Biomimicry as a Valuable Design Tool for Climate Change Adaptation

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Abstract - As built environment professionals face more pressing and difficult issues related to climate change mitigation and adaptation, it can be useful to look at examples of how other living organisms or ecosystems have solved the same problems. This paper examines global climate change impacts on society and ecosystems, primarily caused by human activities and built environments. It explores how buildings can mitigate climate change drivers while adapting to ongoing challenges. Through interdisciplinary perspectives and case studies, it presents strategies for climate-resilient building design. Looking at plants or animals that are highly adaptable or survive extreme climates or climate change can provide insight into how buildings could or should work. Exploring the properties of ecosystems that enable their adaptability and resilience can also offer potential opportunities. Therefore, this chapter explores whether bio mimicry, where organisms or ecosystems are imitated in human design, can be an effective means of mitigating the causes of climate change for which the built environment is responsible, or adapting to the effects on climate change. Different bio mimicry designs are discussed and categorized, a case study and examples illustrate the advantages and disadvantages of each approach. In light of the findings of the study, it is argued that an ecosystem-mimicking model that exploits synergies between climate change mitigation and adaptation strategies can be useful for the long-term biomimetic response of the built environment to climate to change there are also presented theoretical justifications that support it.

***Key Words*:** Biomimicry, Climate Change, Adaptation.

1. INTRODUCTION

In a world facing more and more climate challenges, it's crucial that we find new and sustainable solutions. One exciting idea is bio mimicry – it's like learning from nature to design things that can adapt to climate change. Bio mimicry, which comes from "bio" (life) and "mimicry" (copying), takes inspiration from how nature has solved problems over a really long time. Plants and animals have adapted to all sorts of environments, and bio mimicry is about studying and copying these natural solutions to make human-made things work better. This research paper wants to figure out how bio mimicry could be a useful tool for creating designs that can handle and adjust to the challenges of a changing climate. By using nature's proven strategies, bio mimicry gives us a new way to think about dealing with climate change. It not only promises to help us do things in a more eco-friendly way but also lets us rethink how we interact with the environment. This paper will look at examples where bio mimicry has already helped make designs that can handle climate changes, look at the problems that come with this approach, and talk about what it could mean for making a more sustainable world. Through this study, we want to add to the conversation about how bio mimicry can help us deal with climate change, pointing out where it can make a difference, understanding its limits, and thinking about how it can change the way we create a future that can withstand environmental challenges.

2. BIO MIMICRY'S ROLE IN ADDRESSING CLIMATE CHANGE

The term "bio mimicry" originates from the Greek words bios (life) and mimesis (imitate), representing a novel discipline that studies nature's finest ideas and then replicates these designs and processes to solve human problems. It involves observing nature in action and leveraging that knowledge to spark new ideas, rather than blindly imitating. Bio mimicry serves as a source of inspiration for transforming the principles of nature into effective design solutions. Bio mimicry can be applied to buildings to achieve several goals:

- Enhance materials strength, self-assembly, and self-healing capabilities.
- Utilize natural processes and forces for fundamental building functions.
- Enable buildings to generate resources by integrating natural systems.

Recognizing climate change as a clear and present danger, it becomes imperative to adapt our infrastructure and operational methods. The need for urgent re-evaluation and swift implementation of policies to reduce greenhouse gas emissions is evident, as climate change continues to intensify, impacting the built environment significantly (IPCC 2007a). This sector alone contributes roughly one-third of global anthropogenic greenhouse gas emissions, exacerbating climate change effects. One promising avenue is bio mimicry, which draws inspiration from nature's designs and processes to develop innovative solutions. This paper delves into the benefits of using bio mimicry as a design approach to effectively address the challenges posed by climate change

3. UNDERSTANDING BIOMIMICRY

3.1 Form – Organism Level:

Emulating Natural Shapes and Structures this level involves replicating the physical forms or shapes found in nature. For example, Grinshaw's design for The Waterloo International Terminal drew inspiration from the flexible structure of animals like the pangolin, allowing the building to adapt to variable pressures and forces caused by train arrivals and departures. The scaled exterior facade mimicked the adaptability seen in natural organisms.

Fig.1: Nicholas Grimshaw & Partners Waterloo International Terminal and the pangolin.

3.2. Process-Behavioral Level:

Emulating Natural Behaviors and Functions At this level, bio mimicry involves imitating the behaviors and functions observed in organisms. The CH2 Building in Melbourne, Australia, serves as an architectural example of process-level bio mimicry. Inspired by termite mounds passive ventilation and temperature regulation techniques, the building maintains a thermally stable interior environment. Additionally, water sourced and treated from the building's sewers mimics how certain termite species utilize aquifer water for evaporative cooling.

Fig.2: CH2 building by Mick pierce imitates the ventilation system of a termite mound.

3.3. Ecosystem-Level:

Emulating Natural Materials and Systems Performance .Designing at the ecosystem level involves mimicking materials performance and natural ecosystems functionality. This approach can complement other levels of bio mimicry (form and process) and integrate established sustainable building methods like interfaced or bio-assisted systems. By merging human and non-human systems, ecosystem-level bio mimicry creates mutual benefits for both, promoting sustainability and efficiency.

4. UNDERSTANDING ARCHITECTURE APPROACH IN BIOMIMCRY TOWEARD DESIGN PROBLEM

4.1 STRUCTURE

Digital techniques have advanced dramatically in recent years, offering an exciting opportunity to represent, analyses, create, fabricate, and simulate architectural forms inspired by nature. Whether it's the shells comprising the Sidney Opera House and the regular grids and ornament found in Gothic cathedrals. Structural inspiration from natural forms from rocks to shells to sponge and sea urchins - represent some of the most elegant and sophisticated forms, demonstrating complicated design and engineering principles.

- Beijing Olympic Stadium as Bio mimicry of a Bird's Nest: Evolved concept from series of triangulations devoid of external motifs used to evolve stiffness and aesthetics in structure.
- Crystal Palace London: Evolved concept from Amazonia water lilies the radial ribs stiffened by slender cross ribs provides strength good enough for a person to stand on it.

4.2. MATERIALS AND TECHNOLOGIES

In the natural world biological materials play an important role in achieving structural and functional integrity. In the last few decades, a great number of natural materials have been investigated by scientists and engineers such as lotus leaves, rice leaves, butterfly wings, water strider legs, insect compound eyes, fish scales, red rose petals, brittle stars, spider silks, nacre, glass sponges, gecko feet, mussels, and others in the belief to achieve most efficient multifunctional structures, i.e., functional integration. The optimized biological solution should give us inspiration and design principles for the construction of multifunctional artificial materials with multi-scale structures.

- 30 St. Mary Axe, London: Inspiring strategy is Venus flower basket which is skeleton of sponge provide strength with lightweight materials via its siliceous composition.
- Calera Corporation: Inspired from coral reefs which absorbs Co2 in under water from the atmosphere to produce strong reefs.

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- Whale turbines Technologies: Inspired from Whale flippers used as producing under water turbines to work effectively in low currents.

4.3. BUILDING SYSTEMS

Modern architects are developing a whole host of biomimetic technologies for all areas of building construction including insulation, windows, electric lighting, controls and mechanical systems. These technologies are also being designed to be integrated with one other for greater efficiency and comfort. Models are low emerging that showcase the use of bio-mimetic technologies and the integration that make them so successful.

- Eastgate Centre Building: learning from termites to cool and heat naturally Harare, Zimbabwe

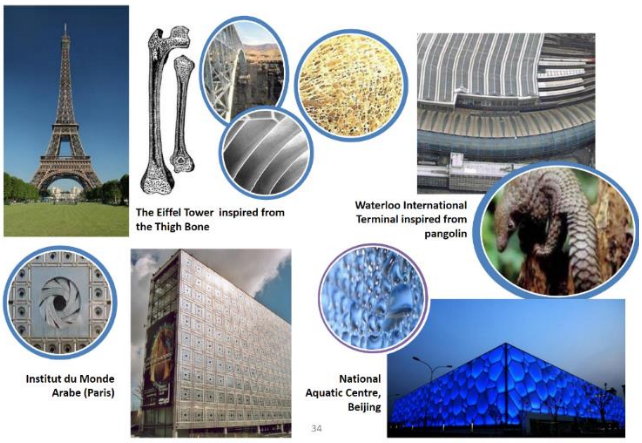

Fig.3: Some examples of building inspired from nature

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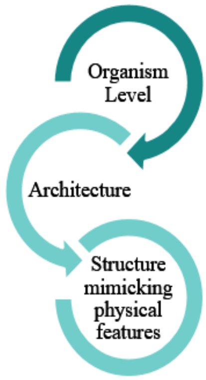
5. CASE STUDY

5.1 Waterloo Internal Terminal (Nicholas Grim Shaw & Partners)

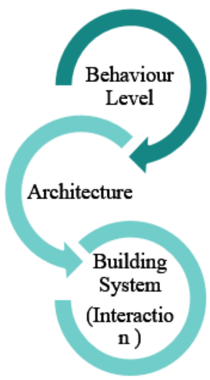


The Beijing National Stadium, designed by Herzog & de Meuron, exemplifies the fusion of natural aesthetics and structural efficiency. Its bird's nest design, governed by advanced geometrical rules, maximizes spectator experience with clear sight lines. Innovative features like inflatable ETFE cushions ensure thermal comfort and sustainability.

Inspiration	Pangolin	
Material Used	Steel & Glass	
Design Perspective	The glass panel fixing that makes up the structure mimic the flexible scale arrangement of pangolin	
Problem Solved	Ability to move in response to the imposed air pressure forces when train enter and Depart.	

Table 1: linking organism level & structure

1. 5.2.The Esategate Center,Harare (Mick Pearce & Arup Associates)
2.



The Eastgate Centre in Harare utilizes biomimetic technologies inspired by termite mounds to achieve natural ventilation and cooling. Heat is stored during the day and vented through chimneys at night, drawing in cool air. The design mimics termite mound convection currents, resulting in a building that uses less than 10% of the energy of conventional ones.

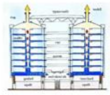
Inspiration	Termite Mound	
Material Used	Concrete	
Design Perspective	The building is designed with a unique ventilation draws outside air and cools or warms it depending on temperature	
Problem Solved	Temperature remains regulated all year around without HVAC system.	

Table 2: Linking Behavioral level & structure

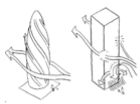
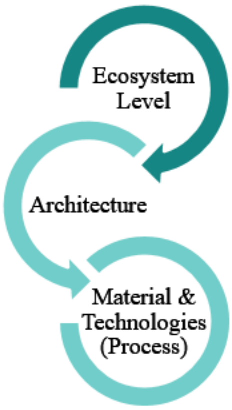
Inspiration	Venus flower Basket	
Material Used	Steel & Glass cladding	
Design Perspective	The building curves allows for a smooth flow of wind around the building. Its radial plan, its energy conscious enclosure resolves walls and roof into a continuous triangulated skin, allowing column-free floor space, light and views.	
Problem Solved	Its egg shape of the building helps the sustainable approach to design. It reduce the amount of volatile winds at pedestrian level and smoothens air flows through the area so there is less heat loss over the surface of the building. This low-pressure system also allows the designers to have large light wells at heights that would be otherwise unfeasible.	

Table 3: Linking Ecosystem level & structure

5.3. 30 St Mary Axe The Gherkin (Norman Foster & Associate)



30 St Mary Axe, London's first ecological tall building, features a unique egg-shaped design that minimizes volatile winds at ground level and optimizes airflow to reduce heat loss. Inspired by the Venus flower basket's lightweight yet strong structure, the building employs a radial plan and a continuous triangulated skin, offering column-free floor space and abundant natural light.

6. BENEFITS OF BIO MIMICRY

- Through the analysis and evaluation of the selected case studies, it can be concluded that the suggested theoretical md methodological framework enable the designer to:
- Develop an architecture that is produced as a result of the existing environmental, materialization and special requirement and therefore specifically tailored to its location and conditions.
- Innovate sustainable architecture for enhanced environmental impact and resilience.
- Design biomimetic as a bridge that can connect architectural and design professions on a route to linking design and environmental issues in a sustainable solutions.
- Design biomimetic can emphasize ways of thinking and designing that bring architecture and industrial design into a process of environmental and biological focus and more responsive, safer building.
- Biomimetic technology offers solutions to environmental challenges like greenhouse gases, global warming, and ozone depletion. Its potential lies in reducing CO2 emissions and enhancing environmental purification, essential for 21st-century progress.

7. CONCLUSIONS

Traditional bio mimicry often focuses on mimicking single organisms to create innovative products or materials. While this approach has led to some sustainability advancements, it may not fully consider systemic implications within the built environment.

However, as we confront climate change and biodiversity loss, bio mimicry tools could play a crucial role in long-term solutions. Rather than just creating technological add-ons, bio mimicry tools can drive systemic change in how we design, construct, and interact with buildings and urban spaces. This involves re-evaluating the relationship between people, their built environment, and the ecosystems they inhabit.

In the short to medium term, existing technologies will remain essential, particularly those that improve energy efficiency and reduce carbon emissions. But these tools should be seen as intermediate steps toward more comprehensive solutions. Biomimetic technologies can aid in replacing fossil fuels, developing climate-resilient building techniques, and enhancing overall sustainability.

In summarizing the concepts outlined in thus study. Nature and architecture share parallels in form, sustainability, efficiency, adaptation, symbolism, and evolutionary processes. Some of which have been studied for centuries and others which only now becoming relevant as we seek to remedy the strained relationship between the built and the natural environment. Whilst conventional approaches to Sustainability focus upon reducing energy and resource consumption bio mimicry provides a tonus whereby engagement with natural systems helps produce a more positive and regenerative design Bio mimicry. Rather than being employed as scientific method of emulating nature ma built form however the technique should be applied in a more holistic sense where designers acknowledge the complex interactions which take place within the annual world and, more importantly understand our position within it.

In conclusion, embracing bio mimicry tools in the built environment can lead to regenerative practices that maintain biodiversity, enhance resilience, and create sustainable living spaces that actively contribute to ecosystem health and human well-being.

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