Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 4, Issue 3; April-June, 2017, pp. 253-257

http://www.krishisanskriti.org/Publication.html

Theory of Biomimicry in Urbanscape

Sirat Toor

MURP, Faculty of Planning CEPT, Ahmedabad
E-mail: sirat.toor.mplan15@cept.ac.in

Parul Kaur

B.Arch, Faculty of Architecture GNDU, Amritsar
E-mail: parul.kaur29@gmail.com

Abstract—*Biomimicry is a facet of sustainable development, aiming at solving human challenges through adaptations of strategies from nature. Throughout history of human existence, nature has been a source of inspiration for inventions, enabling the creation of flying machine by Wright Brothers, the aerodynamically sound bullet trains or the setup of human establishments. Theory of biomimicry explores the sustainable design approach evolved from the balance between the economic and environmental aspects, ensuring it to be the best potential option for architecture and urban planning. However, biomimicry remains a relatively new and untapped area of ecological science offering sustainable solutions. With increased impact of the built environment on our daily lives, it has become imperative to explore the relationship between the nature and the architecture of the cities. The newer cities like Lavasa, have emerged by incorporating the patterns and strategies of the nature around. However, the question of effectiveness of biomimicry in the modern world application and to what extent remains to be explored yet. This paper aims at exploring the theory of biomimicry and its potential to help integrate design and sustainability in the planning of cities and its architecture. The research seeks to find the applicability of this theory in universal terms, specific to the emerging Indian concept of '100 Smart Cities'. The aim is to understand a new urban scenario where 'Smart' is inspired from the nature and incorporates the same into planning the urban scape.*

Theory of Biomimicry

"Biomimetics is not so much a subject matter as it is a point of view." - Otto Herbert Schmitt

Biomimicry is a continuous process inspiration process from nature, to create organs and organisms as an integration to the system [1]. In literal terms, the word biomimicry refers to the emulation of biological forms, processes and ecosystems for the purpose of development in physical or biological world [2]. The relation between man and nature has been explored in innovations since prehistoric times. Fine examples show that around 15,000 BC, the Egyptians started using braided plant fibres to make ropes; the first flying machine model invented by the Wright brothers was based on the shape and mechanics of pigeon's wings; the design of the bullet shaped nose of the bullet train was made after observing kingfishers, to prevent the sonic boom accompanying the high speed. While mentioning the emulation of nature in the design, invention of daily use products such as paper (invented from studying the nests built by wasps) and velcro (imitates the science behind the prickly seed burrs from the burdock plant) also prove the necessity of biomimcry in shaping our world. These are just a few examples of early biomimicry that have shaped our world into what it is today.

The term 'Biomimetics' was coined by an American inventor Otto Schmitt in 1960s, to define the imitation of ideas from biology to technology aspects. However, the ideology of biomimicry was popularized by Janine Benyus in the 1997 through her critically acclaimed book 'Biomimicry: Innovation by Nature'. In this book, Benyus laid out some of the fundamental ideas that she developed and tested herself. This book resulted in a wide-spread movement that revolved around biomimetics and sustainability. She defines Biomimicry as a "new science that studies nature's models and then imitates or takes inspiration from these designs and processes to solve human problems" [3].

The aim of biomimcry is to create new products and policies for regenerative adaptation of the beings on earth, with focus on solutions inspired from nature [4]. The biomimicry study has been growing recently with increase in the applicability of the theory in practice. With the immense pressure on nature for resources, biomimicry accounts for not only economic prospects but also for eco-friendly designs and built environment.

Applicability of Biomimicry

Biomimicry design process is based on the biological knowledge of the nature. The focus of this process is to derive principles from the design of nature and the various processes and to use them as stimulation for the ideas [2]. Research in biomimetics has advanced the innovations by the humans manifold.

Case in example the efficiency of the wind powered turbines, a company named WhalePower has taken inspiration from the humpback whale, which swims easy and effortlessly, mainly due to the front tips of its flippers, which have bumps called tubercules, making the navigation through water easy. This applicability of the tubercules, when applied to the wind turbines increased their efficiency by 8 percent in lift and by reducing 32 percent of drag.

Figure 2.1: Emulation Humpback Whales to create Efficient Wind Power

Similarly, the lesson of creating flow without friction for efficient energy can be imbibed from the nature processes. A company named PAX Scientific Inc. reduced energy usage by 10 to 85 percent in conventional rotors and in noise by 75 percent by imbibing nature models to fans, mixers, propellers, turbines and pumps [5].

Also, a swimwear company called Speedo has integrated shark denticles textures into its range of swimming products boosting swimming speeds by around 3 per cent [6].

Another ground breaking innovation has been made by a California-based cement company Calcera. By studying the sea corals, this company has been successful in converting carbon dioxide emissions into a solid form of calcium carbonate, thus, turning the gas emissions into an expedient source for cement feed.

Apart from offering solutions to our problems, the natural world offers us solutions that are sustainable.

These solutions are fundamentally sustainable because they do not use up the resources from which they were built. The physical example of this scenario is seen with the invention of environment-friendly and energy-saving paint called Lotusan which has been inspired from the self-cleaning mechanism of the lotus leaf. So, biomimcry seeks out efficient, sustainable designs that do not cause any harm to the environment. The incorporation of biomimicry in sustainable design of buildings has been through research, with the aim to build climate specific designs of buildings, with hooded windows, variable thickness of walls and passive cooling techniques. Various architects worldwide have used this methodology to achieve energy efficiency in their structures.

Figure 2.3: National Beijing Stadium, China inspired by Bird's Nest

The Biomimicry Institute is a non-profit organization based in Missoula, Montana, United States; aimed at creating sustainable methods for better livability [7]. The organization brings awareness related to the process of biomimicry through involvement of schools and universities in research programs. The organization also collaborates with its sister company called Biomimicry 3.8 (earlier Biomimicry Guild), a for-profit consulting company.

2.1 Biomimcry and Architecture

As is with the innovation of various products, biomimetic architecture is also not a new phenomenon. Study of ancient buildings reveals the application and understanding of natural design forms in structure and design, whether it is the inspiration behind the columns (said to have been designed from observing the structure of trees) or the more contemporary 'Organic Architecture' which uses nature inspired forms in design.

Biomimetic architecture does not limit itself to using nature as inspiration for aesthetic form but rather seeks to find solutions to a building's design and functional problems. While literal translation of the nature and its forms in designing and functioning of a building result in a structure physically resembling the organism in form or shape, the tacit principles might hold a promise towards solving the functional problems without imposing in the aesthetic appearance of the building.

Hence, biomimicry can work on three levels, viz, the organism, its behaviors, and the ecosystem.

Architecture that follows biomimicry at the organism level results in buildings that imitate the shape and structure of the organism itself. The Gherkin Tower by Norman Foster is inspired by the Venus Flower Basket Sponge on the organism level, hence, its physical appearance. The next level studies the inter-relationship and the interaction between the organism and its environment. This can be witnessed in the Eastgate Centre at Zimbabwe. Termite moulds incorporate intricate

self-cooling systems into their design to control micro-climates and are actually able to maintain temperature within their nest to within a degree even when the outside temperature is experiencing considerable fluctuations [8]. Observing this, architect Mick Pearce along with engineers at Arup Associates designed Eastgate Centre (a shopping and office complex) in Harare, Zimbabwe in 1996. This building uses vertical internal air convection ducts to provide an air conditioning system and only uses 10 per cent of the energy and no water required to run conventional air-conditioning in buildings of similar scale.

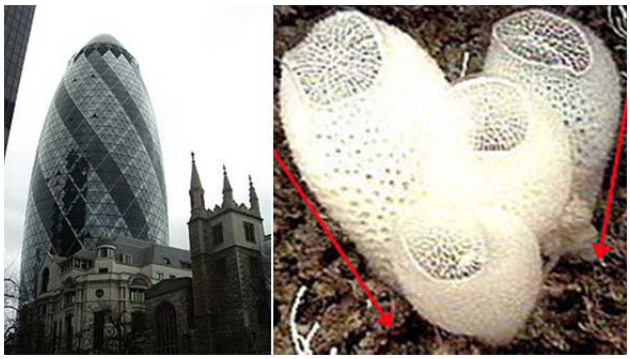

Figure 2.2: The Gherkin Tower in London inspired from Venus Flower Basket Sponge

Figure 2.2: Learning's from termite mounds to build temperature controlled buildings in Zimbabwe

Biomimetic architecture on the ecosystem level focuses on designing a building based on how the different components of the environment tend to work together. This is generally on the urban scale. Lavasa in India is based on this concept.

2.2 Biomimcry and Construction

Ongoing research in field of biomimetics has also resulted in the construction materials that apart from being biomimetic, also come with biological processes built in. Bio-concrete by Dr. Henk Jonkers and 'bio-manufactured' brick by Prof. Ginger Krieg Dosier offer endless possibilities towards the future of biomimetic construction.

Biophilic City and Sustainability

Biophilic Cities is mainly a biodiverse city hosting nature in its every aspect of design and livability. A book written by Timothy Beatley explores the notions of Biophilic cities and its integration into Urban Design and Planning [9]. The biophilic cities are construed to evolve the already existing biodiversity for further restoration and repair of the built environment. In relation to green cities and urbanism, biophilic cities are designed to incorporate nature in its truest sense within the new structures and built project.

Sustainability of the cities is largely depended on three parameters: Density, Specialization and Localized Infrastructure [1]. Dense areas resolve to better means of livability solutions, with public oriented designs. However, urban sprawl leads to more energy consumption. Specialization refers to certain areas which become vital to the sustainability of the city, such as civic centers, plazas and culturally diverse areas. Such parameters initiate a system of self-regulation, sufficiency and reliance on the localized system. Further, localized infrastructure is the availability of services and resources in a reachable manner. Thus, bringing reduction in carbon print and emissions. Hence it can be seen that cities and biological systems are in synchronization in regard to their working ability.

The concern of biophilic cities is related to the ecological integrity of the network of nature, its accessibility and transition of a resident from neighbourhood to larger greener realms. Ebenezer Howard traced the urbanscape of cities ecological space. However, the challenge lays in the integration of nature into already existing cities, with dense network of roads, neighbourhoods and city centers. Cities need to be conceptualized as natural entities, with biomimcry as one potential route to sustainability [8]. Biomimicry can support the planning and design of urban infrastructure in a sustainable healthy living manner as a problem solving methodology. It reconnects the citizens to the nature by innovatively collaborating designs and the various paradigms of a city.

India is currently faced by the issues of Urbanization, climate change and resource constraints, which harbor a major setback to the development wave. It has become imperative to understand the role of ecology in city planning and development. Biomimicry can be used by planners to reduce embodied energy in construction products, reduce material use, produce better explorative designs in architecture and reduce maintenance [8]. Biomimicry in evolutionary process caters to the potential of creating 'living;' cities.

Lavasa: An Urban Example

Lavasa, in Maharashtra is one of the forerunners in urban-scale examples of biomimicry. It is a 12,500 acre mixed use development, designed by the HOK group of London. The city has been designed by keeping the ecosystem of the area in concern. The design team took into consideration six ecosystem services defined by the local moist deciduous forest: water collection, solar gain, carbon sequestration, water filtration, evapotranspiration, and the nitrogen and phosphorus cycle. Emulation of these particular six services drove the whole project design.

Figure 4.1: Town of Lavasa

The aim was to bring effective measures towards the issue of soil erosion caused by the 9m of annual monsoon rainfall. This was done by breaking the effect of rain through structural canopy, slow drainage off buildings by allowing it to be collected and reused through the water storage system of 'Hydraulic Redistribution' local trees display. The process is such that the roots of trees draw the rainwater into the soil to store for the dry season. This is done at city level. This particular strategy justifies the operational costs of the scheme, and also increases the green infrastructure of the development by 20-25 percent, thus decreasing the associated maintenance cost [8].

However, Lavasa city has come under lot of spot light due to its flouting of environmental policies and regulations. The bio-mimicry refers to the only design and the physical development of the city. However, the Indian environmental rules and regulations, refer to the protection of the biodiversity and the eco sensitive areas of the Indian states. Currently phase 1 of the city has been developed, with other phases under development.

'Smart City' Concept of India

India has set an ambitious target to build 100 Smart Cities by the year 2025. This is a step forward in the competition of a new global scenario emerging which involves major cities and countries in the world, working towards the aim of becoming „smarter". Smart cities are essentially built by utilising advanced information and communication technologies (ICT), including broadband networks, wireless sensors, Internet of Things, Big Data, Cloud services, mobile devices and apps. Thus, the context pertains to enabling smart city technology which will generate radically new "smart" services and facilities across the city including all its facets. Case in point includes transportation, healthcare, public safety, food management, education, energy and so on [10].

The smart services are perceived as the parameters to the smart city by the various government leaders, academics and industrial experts as a basis to resolve many global grand challenges. Consequently, Smart city has been given top priority in the national development agenda.

However the smart city concept risks the detachment from the local ecology and the citizens, and more of technical development. The need of the hour is for rejuvenation of the cities through introduction of ecological central development. All the cities form layers of workability through the road networks, sewage systems, administration and residential categorization. The development of these through biological means and understanding of natural processes and correct the mess created by the haphazard growth and urban sprawl in the cities.

This is required to be done as India is plagued by the environmental degradation of the cities, such as Delhi facing air pollution and water scarcity. It has become imperative to ensure the liveability of cities before ensuring their smart character through technological advancement.

The technological advancement of the city cannot be developed without incorporating the biological aspects in the cities. Basic problems related to the city cannot be solved by ignoring the ecological structure of the area. The drainage patterns, tree structures and the design of land use conforming to the needs of the area are the urgent requirement of any city in India.

Conclusion

Even though biomimicry as a subject has lot of arena to be explored, it holds a major impact on the livable environment of the cities. It can bring forward a new way of thinking in the future, which can help create environment friendly choices. To help design ecologically sensitive cities, it is important for designers and urban planners to understand the biological sphere of the area. Design practitioners can set examples by considering the emulation of forms, process and ecosystem.

The concept of 'smart city' being explored in India is the perfect chance for creating environment friendly cities, by imbibing the culture and processes of nature. The major efficiency in biomimetic designs is the concept of adaptability to various scenarios, which redefines the network of planning.

This can only be done by creating awareness among the masses and the development groups for the inclusion of a biologist onto the design table and getting the individuals of the society onboard.

Inspiration by nature is the only and the most effective solution to creating sustainable cities.

References

[1] E. Royall, "Defining Biomimicry: Architectural Applications in Systems and Products," in *UTSoA-Seminar in Sustainable Architecture*.

[2] E. B. Kennedy and D. C. Fecheyrs-Lippens, "Biomimicry : A Path to Sustainable Innovation."

[3] J. Benyus, "Biophilic Cities : What Are They ?," in *Biophilic Cities*, 2011, pp. 45–81.

[4] H. M. S. Ghazy, "Achieving Sustainable Development by Applying Biomimicry in Fashion Design," *J. Basic Appl. Sci. Res.*, vol. 5, no. 12, pp. 42–52, 2015.

[5] P. O. Arnarson, "Biomimicry," 2011.

[6] "Biomimicry learning lessons." [Online]. Available: https://app.croneri.co.uk/feature-articles/biomimicry-learning-lessons-nature?product=17.

[7] "Biomimicry Institute." [Online]. Available: https://en.wikipedia.org/wiki/The_Biomimicry_Institute.

[8] N. T. Buck, "The art of imitating life : The potential contribution of biomimicry in shaping the future of our cities," *Environ. Plan. B Plan. Des.*, pp. 1–21, 2015.

[9] T. Beatley, *Biophilic Cities: Integrating nature into Urban Design and Planning*. Washington DC: Island Press, 2011.

[10] G. of India, "Smart Cities." [Online]. Available: www.smartcities.gov.in.