

## Assessment of Biomimcry Design Concept Adoption in Architecture: Towards a Sustainable Built Environment in Nigeria.

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**Abstract:** This study assessed the adoption of Biomimcry design concept as a sustainable design tool in Architecture in Nigeria, because of its potential to create sustainable and even regenerative built environment. Built environment is increasingly said to be responsible for global environmental and social problems with vast proportion of waste, materials, energy use and green house gases emission, thus the need for energy conscious, eco-friendly and energy efficient designs to minimize the negative effect of buildings on the environment. In this context, Biomimcry has become a globally accepted environmentally friendly concept of design in different field including Architecture. Review of relevant literature, oral interview, and structured questionnaires were employed to obtain necessary data. The study revealed that, the overall percentage rating of awareness and knowledge of Biomimcry is high at 90%, but its practical application in architectural design is very low at 15%. It is recommended that there is a need for sensitization among the stakeholders in built environment in Nigeria, Architects need to create a bio-inspired design adaptation that emulates nature's best ideas, so that all futuristic buildings will be sustainable, and negative impacts of built environment will be minimised.

**Keywords:** Architecture, Biomimcry, Built environment, energy efficient designs, Sustainable.

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### I. Introduction

Environmental sustainability has become a major point of discourse in recent times, as a result of the menace of environmental problems being experienced all over the globe including Nigeria. Various researchers have established that built environment has contributed immensely to these problems, which its negative effects cut across the natural, ecological as well as social system of our environments. As a result of the state of our environment, energy efficiency and eco-friendliness of architectural design became important factors. Attempts by professionals in the built environment to search for a sustainable design and technology to reduce the negative impacts of built environments brought about the concept of Biomimcry as a sustainable design tools. It is a growing area of research in the fields of Architecture and Engineering. Biomimcry is far from being a new idea. This study focuses on the need to know the awareness level and the extent of adoption of this concept in architectural designs in Nigeria. Biomimcry was coined from two Greek words 'Bios' meaning life and 'mimesis' meaning to imitate. According to Benyus (1997, [1]) Biomimcry was defined as innovation inspired by nature. Biomimcry is an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies. (Biomimcry Institute, 2008, [2]). Biomimcry was propagated by Benyus Janine, who is a scientist explained that, Biomimcry is a science that studies the models of nature and then gets inspired from its design to solve human problems and also accentuates sustainability as an objective of Biomimcry. Within the last 10 years there has been a growing interest in this concept of design. Apart from Benyus Janine, other notable researchers that have written comprehensively in the area of Biomimcry include Steven Vogel (professor of biology) and Julian Vincent (Professor of Biomimetics). There are three levels of Biomimcry that may be applied to design problems; they are typically given as form, process and ecosystem (Biomimcry Guild, 2007, [3]). Pedesen (2007, [4]), equally submitted that in view of existing biomimetic technologies, it is apparent that there are three level of mimicry- the organism, the behaviour and the ecosystem and that within these levels, a further five possible dimensions to the mimicry equally exist. Biomimetic design may be in terms of what it looks like, (form), what is made out of (materials), how it is made (construction), how it works (process) or what it is able to do (function).

### Biomimcry in Architecture

Reduction of the impact of human on the environment becomes more critical as every day passes thus the need for sustainable building. Sustainable building is defined as building practises, which strive for integral quality (including economic, social and environmental performance) in a very broad way. Thus the rational use of natural resources and appropriate management of building stock will contribute to saving scarce resources,

reducing energy consumption and improving environmental quality (Fatima, 2012,[5]).The designers and clients, now realize the terrific impact buildings have on the natural environment. As sustainable design becomes widely accepted, a new form of sustainability such as Biomimicry was advanced to achieve a sustainable future (Berkebile & McLennan, 2004, [6]). In this context Biomimicry as a sustainable design tool caught the attention of environmental designers where the Architect is a major player, after it was identified as one of the most important principles of sustainability. Architects have gotten inspiration from biology in the early 19<sup>th</sup> century. Architects have sought not just to imitate the forms of nature but also sought to find methods in design similar to the process of growth and evolution in nature. Biomimicry has been applied to building designs in different part of the world, notable among such buildings include, Eastgate Building in Harare, Zimbabwe, CH2 building in Melbourne, Australia, Hydrological Centre for University of Namibia, Munich Olympic stadium, Germany, The Ultima tower in United State of America, Dog building, Tirau, New Zealand and The Gherkin Tower, United Kingdom.

### **East Gate Building Harare, Zimbabwe**

The East gate building was completed in 1995 (Fig. 1), the project was designed by architect Michael Pearce and engineers Ove Arup Associates. The building was design to be ventilated and cooled by entirely natural means; this building is an example of process and function Biomimicry at the behavioural level. The building is based in part on techniques of passive ventilation and temperature regulation observed in termite mounds in order to create thermally stable interior environment. The termites used to achieve this constant temperature by building breeze-catchers at the base of the structure which draw in air, then cool it by pulling it through chambers carved out of the wet mud at the base, while hot air escapes through flues at the top of the mound.



**Fig.1:** East gate building Harare, Zimbabwe taking its concept from the termite mound.

Source: [www.arupassociates.com](http://www.arupassociates.com) (2014)

### **The Munich Olympic Stadium, Germany**

The stadium was designed by Architect Gunther Behnisch and engineer Frei Otto. The stadium is an example of using nature as a model for design. Dragonfly wings are one three-thousandth of a millimetre thick, despite being so thin; however, they are very strong since they consist of up to 1,000 sections (Harun, 2008, [7]). This is as a result of the compartmental structure of the wings which do not tear, and are able to withstand the pressure that forms during flight. The roof of the Munich Olympic Stadium was designed along the same principle of compartmentalization (Fig. 2).

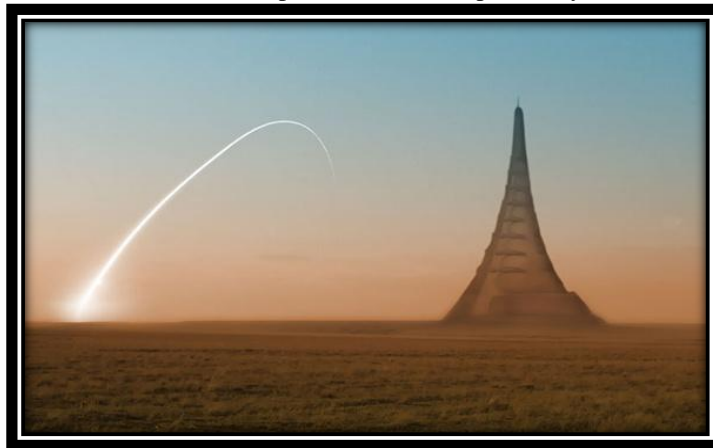


**Fig. 2:.**The Munich Olympic stadium and the dragon fly.

Source: <http://www.harunyahaya.com> (2014)

### **Ultima Tower, United State of America**

The Ultima is a hypothetical super tall skyscraper design by American Architect, Eugene Tsui in 1991. The building comprises 500 stories with a total height of 3,218.7 metres (10,560ft) with a base diameter of 6000 feet (Fig. 3). The shape of the structure takes the shape of a termite mound. The structure contains residential, commercial, and entertainment activities. The architect chose the termite mound form because no other shape can dispel loads from top to bottom, its effective aerodynamic form help to retain stability in a tall building. The building is intended to handle problems with overpopulation and to create mini-ecosystem for its inhabitants. The tower will use the atmospheric pressure difference between the bottom and the top of the tower to create electricity throughout the tower. Such a tall structure was proposed to minimize the ‘footprint’ of our human-made environments and maximize the sense of openness and close proximity to our natural surroundings.

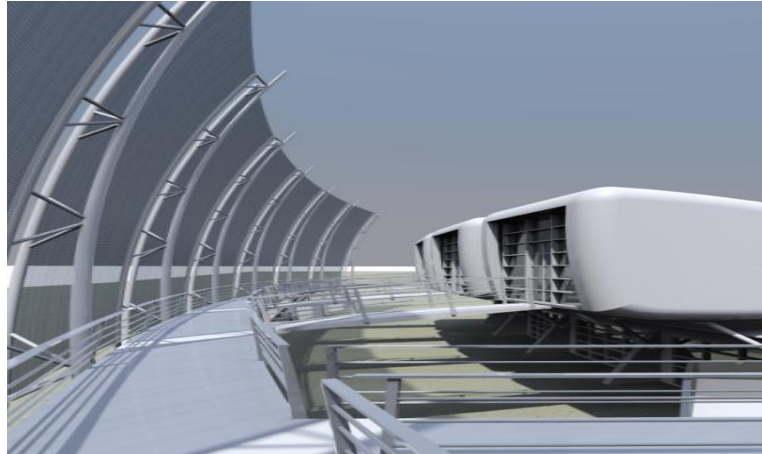


**Fig. 3:** Ultima tower designed to mimic the form of a termite mound by Eugene Tsui

Source: <http://www.gizmag.com/ultima-tower-eugene-tsui-population-challenge/9262/> (2014)

### **Hydrological Centre for University of Namibia**

This particular building mimics the Namibia desert beetle, *stenocara* (Garrod, Harris, Schofield, McGettrick, Ward, Teare and Badyal, (2007, [8]). The beetle resides in the desert with negligible rainfall. It is able to capture moisture however from the swift moving fog that moves over the desert by tilting its body into the wind. Droplets form on the alternating hydrophilic-hydrophobic rough surface of the beetle’s back and wings and roll down into its mouth (Parkes and Lawrence, 2001, [9]). Architect Mathew Parkes demonstrated biomimicry at organism level inspired by the beetle.



**Fig. 4:** Hydrological Centre for University of Namibia

Source: <http://www.nature.com> (2014)

### **The Bird Nest Stadium**

The stadium was designed by a Swiss architecture firm, Herzog and De Meuron and over Arup Associate as the engineer. The Bird Nest Stadium (Fig. 4) is not only energy efficient and eco-friendly but also inspired by nature. The architectural design is based on water bubbles in foam (Plate 4); the building structure is framed in steel, while the bubbles themselves are made from Ethylene tetrafluoroethylene pillows. The membrane let in more light and heat than traditional glass does, which keeps all the 5 pools warmer, thus reducing energy cost by 30 percent. Rain water from the roof is collected and recycled with efficient filtration and backwash system.



**Fig. 5:** The Water Bubble and the Bird Nest Stadium

Source: Rajshekhar (2014)

## **II. Problem Statement**

The issue of environmental problems is now a global reality. The built environment is increasingly held accountable for global environmental and social problems with vast proportion of waste, materials, energy use and green house gases emission attributed to the habitats human beings have created for themselves (Mazria, 2003, Doughty and Hammand, 2004, [10]). The growing concern on the state of our environment has led to the need for energy conscious, eco-friendly and energy efficient designs to minimize the negative effect of buildings and its related activities on the environment. In this context the issue of sustainable architecture became paramount among Architects all over the globe including Nigeria.

## **III. Aim and Objectives of the Study**

The aim of this study is to assess the adoption of Biomimcry design concept as a sustainable design tool in architecture, because of its potential to create sustainable and even regenerative built environment. The objectives are:

1. To assess the level of awareness/knowledge of Biomimcry concept as a sustainable design tool in architecture.
2. To assess the application of Biomimcry design concept in architectural design.

#### IV. Methodology

For the purpose of this study, Nigeria was divided into six zones, based on the geo-political classification of the country (Fig. 6), namely- North West-zone, North-east zone, North-central zone, South-west zone, South-east zone, and South-south zone (National population commission, 2006, [11]). A state was picked by random sampling from each geo-political zone. The states are Kaduna, Bauchi, Kwara, Lagos, Enugu, and Edo. The study adopted the review of relevant literature, oral interview and structured questionnaire to obtain necessary data. Fifty (50) questionnaires were administered in each state making a total of 300 to professional architects both within and outside academics and all questionnaires were returned. In each of the state, 25 questionnaires were administered to architects outside academics and 25 questionnaires to architects in academics. The data were analysed using MS Excel and Statistica (version 9.0) and the results were presented by simple statistical methods, frequency table and percentages.

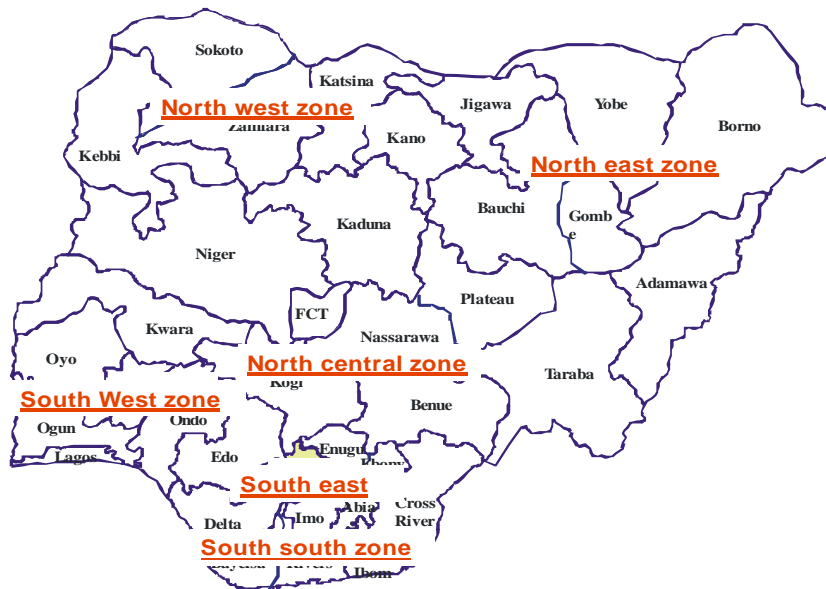


Fig. 6: The six geo-political zones of Nigeria

Source: National Population Commission (2006)

#### V. Results and Discussion of Findings

Table1: Percentage ratings of awareness /knowledge of Biomimcry in the six zones

Geographical Zone	State Sampled	No Of Questionnaires Administered	Awareness/Knowledge Of Biomimcry		Percentage
			Architects Outside Academics	Architects In Academics	
North west zone	KADUNA	50	22	23	90%
North east zone	BAUCHI	50	22	22	88%
North central zone	KWARA	50	23	23	92%
South west zone	LAGOS	50	23	24	94%
South east zone	ENUGU	50	21	23	88%
South south zone	EDO	50	21	23	88%
<b>Overall Percentage</b>			<b>132 (88%)</b>	<b>138 (92%)</b>	<b>(270) 90%</b>

Source: Author’s fieldwork (2014)

The results of the assessment of awareness/knowledge of Biomimcry as a sustainable design tools were presented in table 1. The percentage rating of the architects from the six geo-political zones (North-west zone, North-east zone, North-central zone, South- west zone, South-east zone, South-south zone) were 90%, 88%, 92%, 94%, 88%, 88% respectively. These results implied that there was high level of awareness and also a good knowledge of Biomimcry concept as a sustainable design method in architecture among the Architects. Also the overall percentage ratings of Architects outside and within academics were 88% to 92%. The results shown that Architects within academics were slightly more informed on the subject than their counterparts outside academics.

**Table 2:** Percentage ratings of application of Biomimicry concept in architectural design

Geographical Zone	State Sampled	No Of Questionnaires Administered	The Application Of Biomimicry Concept In Architectural Designs		Percentage
			Architects Outside Academics	Architects In Academics	
North west zone	KADUNA	50	4	3	14%
North east zone	BAUCHI	50	3	3	12%
North central zone	KWARA	50	5	4	18%
South west zone	LAGOS	50	5	6	22%
South east zone	ENUGU	50	2	4	12%
South south zone	EDO	50	3	3	12%
<b>Overall Percentage</b>			<b>22(14.67%)</b>	<b>23(15.33%)</b>	<b>45(15%)</b>

Source: Author's fieldwork (2014)

For the purpose of this study Biomimicry concept was assessed in terms of what it looks like, (form), what is made out of (materials), how it is made (construction), how it works (process) or what it is able to do (function). In accordance with the result of the assessment of the use of Biomimicry concept in architectural designs, 14%, 12%, 18%, 22%, 12%, 12% represented the percentage ratings of the architects from the six zones (North-west zone, North-east zone, North-central zone, South-west zone, South-east zone, South-south zone) respectively. It was established that only Lagos in the south-west zone had a rating above 20%, other zones had less than 20%. Also, 14.67% to 15.33% represented the overall percentage ratings of architects outside and within the academics. This means that slightly more architects in the academics have employed the concept more than their colleagues outside the academics. Finally, The overall percentage rating of 15% implied that currently there is a low patronage of Biomimicry concept as sustainable design method in Nigeria and all the architects sampled have mimic only seek inspiration from nature in term of form.

## VI. Conclusion and Recommendation

The fact that built environment is contributing immensely to the global environmental and social problems can not be over-emphasised. It is clear that there is a need to make a shift in the way built environment is created and maintained to transform the environmental performance of built environment. The study revealed that the level of awareness and understanding of Biomimicry concept as a tool for sustainable architecture is very high, but its practical application in architectural design is very low in terms of patronage. The study recommended that there is a need for sensitization among the stakeholders in built environment in Nigeria. Architects and designers need to create a bio- inspired design adaptation that emulates nature's best ideas, so that all futuristic buildings will be sustainable, so that the negative impacts of built environment will be minimised.

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