank & Soumya, 2020). In addition there is increasing interest in biomimicry, as illustrated by the growing number of research studies, design projects, and sustainable innovations inspired by nature (Verbrugghe et al., 2023).

Key characteristics of biomimicry include adaptation, efficiency, resilience, and the ability of natural systems to regulate energy and resources effectively. Rather than simply copying the appearance of natural organisms, biomimicry focuses on understanding underlying functional mechanisms that enable organisms to survive in challenging environments (Tezel Ersanli & Ersanli, 2023). Biomimicry in architectural and engineering design draws inspiration from nature to foster sustainability and innovation, with two primary approaches: the top-down approach (Problem Based), and the bottom-up approach (solution-based) (Irene, 2025; Yeter et al., 2023). The problem-based approach (Design to Biology), also known as the top-down method, begins with a specific human design challenge and then seeks appropriate biological analogues to inspire solutions, whereas the solution-based approach (Biology to Design), or bottom-up method, starts by exploring biological phenomena, processes, or strategies in nature and subsequently applies these insights to address human design problems. In recent years, architects and engineers have increasingly explored biomimetic principles in building design to enhance sustainability and reduce energy consumption (Bijari et al., 2025). Nature-inspired architectural solutions have been applied in facade systems, structural forms, ventilation strategies, and shading devices. By integrating biological principles into architectural design, biomimicry enables the creation of buildings that are more adaptive, resource-efficient, and environmentally responsive.

2.4 BIOMIMICRY - INSPIRED COOLING STRATEGIES IN BUILDINGS

Biomimicry is the emulation of strategies seen in the living world as a basis for design and is a source of innovation, particularly in the creation of more sustainable architecture. It is the mimicry of an organism, an organism's behaviour or an entire ecosystem in terms of its form, material, construction method, process strategies or function. Research demonstrates that biomimicry can successfully address climatic challenges, with nature serving as "model, mentor and measure" for innovative architectural solutions (Cuce et al., 2019). Below Table 1 demonstrate the biological strategies provide valuable insights for developing passive cooling systems that can be adapted for architectural applications.

Table 1: Various biomimicry strategies used in architecture

Design concept	Building	Biomimetic performance and building benefits
Termite Mounds	The Estate building in Harare, Zimbabwe	This innovative approach has resulted in a remarkable 100% reduction in energy consumption for HVAC systems.

Design concept	Building	Biomimetic performance and building benefits
		Additionally, the building design facilitates natural ventilation and lighting, further enhancing its energy efficiency.
	The Council House 2, Melbourne	Towers provide a reduction of 4-13 degrees C from the top of the tower to the bottom. Air is 100% filtered Natural lighting and ventilation saved by 65% Maximizes natural ventilation
Beehive	Sinosteel International Plaza	The hexagonal windows, designed in five sizes and arranged in an energy-efficient configuration, minimize conventional energy use, eliminate the need for internal structures, and achieve 75% energy efficiency.
Glass sponge	Swiss Re Headquarters, London	An aerodynamic glazed facade with triangulated geometry reduces wind loads, maximizes natural light and ventilation, and cuts building energy use by up to 80%.

Source: (Dixit et al., 2023; Rahubadda & Kulatunga, 2024; Waheeb et al., 2024)

Overall, biomimicry provides a versatile framework for developing climate-responsive architecture in tropical regions. By emulating natural systems and organisms, these strategies enhance energy efficiency, reduce reliance on mechanical cooling, and improve occupant comfort, thereby contributing to sustainable urban resilience and effective climate change adaptation (Amraoui et al., 2024).

2.5 BIOMIMICRY AS A SOLUTION FOR ENERGY EFFICIENCY

Improving the thermal performance of building envelopes, particularly facades, is essential for reducing operational energy consumption while maintaining indoor thermal comfort. Biomimicry provides nature-inspired strategies that can significantly reduce energy demand for heating, ventilation, and lighting by emulating efficient natural systems (Varshabi et al., 2022). Research has highlighted the potential of integrating biomimicry principles into building skins to enhance energy performance while addressing environmental aspects such as resource efficiency and material use. The Eastgate Centre in Harare demonstrates the effectiveness of biomimicry-inspired ventilation systems, achieving around 90% reduction in energy requirements compared with conventional building designs (Adarsh & Thomas, 2024). Despite these successful applications, the integration of biomimicry in high-rise residential and commercial buildings remains limited, particularly in shortage of skilled professionals. This highlights the need for further research to explore biomimicry-inspired strategies that can enhance energy efficiency in high-rise buildings (Rodriguez et al., 2024).

3. METHODOLOGY

This study adopted a mixed-method approach to combine qualitative insights from interviews and document reviews with quantitative energy simulation analysis, thereby providing a more comprehensive evaluation of biomimicry-inspired strategies for improving building energy efficiency. According to Nair and Prem (2020) mixed-method research enables a better understanding of complex research problems through the integration of qualitative and quantitative data. The study included a literature review, preliminary interview, document review, development of conventional and biomimicry-inspired building models, and energy simulation analysis. The overall research process is illustrated in Figure 2.

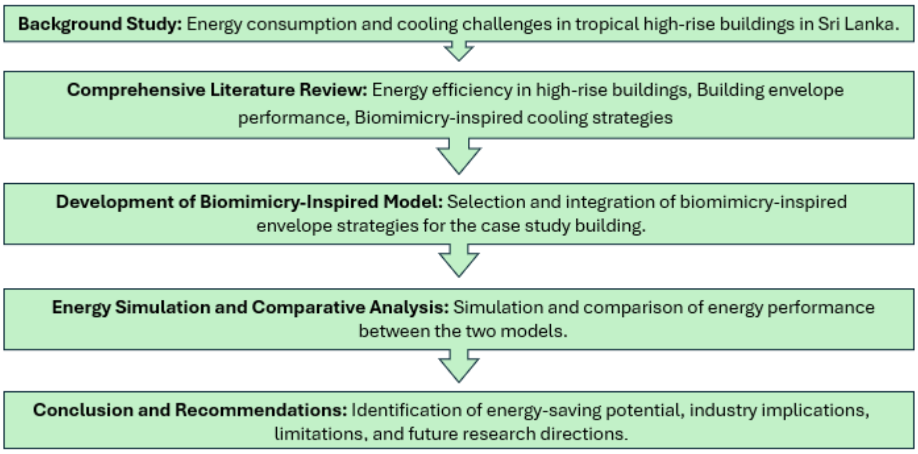

Figure 2: Research process

The process began with a background study and comprehensive literature review to identify relevant biomimicry principles applicable to improving energy efficiency in tropical high-rise buildings. In addition, preliminary interviews and document reviews were conducted to gather expert insights and building-related information. Based on these findings, a conventional building model and a biomimicry-inspired building model were developed. Finally, energy simulation and comparative analysis were carried out using Revit energy analysis tools to evaluate and compare the energy performance of both models, leading to the study conclusions and recommendations.

3.1 CASE STUDY SELECTION

A 12-storey commercial office building located in Colombo, Sri Lanka, was selected as the case study for this research. The building has a total floor area of approximately 18,805.50 m² and utilizes a reinforced concrete frame structural system. Preliminary interviews with building representatives and a review of available architectural and technical documents were conducted to collect relevant building information. The external envelope of the building primarily consists of a single-glazed tinted curtain wall facade, while secondary facade areas are constructed using 225 mm reinforced concrete walls. Figure 3 demonstrates the architectural layout of the selected building, site plan, unit layout, and ground floor design.

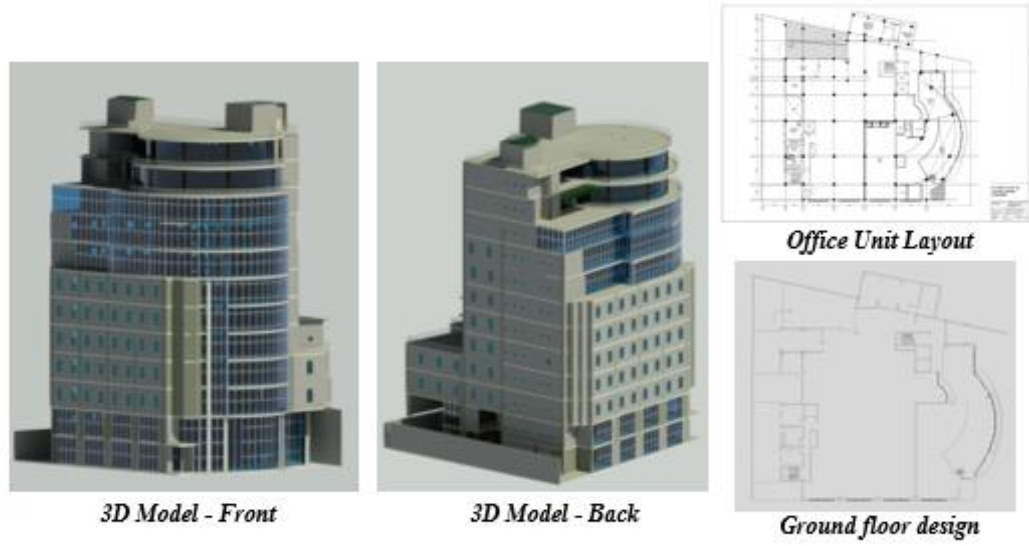

Figure 3: Architectural layout of the selected building, site plan, unit layout, and ground floor design

The selection of the case study building in Colombo, Sri Lanka, was guided by several key considerations. First, the building features a high glazing facade ratio of approximately 90%. Second, the building utilizes tinted glazing with a relatively high U-value, indicating lower thermal resistance and increased heat transfer through the facade. Third, the structure follows a reinforced concrete frame system with a glass curtain wall as the primary facade, representing a common typology in contemporary commercial high-rise buildings. Finally, the building provides sufficient architectural and technical information through interviews and documentation, enabling the development of a representative conventional model for evaluating biomimicry-inspired strategies aimed at improving energy efficiency.

3.1.1 Preliminary Interview

A preliminary interview was conducted with a participant who is highly familiar with the building. The participant is the operations manager of the building, who has 10 years of experience in the built-environment sector and sustainability. The data were analysed using a thematic analysis to identify key insights and inform the development of the model. Although only a single interview was conducted, this approach allowed the systematic extraction of meaningful observations from the participant's experience with the building.

3.1.2 Document Review

A document review was conducted to collect and analyse relevant building-related data. Energy consumption records and electricity bills were examined to obtain monthly energy usage patterns. Architectural layout plans were reviewed to support the development of the building model, while building handover documents were analysed to identify material specifications and usage. This document-based analysis provided reliable secondary data to inform the model development.

3.2 DEVELOPMENT OF THE BUILDING MODELS

To develop the conceptual biomimicry-inspired design model, Autodesk Revit, a Building Information Modelling (BIM)- platform, was used to create digital representations of both the conventional building and the biomimicry-inspired building models. The conventional model was developed based on the collected building data and served as the baseline condition representing the existing building design. Subsequently, a biomimicry-inspired model was created by incorporating selected nature-based cooling strategies identified from the literature review. To ensure a reliable comparison between the two models, identical building functions, spatial layouts, and environmental settings were maintained across both models.

3.2.1 Biomimicry Model Development

In this study, the top-down (problem-based) approach was adopted, where the research first identifies the problem of high energy consumption in tropical high-rise buildings. The biomimicry-inspired model was developed by incorporating selected biomimicry-inspired envelope features derived from natural systems. A triangular parametric facade was introduced as an external shading system to minimize direct solar radiation and enhance daylight control. The concrete wall system was modified using mycelium-bound composite tiles with elephant-skin textured cladding, selected for their ability to increase surface roughness and promote heat dissipation. In addition, the rooftop was enhanced with a hexagonal ZnO microrods coating, chosen for its high reflectivity and emissivity to reduce solar absorptance. Figure 4 illustrates the development process of the biomimicry inspired building model.

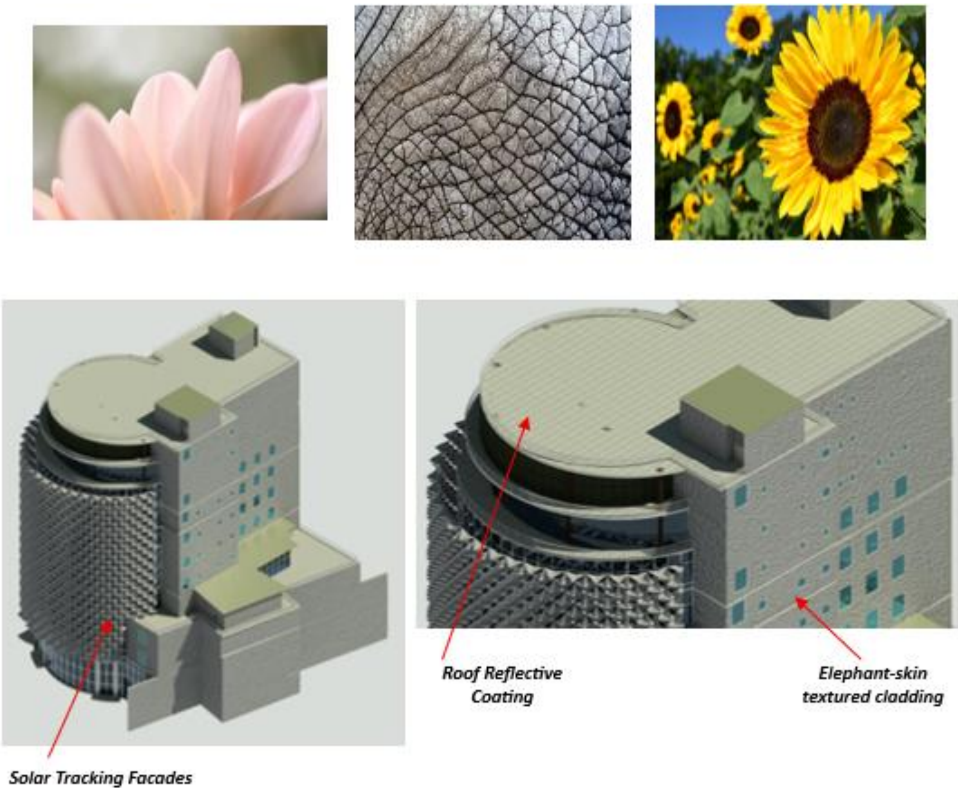

Figure 4: Development process of the biomimicry inspired building model

3.3 BUILDING ENERGY SIMULATION

Energy simulation for both the conventional and biomimicry-inspired building models was carried out using Energy Plus platform to evaluate the performance under tropical climatic conditions. The simulation was conducted using the Colombo Bandaranaike International Airport weather file, representing local environmental conditions. The model was simulated over an annual period of 8760 hours.

The analysis focused on the Annual Building Utility Performance Summary (End Uses by Subcategory), which provides a detailed breakdown of building energy consumption. Key end-use categories considered in this study include cooling, interior lighting, and interior equipment, as well as the total energy consumption associated with heating and cooling systems. These outputs were used to establish the baseline energy performance of the conventional building and to enable comparison with the biomimicry-inspired model in terms of energy efficiency improvements.

4. RESEARCH FINDINGS AND DISCUSSION

4.1 THEMATIC ANALYSIS FOR INTERVIEW

Table 2 presents the thematic analysis conducted based on preliminary interview responses. The findings indicate that the building follows a conventional design approach with a heavy reliance on centralized HVAC systems, leading to high energy consumption, particularly due to cooling demand. The extensive use of a glass curtain wall façade contributes significantly to solar heat gain, further increasing the cooling load. According to the respondent “internal blinds are used as shading elements”, advanced passive design strategies are absent. However, the interviewer revealed that “I have some general awareness of biomimicry” and highlighted their potential application, particularly in façade design, to reduce heat gain and improve energy efficiency. These insights were used to inform the development of the proposed biomimicry-based facade model.

Table 2 - Thematic analysis of the preliminary interview

Theme	Code	Participant’s responses and evidence
Building Design Characteristics	Conventional Design	No biomimicry-based features were adapted in the building
Energy Usage	HVAC Dependency	Centralized HVAC system operates during weekday working hours
	High Cooling Demand	Solar heat gain becomes a major issue in increased cooling load.
Facade Performance	Glazed Facade Impact	Glass curtain wall facade is a significant portion of the external envelope.
	Limited Passive Strategies	Internal blinds are used as a basic shading element. No advanced solutions.
Biomimicry Awareness	Basic Awareness	Awareness exists but is not deeply implemented.
Biomimicry Potential	Need for Biomimicry Solutions	Strong potential for biomimicry in improving energy performance.

4.2 DOCUMENT REVIEWING

The document review of the selected building indicates a high level of annual electricity consumption (6,490,160Kwh) primarily driven by cooling demand under tropical climatic conditions. The analysis reveals that the building is cooling-dominated, with a significant portion of total energy use attributed to the centralized HVAC system. This is largely influenced by the building's high glazing facade ratio (approximately 90% of the total facade area) and thermal properties of the envelope, which contribute to increased solar heat gain and indoor temperature rise. In addition, the roof's high solar absorptance further intensifies heat transfer into the building. The building operates during standard office hours, resulting in consistent energy demand throughout the year. Overall, the findings highlight a strong reliance on mechanical cooling and the absence of effective passive design strategies, emphasizing the need for biomimicry-inspired solutions to enhance energy efficiency.

4.3 Comparison of Energy Simulation Between Conventional and the Biomimicry Inspired Building Models

Figures 5 and 6 illustrate the comparison of energy simulation results between the conventional building model and the biomimicry-inspired building model.

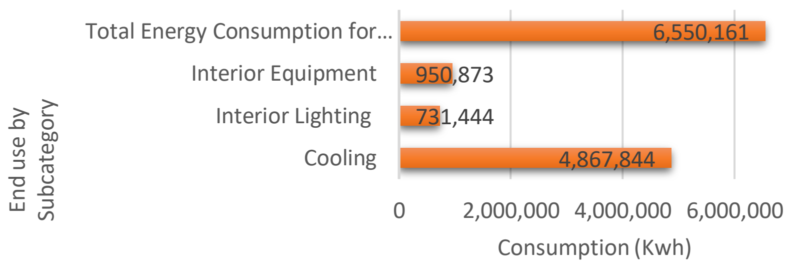

Figure 5 - Total energy consumption (end use by subcategory) of the conventional building

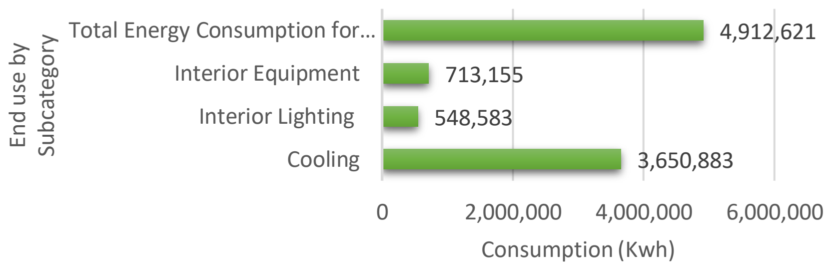

Figure 6 - Total energy consumption (end use by subcategory) of the biomimicry inspired building

A comparative analysis of energy consumption between the conventional and biomimicry-inspired building models, based on the End Uses by Subcategory (Cooling, Interior Lighting, and Interior Equipment) obtained from the simulation results, is presented in the following sections.

4.3.1 Comparison of Cooling Energy Consumption

Figure 7 illustrates the Comparison of Cooling Energy Consumption between the conventional building model and the biomimicry-inspired building model.

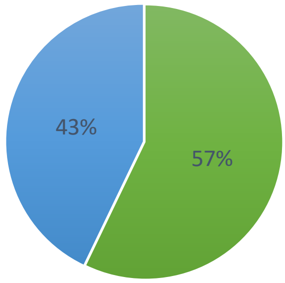

Figure 7 - Cooling energy consumption

The results indicate a significant reduction in cooling energy consumption in the biomimicry-inspired building model compared to the conventional building. The conventional building recorded a cooling energy consumption of 4,867,844 kWh, whereas the biomimicry-inspired model reduced this value to 3,650,883 kWh. This represents a reduction of approximately 1,216,961 kWh, equivalent to about 25% decrease in cooling energy demand.

4.3.2 Comparison of Interior Lighting and Equipment Energy Consumption

In addition to cooling energy, the comparison of interior lighting and interior equipment energy consumption between the conventional and biomimicry-inspired models demonstrates a noticeable reduction. The conventional building recorded 731,444 kWh for interior lighting and 950,873 kWh for interior equipment, whereas the biomimicry-inspired model reduced these values to 548,583 kWh and 713,155 kWh**,** respectively. This reduction can be attributed to the improved building envelope performance in the biomimicry-inspired model, which enhances daylight utilization and reduces dependence on artificial lighting. Furthermore, improved thermal conditions reduce internal heat gains, indirectly lowering equipment-related cooling loads. Figure 8 illustrates the Comparison of Interior Lighting and Equipment Energy Consumption between the conventional building model and the biomimicry-inspired building model.

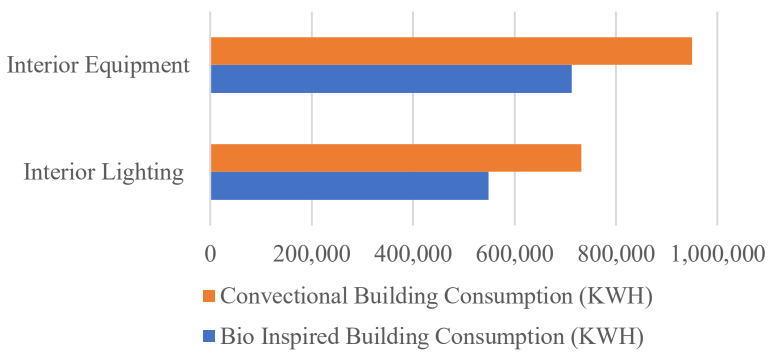

Figure 8 : Comparison of interior lighting and equipment energy consumption

The findings are consistent with previous studies that identified biomimicry-inspired facade systems as effective passive cooling strategies in tropical climates. For example, He et al. (2023) reported significant reductions in cooling energy demand through nature-inspired envelope adaptations. Similarly, Shet (2026) emphasized that biomimetic facade systems improve thermal regulation and reduce dependency on mechanical cooling. Compared with previous studies, the present research specifically contributes to the Sri Lankan context by demonstrating the applicability of biomimicry-inspired envelope strategies for commercial high-rise buildings under Colombo climatic conditions. Unlike many previous conceptual biomimicry studies, this research quantified energy performance improvements through simulation modelling.

5. CONCLUSIONS

This study emphasizes the importance of building envelope design in improving building energy performance compared with conventional approaches that mainly rely on mechanical systems. By maintaining consistent operational and climatic conditions across both models, the findings confirm the potential of biomimicry-inspired strategies in enhancing passive energy efficiency in high-rise buildings.

The simulation results revealed a significant reduction in energy consumption in the biomimicry-inspired model compared to the conventional building. Cooling energy consumption was reduced by approximately 25%, demonstrating the effectiveness of strategies such as external shading, textured facade surfaces, and reflective roof coatings in minimizing solar heat gain and improving passive thermal regulation. These findings are consistent with previous studies highlighting the effectiveness of biomimicry-inspired façade systems in tropical climates. In addition, reductions in lighting and equipment energy consumption indicate the broader impact of improved envelope performance on overall building efficiency.

Furthermore, in industry terms, the research illustrates that the strategies in envelope design inspired by biomimicry can aid architects and developers in creating high-rise buildings in tropical climates that are more energy efficient. From a research perspective, the study contributes to the limited knowledge on biomimicry applications in Sri Lankan high-rise buildings and provides a foundation for future research on adaptive façade systems and biomimetic materials. However, this study is limited to a single case study and simulation-based analysis; therefore, the findings represent a case-specific evaluation and may not be fully generalizable. Future studies should incorporate multiple case studies, field measurements, and broader climatic comparisons to improve generalisability and validation of biomimicry-inspired design strategies. Overall, the study demonstrates that biomimicry-inspired envelope strategies can effectively reduce energy consumption in high-rise buildings under tropical climatic conditions.

6. REFERENCES

Abdou, A., & Reffat, R. (2025). Integrated analysis of building form, orientation and envelope factors on energy efficiency in high-rise offices in hot-humid climates. *Archnet-IJAR: International Journal of Architectural Research*, 1–26. https://doi.org/10.1108/ARCH-02-2025-0092

Adarsh, S., & Thomas, A. V. (2024). A review on the applications of biomimetic principles for sustainable construction. *IOP Conference Series: Earth and Environmental Science*, *1326*, 012154. https://doi.org/10.1088/1755-1315/1326/1/012154

Anarene, B. (2024). Revolutionizing energy efficiency in commercial and institutional buildings: A complete analysis. *International Journal of Scientific Research and Management (IJSRM)*, *12*(09), 7444–7468. https://doi.org/10.18535/ijsrm/v12i09.em12

Araque, K., Palacios, P., Mora, D., & Chen Austin, M. (2021). Biomimicry-based strategies for urban heat island mitigation: A numerical case study under tropical climate. *Biomimetics*, *6*(3), 48. https://doi.org/10.3390/biomimetics6030048

Azima, M., & Seyis, S. (2022). Evaluating the impact of building envelope on energy performance: A cooling analyses. *Journal of Construction Engineering, Management & Innovation*, *5*(1), 28–44. https://doi.org/10.31462/jcemi.2022.01028044

Bijari, M., Aflaki, A., & Esfandiari, M. (2025). Plants inspired biomimetics architecture in modern buildings: A review of form, function and energy. *Biomimetics*, *10*(2), 124. https://doi.org/10.3390/biomimetics10020124

Christopher, S., Vikram, M. P., Bakli, C., Thakur, A. K., Ma, Y., Ma, Z., Xu, H., Cuce, P. M., Cuce, E., & Singh, P. (2023). Renewable energy potential towards attainment of net-zero energy buildings status – A critical review. *Journal of Cleaner Production*, *405*, 136942. https://doi.org/10.1016/j.jclepro.2023.136942

Cuce, E., Nachan, Z., Cuce, P. M., Sher, F., & Neighbour, G. B. (2019). Strategies for ideal indoor environments towards low/zero carbon buildings through a biomimetic approach. *International Journal of Ambient Energy*, *40*(1), 86–95. https://doi.org/10.1080/01430750.2017.1372807

Dash, S. P. (2018). Application of biomimicry in building design. *International Journal of Civil Engineering and Technology (IJCIET),* *9*(2), 644-660. _09_02_062_Cite_this_Article_Shanta_Pragyan_Dash_Application_of_Biomimicry_in_Building_Design/links/61458f8c519a1a381f691641/Article-ID-IJCIET-09-02-062-Cite-this-Article-Shanta-Pragyan-Dash-Application-of-Biomimicry-in-Building-Design.pdf

Dixit, S., Stefańska, A., & Singh, P. (2023). Manufacturing technology in terms of digital fabrication of contemporary biomimetic structures. *International Journal of Construction Management*, *23*(11), 1828–1836. https://doi.org/10.1080/15623599.2021.2015105

Dutta, A., & Samanta, A. (2020). Determining factor/s of window glazing regarding reduction in electrical energy consumption. *Journal of Energy Resources Technology*, *142*(3), 032101. https://doi.org/10.1115/1.4044888

Ge, J., Wang, Y., Zhou, D., Gu, Z., & Meng, X. (2023). Building energy demand of urban blocks in Xi'an, China: Impacts of high-rises and vertical meteorological pattern. *Building and Environment*, *244*, 110749. https://doi.org/10.1016/j.buildenv.2023.110749

Harputlugil, T., & De Wilde, P. (2021). The interaction between humans and buildings for energy efficiency: A critical review. *Energy Research & Social Science*, *71*, 101828. https://doi.org/10.1016/j.erss.2020.101828

He, Q., Tapia, F., & Reith, A. (2023). Quantifying the influence of nature-based solutions on building cooling and heating energy demand: A climate specific review. *Renewable and Sustainable Energy Reviews*, *186*, 113660. https://doi.org/10.1016/j.rser.2023.113660

Irene, N. J. (2025). Biomimicry: Designing sustainable solutions from nature. *IAA Journal of Biological Sciences*, *13*(1), 75–80. https://doi.org/10.59298/IAAJB/2025/1317580

Jayasinghe, P., Raghavan, V., & Yonezawa, G. (2021). Exploration of expansion patterns and prediction of urban growth for Colombo City, Sri Lanka. *Spatial Information Research, 29,* 465-478. https://doi.org/10.1007/s41324-020-00364-4

Amraoui, k., Zemmouri, N., & El Bar, S. (2024). Towards resilient cities: biomimetic strategies for urban adaptation. *International Journal of Innovative Technologies in Social Science*, *4*(44). https://doi.org/10.31435/ijitss.4(44).2024.3082

Chaurasia, M., & Srivastava, S. (2020). Biomimicry and its applications - a review. *International Journal of Engineering Applied Sciences and Technology,* *4*(12), 545-549. https://doi.org/10.33564/IJEAST.2020.v04i12.098

Mostafavi, F., Tahsildoost, M., & Zomorodian, Z. (2021). Energy efficiency and carbon emission in high-rise buildings: A review (2005-2020). *Building and Environment*, *206*, 108329. https://doi.org/10.1016/j.buildenv.2021.108329

Omer, A. M. (2020). Design and operation of low energy consumption passive human comfort solutions. *Journal of Commerce and Management Thought*, *11*(1), 40-62. https://doi.org/10.5958/0976-478X.2020.00004.x

Qahtan, A. M. (2024). Aesthetic and thermal suitability of highly glazed spaces with interior roller blinds in Najran university buildings, Saudi Arabia. *Sustainability*, *16*(5), 2030. https://doi.org/10.3390/su16052030

Rahubadda, A., & Kulatunga, U. (2024). Harnessing nature's blueprint: biomimicry in urban building design for sustainable and resilient cities. In: Sandanayake, Y.G., Waidyasekara, K.G.A.S., Ranadewa, K.A.T.O. and Chandanie, H. (Eds.), *Proceedings of the 12th World Construction Symposium*. (pp. 532-543). Department of Building Economics. https://doi.org/10.31705/WCS.2024.42

Rodriguez, N., Katooziani, A., & Jeelani, I. (2024). Barriers to energy-efficient design and construction practices: A comprehensive analysis. *Journal of Building Engineering*, *82*, 108349. https://doi.org/10.1016/j.jobe.2023.108349

Nair, S. S., & Prem, S. (2020). A framework for mixed-method research. *Shanlax International Journal of Management,* 8(2), 45–53. https://doi.org/10.34293/management.v8i2.3220

Shet, A. (2026). Biomimetic adaptive facades: optimizing energy efficiency through natural analogues. *International Journal for Research in Applied Science and Engineering Technology(IJRASET)*, *14*(2), 835–841. https://doi.org/10.22214/ijraset.2026.77493

Tezel Ersanli, E., & Ersanli, C. C. (2023). Biomimicry: Journey to the future with the power of nature. *International Scientific and Vocational Studies Journal*, *7*(2), 149–160. https://doi.org/10.47897/bilmes.1388402

Varshabi, N., Arslan Selçuk, S., & Mutlu Avinç, G. (2022). Biomimicry for energy-efficient building design: A bibliometric analysis. *Biomimetics*, *7*(1), 21. https://doi.org/10.3390/biomimetics7010021

Vasanthanathan, A., Siddharth, U., Vignesh, M., & Pravin, R. (2020). Biomimicry: An overview of structures, designs and materials inspired from nature. *Current Materials Science*, *13*(1), 3–15. https://doi.org/10.2174/2666145413666200212103324

Verbrugghe, N., Rubinacci, E., & Khan, A. Z. (2023). Biomimicry in architecture: A review of definitions, case studies, and design methods. *Biomimetics*, *8*(1), 107. https://doi.org/10.3390/biomimetics8010107

Waheeb, M. I., Hemeida, F. A., & Mohamed, A. F. (2024). Improving thermal comfort using biomimicry in the urban residential districts in New Aswan city, Egypt. *Environment, Development and Sustainability*, *28*, 9789-9809. https://doi.org/10.1007/s10668-024-05310-0

Weerasinghe, A. S., Ramachandra, T., & Rotimi, J. O. B. (2022). Towards sustainable commercial buildings: An analysis of operation and maintenance (O&M) costs in Sri Lanka. *Smart and Sustainable Built Environment*, *11*(3), 454–468. https://doi.org/10.1108/SASBE-04-2020-0032

Yeter, I. H., Tan, V. S. Q., & Le Ferrand, H. (2023). Conceptualization of biomimicry in engineering context among undergraduate and high school students: An international interdisciplinary exploration. *Biomimetics*, *8*(1), 125. https://doi.org/10.3390/biomimetics8010125