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# Biomimicry in Malaysian Architecture: Crafting A Modular Framework for Sustainable Design

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**Abstract**

This research investigates how Malaysian architecture may use biomimicry concepts to alleviate environmental issues and advance sustainability. Notwithstanding Malaysia's dedication to sustainable development, the country's fast industrialization and urbanization have a substantial ecological influence on the architectural industry. There is a need to adopt biomimicry—a technique modelled after the structures and functions of nature—in this setting since traditional sustainable approaches are insufficient. This study develops a framework for biomimetic design criteria using semi-structured interviews with architects, precedent studies, and literature evaluation. Anticipated outcomes encompass the identification of economical and energy-efficient construction techniques that mitigate environmental effects, augment societal welfare, and foster economic expansion. By expanding the body of knowledge on biomimicry and offering useful recommendations for architects and policymakers, the project seeks to advance the academic community. This will ultimately foster innovation in sustainable architecture, aligning with Malaysia's sustainability goals and potentially serving as a model for other regions.

**Keywords:** Biomimicry, sustainable architecture, Malaysia, design framework, environmental adaptation

## Introduction

Sustainable design has developed over centuries in response to humanity's rising environmental consciousness and the need for responsible resource management. That fact came to be realised as early as the 60s of the previous century, when people first began to be really conscious of environmental problems (Kunszt, 2003). Often referred to as "green architecture," sustainable architecture aims to reduce the adverse effects that buildings have on the environment by using resources like energy, materials, and development space and

ecosystems more wisely and moderately. Sustainable architecture is the philosophy, science, and architectural style of buildings designed and constructed in compliance with ecologically friendly principles. It employs a mindful approach to energy and ecological conservation in the design of the built environment (Harindra Syam et al., 2023). In this context, the emergence of Biomimicry.

Biomimicry is a paradigm shift in sustainable design that takes cues from nature's tried-and-true methods, dealing with direct imitation to find innovative solution to solve problems for humans (Pooja Srinivsan, 2020). Biomimicry goes beyond traditional sustainable practices by mimicking the effectiveness, resilience, and adaptability of nature, as opposed to their primary focus on limiting adverse environmental consequences. Understanding how animals have evolved to flourish in their habitats, analysing their structures, processes, and functions, and utilizing these observations to inspire creative design solutions are key themes in biomimicry. Biomimetic design is guided by ideas like "use waste as a resource," "emulate nature's forms and processes," and "optimize rather than maximize"(Adekunle et al., 2021; Pooja Srinivsan, 2020; Tavsan et al., 2015; Yetkin, 2021). Recent advancements in biomimicry have demonstrated its potential to surpass conventional sustainable approaches. The incorporation of biomimicry idea in architectural design is believed to be more sustainable and energy - efficient for reduction of energy usage and operating cost consumption along with design renewal in the future (Dash, 2018). In order to mimic the healing process in bones, for instance, researchers have created biomimetic materials, such as self-healing concrete, whose qualities are inspired by natural structures (Adekunle et al., 2021). The same passive cooling techniques and natural ventilation systems found in termite mounds and desert plants have also been used to increase building energy efficiency through the use of biomimetic design concepts.

Moving on to the architectural scene in Malaysia, it is important to comprehend the effects of the nation's explosive economic expansion on the built environment. Malaysia, a middle-income nation, has seen a substantial shift in its economy from one centred on agriculture to one centred on industry, which has accelerated urbanization and growth. But this expansion has had negative effects on the environment, degrading the ecosystem and lowering living standards and societal well-being as well as the environment (Mokthsim & Salleh, 2014). Despite these challenges, Malaysia has demonstrated a commitment to sustainable development, aligning with international frameworks such as the Sustainable Development Goals (SDGs). Embracing concepts of sustainability, Malaysia has adopted initiatives like the Local Agenda 21 (LA21) and Millennium Development Goals (MDGs), showcasing its dedication to achieving sustainable development objectives. Malaysia's early participation in presenting Voluntary National Reports (VNR) on SDG progress reflects its proactive stance in addressing environmental and social issues on a global scale, emphasizing the importance of integrating sustainability principles into national development strategies (Idham Bin Mohd Yusof & Ariffin, 2020). Malaysia is positioned to embrace sustainable building practices ahead of other countries due to its potential economic and environmental advantages. Sustainable building is changing the way that buildings are built. The information that is currently available points to the possibility that demand for green buildings will rise in tandem with rising environmental consciousness, a rise in corporate social responsibility among businesses, and an expanding body of research proving that green buildings are financially sensible (Aliagha et al., 2013).

Integrating biomimicry principles into Malaysian architecture holds significant potential to address environmental challenges while fostering innovation and sustainability. By considering factors such as climate, culture, and local architectural traditions, biomimicry can offer tailored solutions that harmonize with Malaysia's unique context. Exploring how biomimicry principles can be adapted and applied in Malaysian architecture will not only enhance environmental performance but also contribute to the country's vision of sustainable development. By incorporating Biomimicry - Life's Principles (BLP) into the Green Building Index (GBI) Malaysia, a higher level of environmental sustainability could be achieved (Ariffin & Gad, 2017).

Although biomimicry has the potential to provide creative and ecologically conscious design solutions, its uptake in Malaysia has been limited due to several challenges which are caused by a number of things, including as cultural beliefs, legal restrictions, technology limitations, and the higher expense of research (Oguntona & Aigbavboa, 2019). Hence, a non-existing module framework. This disparity points to a chance for Malaysia to investigate and use biomimicry concepts more thoroughly in order to tackle urgent environmental issues and get closer to a more sustainable built environment.

The incorporation of biomimicry ideas into architectural practice is a possible route for solving environmental concerns and promoting innovation as Malaysia navigates its way towards sustainable development amid fast economic expansion. The potential advantages of biomimicry in improving environmental performance and encouraging sustainable design cannot be disregarded, despite facing challenges including cultural beliefs, legislative limits, and technology limitations. Malaysia may steer towards a more balanced interaction between the natural and built environments, leading to a more sustainable future, by investigating and integrating biomimicry in the country's architectural landscape.

**Problems Statement**

*Motivational Problems*

According to Minister of Natural Resources, Environment and Climate Change (NRECC), Nik Nazmi Nik Ahmad, sustainability is at the centre of Malaysia's development strategies because it not only ensures the nation's survival but also offers opportunity for growth. This was stated at the JC3 Journey to Zero Conference 2023. The goal of the JC3, which was co-chaired by the Securities Commission Malaysia (SC) and Bank Negara Malaysia (BNM) in 2019, is to strengthen climate resilience in the Malaysian financial industry. Members of JC3 include financial sector leaders and senior officials from Bursa Malaysia. Given its enormous power as guardians of cash and investments, Nik Nazmi emphasized that the financial industry had to take the lead in tackling climate change. In the meanwhile, the government is carrying out its mandate by supporting and enacting policies that are helpful, such the enhanced ecological fiscal transfer to states included in the newly approved Budget 2024. Since Malaysia is rapidly experiencing the effects of climate change, it is imperative that we take steps to both minimize and adapt to these changes (THE EDGE MALAYSIA, 2023).

Nevertheless, in accordance with the national investment goals, the government is dedicated to achieving the six objectives listed in the New Industrial Master Plan 2030 (NIMP 2030). The objectives of the NIMP include raising economic complexity, generating high-value employment possibilities, expanding domestic connections, fostering the growth of both new

and existing clusters, enhancing environmental, social, and governance (ESG) standards, and improving inclusiveness. In addition, the NIMP 2030 lays out 12 outcome-based targets, two of which are the country's pursuit of net zero goals and derisking the economy against environmental, social, and governance (ESG) concerns (Bernama, 2023).

That being said, since nature has developed over 3.8 billion years to live in increasingly hostile surroundings, it offers the best model from which to examine the most practical sustainability solutions. In addition to increasing portfolio resilience, actively collaborating with businesses and initiatives that are pioneering applied biomimicry principles enables the development of productive, sustainable, and environmentally conscious systems. By using biomimicry to reduce our carbon footprint and resource consumption, we may be able to experience nature in the comfort of our own homes in a future where everything is designed to be regenerative, much like nature (Nasdaq, 2023). As the effects of industrialization, urbanization, and unchecked economic expansion become more apparent, we must turn to nature for sustainable answers (GreenBiz, 2023). Contemporary construction methods consume a lot of materials and are harmful; they account for 40% of greenhouse gas emissions worldwide and around 25% of changes to the land system. An area the size of Paris is being developed every week, addressing the need for improvement (vinzero, 2022).

The built environment plays a crucial role in mitigating climate change, as shown by the most recent report from the Intergovernmental Panel on Climate Change, which issued yet another severe warning (ipcc, 2024). From the level of cities to the level of building design to the level of materials and components, nature can teach us how the construction industry might develop a more resilient, sustainable economy (GreenBiz, 2023).

In essence, Malaysia is prioritizing sustainability in its development strategies, recognizing it as crucial for survival and growth. The government encourages the financial industry to take the lead in addressing climate change. In regards, biomimicry principles, inspired by nature, offer sustainable solutions, particularly in construction, vital for mitigating climate change. This approach emphasizes the importance of learning from nature to create a resilient and sustainable economy. However, to implement this in Malaysia, more research and a define criterial framework is needed which will ensure efficient and successful adoption.

**Research Problem**

Commencing with the foundational principles of design, van der Voordt (2009) underscores three essential elements: functionality, build standard, and impact. These facets encompass critical considerations such as usage, access, spatial design, engineering standards, environmental impact, and societal integration.

Chairiyah (2023) emphasizes its primary focus on resolving human issues by shifting to a biomimicry building, which in turn influences human health indirectly. This emphasizes how biomimetic ideas must be included into architectural frameworks in order to successfully address contemporary concerns.

Pedersen Zari & Storey, (2007) distinguishes between the Problem-Based Approach and the Solution-Based Approach as two essential biomimicry techniques. The former involves looking to nature for inspiration when solving particular design problems, whereas the later incorporates biological knowledge to guide more general design choices. These strategies

provide distinctive ways to advance environmentally friendly architecture practices (Zari & Hecht, 2020).

This problem to solution theories is further investigated by Mahmoud (2023) whereby, when architects create any element of a structure that draws inspiration from nature, they should respect the ideas and principles found in nature. The decision to utilize nature as a model, gauge, or observer embodies bio-design. There are two primary methods for using biomimicry in design when considering natural adaptability, and they are as follows: Indirect approaches (biology to design) necessitate having pertinent biological or ecological knowledge and study rather than a design challenge. Direct approaches (design to biology) require designers to identify problems and biologists to match them to creatures that have addressed comparable concerns. This type of process helps us to construct systems we couldn't even imagine, and it leads to the production of variable ways of sustainable bio-design that help to solve many problems in different cases both according to his condition. As scientists explain, the indirect one has the best results in architecture to solve problems, so this study adopts this approach.

Furthermore, Pedersen Zari & Storey (2007), elaborates on the concept of biomimicry and describes three hierarchical layers of mimicry: form (Organism), process (behaviour), and ecology. These levels provide architects with a well-organized framework to utilize biomimetic techniques, directing their choice of natural characteristics to mimic in architectural solutions. At the organism level, a designer examines the structure and functionality of a particular organism, with the option to imitate a single component or the entire organism. In order to create a structure that blends in seamlessly with its surroundings, organisms at the behaviour level imitate how they interact with their immediate surroundings. The third level is imitating how an organism interacts with its surroundings and how various parts function together; this is typically done on an urban size or in a larger project that has several components as opposed to a single building (Nkandu & Alibaba, 2018). Moreover, Dash (2018) highlights the need for biomimicry applications to be contextualized in order to enable their practical use in design difficulties. This emphasizes how important it is to do thorough investigation and study in order to understand the functional dynamics of natural materials or creatures and how to use them wisely in architectural contexts.

Pooja Srinivsan (2020), highlights how biomimetic concepts might be applied to increase the flexibility of building facades in a transformational way. This strategy promotes cost-effectiveness and innovation in building and design techniques in addition to resource efficiency and environmental sustainability. Finally, Ali Hussein Mohamed et al (2022) elaborates on the characteristics and aspects of biomimicry, including techniques that are problem- and solution-based, innovative principles, and degrees of biomimicry that are hierarchical. These observations provide light on the complex relationship between biomimicry and sustainable building design.

However, there is a notable gap. A modular framework for Biomimicry Design Criteria has yet to establish to cater the adoption of this principle in Malaysia. The lack of research on biomimicry Malaysia restricts our knowledge of its possible uses and effectiveness in the built environment of Malaysia, emphasizing the urgent need for research projects to close this

knowledge gap and open the door to the incorporation of biomimicry principles into Malaysian architectural practice.

Therefore, the research aims to explore two key questions. The first question focuses on how biomimicry principles can be effectively applied in architectural design to enhance both sustainability and functionality. The second question seeks to determine which design criteria specific to biomimicry should be considered for architectural projects in Malaysia, particularly in terms of their potential impact on sustainable building design.

To address these questions, the research objectives are as follows: The first objective is to analyze existing literature to explore the integration of biomimicry principles in architectural design, with a focus on their implications for enhancing sustainability and functionality. The second objective is to identify and evaluate the design criteria derived from biomimicry principles that can be applied to architectural projects in Malaysia, emphasizing their potential to improve sustainable building design outcomes.

**Literature Review**

The literature on biomimicry in architecture emphasizes various approaches that integrate nature-inspired designs into sustainable building practices, showcasing the potential of biomimicry to transform urban and architectural design. First, Ferwati (2019) introduces the concept of biomimicry in urban metamorphosis, underscoring its potential to address the environmental challenges posed by modern urbanization. Historically, humans have sought independence from nature, yet the increasing ecological degradation resulting from industrialization necessitates a reconnection with natural processes. Ferwati's study argues that by prioritizing sustainability, urban development can shift toward more eco-conscious designs, incorporating biomimicry to foster low-carbon cities, advanced infrastructure, and adaptive urban forms. This foundational perspective provides a critical understanding of how biomimicry can reshape urban planning in the context of sustainable development.

Building on this, Nkandu (2018) explores the potential of biomimicry as a solution to sustainability challenges in architecture. While Ferwati emphasizes urban transformation, Nkandu focuses specifically on building design, where natural systems and processes are imitated to optimize resource efficiency. This research highlights a gap in sustainable design approaches, as conventional methods often fail to minimize resource wastage. By analyzing case studies, Nkandu demonstrates how biomimetic design not only reduces the environmental footprint of buildings but also promotes a regenerative built environment. This complements Ferwati's findings by expanding the application of biomimicry from urban planning to individual building structures, emphasizing the need for holistic integration of natural systems at both micro and macro scales.

In addition to addressing environmental concerns, biomimicry also plays a crucial role in enhancing human health within built environments. Chairiyah (2023), shifts the focus toward the health benefits of biomimicry, stressing the importance of creating healthy and sustainable buildings. While both Ferwati and Nkandu highlight sustainability, Chairiyah introduces a new dimension by exploring how biomimicry can directly improve physiological and psychological well-being. By using nature as a guide, architects can design buildings that not only reduce environmental harm but also foster healthier living spaces for occupants. This

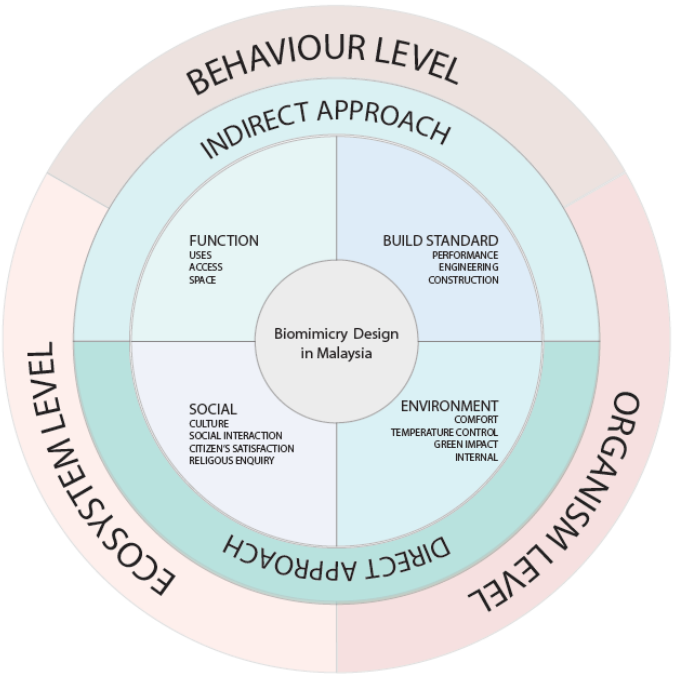
perspective adds depth to the discussion, illustrating how biomimicry can serve multiple purposes—improving both ecological and human health outcomes.

Similarly, Elmeligy (2016) further advances the discourse by emphasizing biomimicry's role in ecological sustainability. Elmeligy's study highlights the historical roots of biomimicry in design, tracing it back to Leonardo da Vinci's early imitations of nature. Like Nkandu, Elmeligy argues that architects can learn from natural processes to create more sustainable designs. However, Elmeligy takes this further by suggesting that biomimicry not only enhances resource efficiency but also fosters a deeper connection between humans, buildings, and the natural world. This connection aligns with Chairiyah's argument that biomimicry contributes to healthier environments, thus reinforcing the broader ecological and human benefits of adopting biomimetic principles.

Moreover, Mahmoud (2023) expands on these ideas by exploring how biomimicry can enhance the functional performance of buildings. While previous studies have focused on sustainability and health, Mahmoud delves into the technical aspects of biomimicry, examining how mimicking nature's behaviors can lead to more adaptive and efficient building designs. Mahmoud's study reveals that by integrating bio-inspired solutions, buildings can better respond to environmental forces, improving their performance and resilience. This complements Elmeligy's findings by adding a practical layer of application, showing how biomimicry can improve the operational efficiency of buildings while maintaining ecological integrity.

In conclusion, the literature collectively supports the idea that biomimicry offers a multifaceted approach to sustainable architecture, addressing environmental, health, and functional challenges. Ferwati's focus on urban transformation, Nkandu's emphasis on resource efficiency in building design, Chairiyah's exploration of health benefits, Elmeligy's historical and ecological perspective, and Mahmoud's technical focus all contribute to a comprehensive understanding of how biomimicry can revolutionize architecture. Together, these studies demonstrate the wide-ranging potential of biomimicry to create a sustainable future that harmonizes human needs with the natural world.

**Conceptual Framework**




The framework further distinguishes between two approaches to biomimicry design: Solution-Based and Problem-Based. Each approach leads to different design outcomes based on specific criteria and strategies. By establishing these approaches, the framework enables a structured discussion on the principles and applications to be applied in building design.
In the context of Malaysia, it's crucial to tailor the design criteria to the local environment and social context. The text highlights potential barriers to biomimicry design within the Malaysian context, such as environmental and social factors. Therefore, the derived conceptual framework aims to ensure that the criteria for designing biomimicry in Malaysia are efficient and successful.

Creating a specified criteria framework for biomimicry in Malaysia is crucial for several reasons. First, it takes into account Malaysia's unique environmental and social conditions, ensuring that biomimicry solutions are relevant and effective within the local context. Second, the framework helps address specific challenges, such as environmental degradation or social inequalities, by guiding the development of solutions that directly tackle these issues. Third, a tailored framework optimizes resource utilization by focusing on biomimicry solutions that align with Malaysia's needs and priorities, leading to more efficient and cost-effective designs. Finally, by providing clear criteria and guidelines, the framework enhances the effectiveness of biomimicry implementation in Malaysia, ensuring that projects meet desired outcomes and contribute positively to sustainability goals. Overall, such a framework acknowledges the importance of context-specific considerations and maximizes the potential benefits of biomimicry in addressing local challenges and promoting sustainable development.

## Conclusion

Enhancing sustainability and tackling environmental issues may be accomplished via the use of biomimicry into Malaysian architecture. Building designs based on biomimicry are creative, robust, and efficient; they complement the particular environmental and socioeconomic conditions of Malaysia. This strategy directly advances Malaysia's commitment to the Sustainable Development Goals (SDGs), especially those pertaining to responsible consumerism, climate action, and sustainable cities.

In order to achieve environmental sustainability, biomimicry improves energy efficiency, lowers carbon footprints, and fosters biodiversity by imitating natural tactics. Furthermore, biomimetic designs maximize resource utilization, which is consistent with Malaysia's objective of producing and consuming responsibly. Sustainable construction approaches may be made successful and context-specific by utilizing a customized biomimicry framework, which can overcome obstacles including cultural beliefs, legal limits, and technology limitations. In general, Malaysia has a great chance to promote a sustainable and balanced future by integrating built environments with natural ecosystems and achieving the country's sustainability objectives through the use of biomimicry concepts.

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