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BIOMIMETIC ARCHITECTURE: AN INNOVATIVE APPROACH TO ATTAIN SUSTAINABILITY IN A BUILT ENVIRONMENT

Zeeshan Haider Khan[1*], Mohammad Salman[2], Alemea Girma[3]

[1]*Department of Architecture, Srinivas Institute of Technology, Mangalore, India*

[2]*Faculty of Architecture, Planning & Design, Integral University, Lucknow, India*

[3]*Faculty of Architecture & Urban Planning, AMiT, Arba Minch University, Ethiopia*

*Corresponding Author Email: *ar.zeeshanhaider@gmail@.com*

Abstract

Architecture has always inserted itself into and interacted with the natural environment. Biomimetics is an applied science that infers motivation for answering human issues through the investigation of common plans from nature. Biomimetics has been used in design for many years. It is the fastest-growing research in the area of architecture. This is because of the innovative and problem-solving approach to achieving sustainability in design. However, the application of biomimetic design to achieve sustainability requires a proper understanding of the relationship between biology and environmental science. The review of achievements using biomimetic architecture could make understanding the relationship between biomimetic ecosystems and the built environment easier and therefore contribute to environmental sustainability. This paper elaborates on the different approaches to attaining sustainability through different literature studies and case-based analytical studies. Finally, the paper summarizes and concludes that these varied approaches have different outcomes in terms of sustainability.

Keywords: ***Sustainable Architecture, Biomimetic Architecture, Built Environment, Ecosystem*.**

I. Introduction

Biomimetics is an applied science that acquires inspiration for the solution of built environment problems through the study of Flora and Fauna or the whole ecosystem. This is because of both the way that it is a helpful wellspring of conceivable new advancement and on account of the potential it offers to make an increasingly maintainable assembled condition [1]. Biomimetics or the entire ecosystem are copied as a design base. It is the fastest-developing exploration in the field of architecture. The functional information of biomimetics as a design approach is very cagey.

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However, the use of these biomimetic approaches in a built environment requires a legitimate comprehension of the elements of an ecological system [2]. To acquire this biomimetic knowledge, one needs a fine understanding of the relation between science and ecological science. The review of achievement by the use of biomimetic design could make it easier to understand the relationship between the biomimetic ecosystem and the built environment and therefore contribute to environmental sustainability in building [2]. This paper elaborates on different approaches to different levels of biomimetic design to achieve sustainability. These varied approaches have various results regarding sustainability in general.

II. Research Methodology

The employed research methodology consists of a literature review and numerous case study analyses. The literature review involves an extensive examination of existing research articles, books, journals, and conference papers related to biomimetic architecture and sustainability. The focus is on understanding the relationship between biology, environmental science, and sustainable design. This exhaustive review serves as the theoretical foundation for the study. Multiple case studies are selected to analyze the practical implementation of biomimetic design in achieving sustainability. These case studies encompass a range of building types, allowing for a comprehensive evaluation of biomimetic architecture in different contexts. Data is collected from various sources, including architectural drawings, project reports, photographs, and interviews with architects and designers. The results of the literature review and case study analysis are presented and discussed, highlighting the outcomes achieved through different biomimetic design strategies. These strategies are categorized into organism-level, behavior-level, and ecosystem-level approaches. Finally, the implications and significance of the findings are discussed along with potential applications in future architectural projects.

III. Approaches to Biomimetics Design

A. Top Down Approach

As depicted in Fig.1, Top-down Methodology highlights how fashioners seek nature and life forms for arrangements where architects must perceive precisely their structural issues and coordinate

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their issues with life forms that have tackled comparative issues. This methodology is because of the architect's information on the ecological life and triggers of their structure[3].

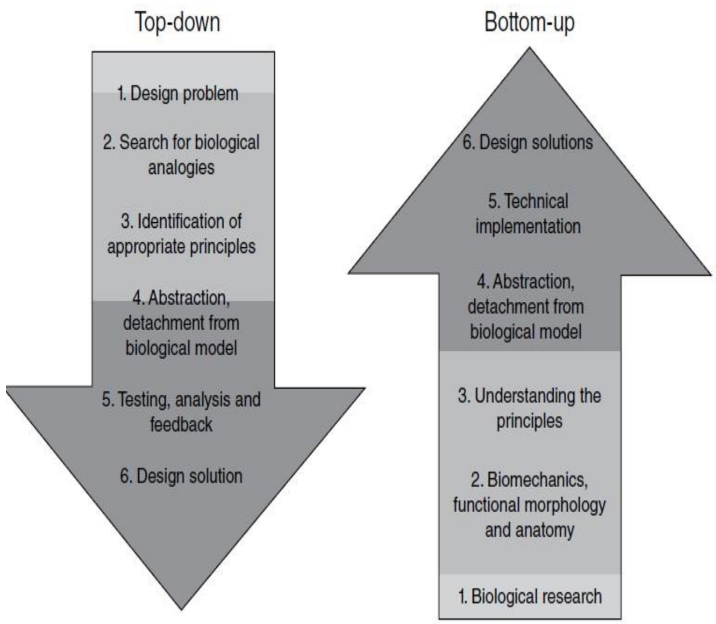

Fig. 1. Biomimetic Approach

B. Bottom Down Approach

As depicted in Fig. 1, the bottom-up approach alludes to a similar significance, where this methodology relies upon the past information on organic examination and arrangements not to look for arrangements in nature, and at that point applying this information on the plan issue[3].

IV. Levels of Biomimetic Designs

There are three levels of biomimetic Architecture i.e., 1) Organism level, 2) Behavior level, and 3). Ecosystem level. Inside every one of these levels, a further five potential measurements to mimicry exist. The structure might be biomimetic for instance regarding what it resembles (structure), what it is made of (material), how it is made (development), how it works (process), or what it can do (work).

The contrasts between every biomimicry are depicted in Table I and are exemplified by taking a gander at how various parts of levels, or parts of biological systems could be impersonated[3].

A. *Organism Level*

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This building mimics the Namibia desert bug and steno Cara. The scarab dwells in the desert with irrelevant precipitation. It can catch dampness anyway from the quick-moving haze that moves over the desert by inclining its body into the breeze. Beads structure on the substituting hydrophilic-hydrophobic harsh surface of the creepy crawl's back and wings and fold down into its mouth [4]. Motivated by the creepy crawly, a mist catcher structure was proposed for the Hydrological Place at the College of Namibia. The surface of the beetle has been examined and emulated to be utilized for other potential applications such as to clear fog from airport runways equipment[5].

Table I: Organism Level

Levels	***Dimension***	***Remarks***
	Structure	The structure appears like a Namibia Desert Scarab
	Material	The Structures are produced using a similar material as a termite, a material that emulates Bug exoskeleton/skin (Mimicry of a Particular life form)
	Construction	The Structure is made similarly to a Desert Creepy crawly it experiences different development cycles.
	Process	The structure Works similarly to an individual Beetle.
	Function	It can Catch Dampness from the Quick-moving haze.

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Fig. 2. Hydrological Centre for the University of Namibia

Fig.3. Calla lily flower

B. Behavior Level

This is depicted in Table II. Another Calla lily-formed (Fig. 3) exploration place for Wuhan College is set to sprout in China as one of the most manageable structures in the world. Situated in Wuhan, The Wuhan New Vitality Community (likewise called the Energy Flower) was intended

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to take after a lily (Fig. 2), with a 140-meter tower on the inside encompassed by lower towers looking like blossoms and shrouded in vegetation. The inside pinnacle extends upwards into a bowl and is covered in an enormous sunlight-based exhibit confronting the sun, absorbing beams simply like a genuine plant. A vertical pivot wind turbine shoots up out of the focal point of the pinnacle like a pistil (Fig. 4). Water is gathered in the bowl and a 120-meter sun-based stack in the pinnacle ousts blistering air from the structure while pulling in cooler air beneath [6]. To limit the requirement for cooling (Fig. 5), the architect Grontmij saw building structures that could amplify the concealing of the southern façade. The Wuhan vitality blossom profits from the enormous overhanging rooftop for another explanation as it expands the zone on which to introduce photovoltaic boards, which the establishment is utilizing to communicate its sustainability[7].

Table II: Behavior Level

Levels	***Dimension***	***Remarks***
	Structure	The structure appears as though it is made looking like a calla lily
	Material	The structure is produced using the same material idea as utilized by Calla Lily.
	Construction	The structure is made similarly to calla Lily Blossom Work.
	Process	The inside pinnacle extends upwards into a bowl and is covered in a huge sun-powered exhibit confronting the sun, absorbing beams simply like a genuine plant. A vertical pivot wind turbine shoots up out of the focal point of the pinnacle like a pistil.
	Function	The functional processes silently at work are inspired by the way calla lily flowers keep themselves cool in hot & humid climates.

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Fig. 4. Wuhan New Energy Center

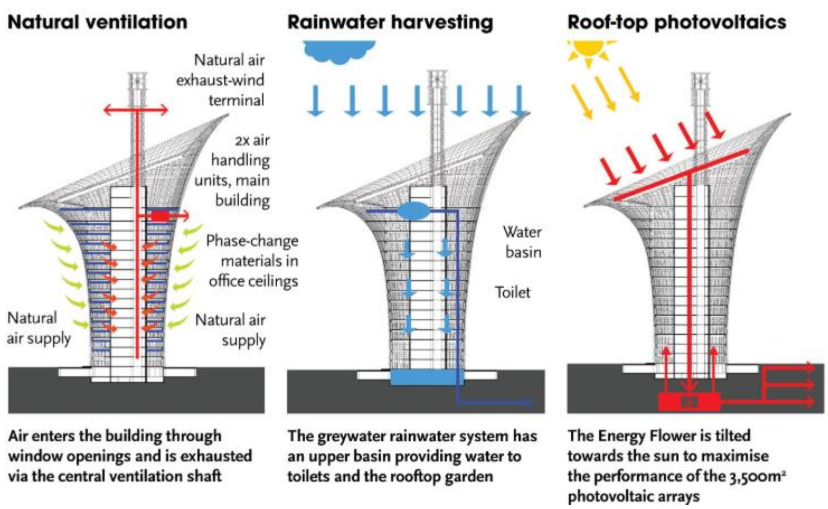

Fig.5. Section Showing Passive Cooling in the Building

C. Ecosystem

The ecosystem level is depicted in Table III. The Sahara Forest Project (Fig. 6) is a facility situated in the core of Qatar's desert intended to use saltwater and CO2 contributions to deliver food, water, and vitality. There is a progression of desalination frameworks, water recovery equipment, and

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sun panels. The Sahara Forest Project is located on 107,639 sq. ft. The organization guarantees a facility that size can deliver 34,000 tons of vegetables, utilize more than 800 individuals, send out 155 GWh of power, and conceal 8,250 tons of CO2. One of the Goals of the Sahara Forest Project is also to demonstrate the potential for cultivating desert land and making it green. Open-air vertical evaporators will create shielded and sticky conditions for the development of plants [8].

Table III: ECOSYSTEM LEVEL

Levels	***Dimension***	***Remarks***
	Structure	The Building resembles an Ecosystem.
	Material	The structure is produced using a similar sort of materials that the biological system is made of. It utilizes normally happening regular mixes and water as the essential concoction mode for instance
	Construction	The building is gathered similarly as a biological system.
	Process	The structure works similarly to a biological system. It catches and changes over vitality from the sun and stores water for instance.
	Function	The building can work similarly to an environment and shape some portion of a mind-boggling framework by using the connections between forms. it can take part in the hydrological carbon nitrogen cycles and so forth like a biological system.

Fig. 6. Sahara Forest Project

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Open-air vertical evaporators will create shielded and humid conditions for the development of plants. The Project will contain outside hydroponic raceways for the development of halophytes – plants lenient toward water system with salty water.”[8]

Fig. 7. Sahara Forest Project’s Algae Test Facility (the first of its kind in Qatar and the larger region).

V. Conclusion

In conclusion, this research paper explored the application of biomimetic architecture as an innovative approach to attaining sustainability in the built environment. Through a comprehensive literature review and analysis of the case studies, the study has highlighted the potential of biomimetic design principles in addressing sustainability challenges. The findings of the study demonstrate that biomimetic architecture offers promising solutions for achieving sustainability. By drawing inspiration from nature and emulating its design principles, architects and designers can create buildings that are not only aesthetically pleasing but also environmentally friendly and resource-efficient. The three levels of biomimetic design (organism, behavior, and ecosystem) provide a framework for incorporating natural strategies into architectural projects. The case-based analytical studies analyzed in this research paper have showcased various successful applications of biomimetic architecture. These projects have demonstrated improved energy efficiency, reduced carbon emissions, enhanced natural ventilation and lighting, and better integration with the surrounding ecosystem. The outcomes of these research projects serve as evidence of the positive impact that biomimetic design can have on sustainability in the built environment.

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VI. Recommendations

Based on the findings of this research, the following recommendations are proposed for further exploration and advancement of biomimetic architecture in achieving sustainability:

I. *Continued Research:* Further research is needed to deepen our understanding of the relationship between biology, environmental science, and architectural design. This will help uncover more biomimetic design principles and strategies that can be applied to enhance sustainability in the built environment.

II. *Collaboration and Interdisciplinary Approaches:* Encouraging collaboration between architects, biologists, engineers, and other relevant disciplines can foster innovative solutions. Interdisciplinary research and design teams can work together to develop biomimetic approaches that address complex sustainability challenges effectively.

III. *Knowledge Exchange and Education:* Promoting knowledge exchange and educational initiatives among architects, designers, and students can raise awareness and understanding of biomimetic design principles and their potential for sustainability. Integration of biomimicry into architectural curricula can nurture a new generation of architects equipped with the skills and knowledge to create sustainable built environments.

IV. *Policy and Regulation:* Governments and regulatory bodies can play a crucial role in promoting biomimetic architecture by incentivizing sustainable design practices and incorporating biomimetic principles into building codes and regulations. This can create a supportive environment for the adoption of biomimetic approaches in architectural projects.

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