

# Applicability of Inspirations from Nature and Wisdom from Vernacular Architecture in Synergy with AI for Design of Sustainable Buildings



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**Abstract:** *The climate change is there and its adverse effects are being experienced world over. This is not a new phenomenon and has been happening for many ages. Nature provides a large number of examples where species living in different climatic zones have learned to modify themselves with the frequent and cyclic climatic changes and have survived for millions of years. Human beings have also learned, through experience of ages, to live in different climatic conditions by modifying their habitat. The paper proposes to take lessons from nature and the vernacular wisdom in order to use the same in the modern architecture, through the application of the Artificial Intelligence in process of making sustainable modern architecture compatible with environment and capable of adapting to the changes.*

**Keywords :** *Climatic Change; Vernacular Wisdom; Artificial Intelligence; Inspirations from Nature; Sustainable Development.*

## I. PREFACE

Climate world over is changing drastically. Not only the cycle is changing but it is adversely affecting our reserves. Oroville, California, which was once full of water reserves is now experiencing “exceptional” drought. All the glaciers are depleting and causing flood and raising the level of sea. This phenomenon is changing the coastlines and changing the world map very fast. Some of the cities on the sea shore are facing the danger of being submerged and some small islands have completely disappeared from the world map. Urban growth is causing pressure on the agricultural and pastoral

lands. Impact of climate change is felt all over the world. Some parts of the world are facing severe floods while others are facing draught. Leaders all over are abreast of the situation and raising their concern. Unfortunately nothing tangible has been possible so far, although the efforts have started showing positive results. The urbanization and building industry is one of the biggest culprit in the entire game having a role of nearly 40%. This industry is the single biggest industry consuming electricity, adding pollution, occupying the agricultural lands, cutting down trees all that add negativity to the environment. The biggest factor has been that the human being have been modifying the environment to suit to their requirements rather than modifying themselves to suit the variations in the nature. This has created a conflict in natural processes resulting into the global warming and related impacts.

Present paper is based on research done by the authors on how the building industry could be made more sustainable by taking inspirations from the nature that has evolved processes that shall help construction of more sustainable buildings by creating a synergy between the knowledge from nature, vernacular wisdom and the modern technology.

Nature has been a wonderful store house knowledge and has been inspiring generations in every walk of life, be it the scientists, engineers, architects, researchers, philosophers or even the artist. The architects and engineers have especially depended on nature for development of the forms, shapes and even the structural systems. In fact the initial habitations were in close synergy with the nature. They were made out of the natural produce and in the nature. It is the process of urbanization triggered by industrialization that the man-nature distance started increasing. Today in the process of environmental crisis, it is felt necessary to go back to the basics and have a close look at the nature once again, this time with fresh perspective to derive fresh inspirations and have a second thought to utilise these inspirations in our building industry, in synergy with the modern technology, to make it compatible with the processes of nature and relevant to modern times.

## II. INSPIRATIONS FROM NATURE

Nature is the best designer and has inspired the designers and scientist equally towards their inventions. Everyone looks towards nature for some kind or the other inspiration.

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Unfortunately architects have given very little attention to this aspect. If you have a little closer look at nature and its processes it shall be noted that it is the storehouse of inspirations for all possible actions. It has all the clues for making the sustainable buildings and sustainable living. It has been noted that in its 3.8 billion year history, nature has already found solutions to many problems we are trying to solve, and we humans could, if not learn, get inspired and answer the many problems we face. Some examples are:

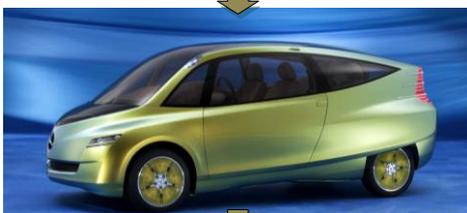
**A. Spider Silk**

Spider silk which looks so fragile but it is 5 times stronger than Steel.



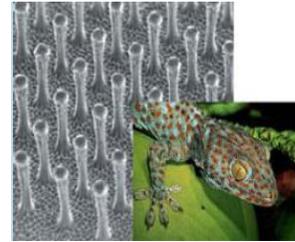
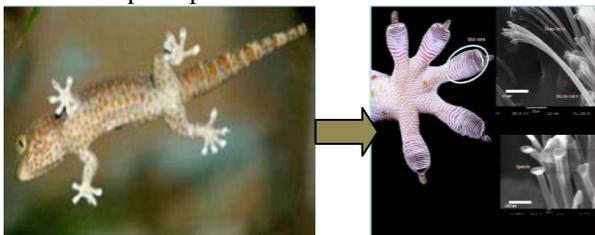
**B. The Boxfish**

The *Box fish* has inspired designers of Bionic car by Daimler Chrysler (Mercedes Benz) 2007. It consumes 20% less fuel and produces 80% less nitrogen oxide.



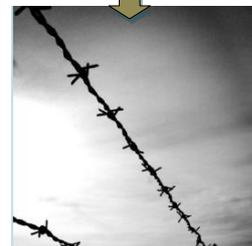
**C. Gecko foot hair**

It has inspired production of the re-usable adhesive.



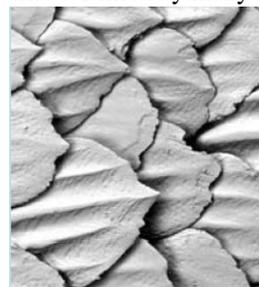
**D. Rose Thorns**

It inspired the production of the Fencing wire, an 1868 Michel Kelly Patent.



**E. Shark skin**

Sharks are known as the fastest and most agile swimmer. Its skin inspired the development of fabric for the production of swim suits. The U-shaped channels on a Shark generate tiny vortices that bring water closer to the body reducing the drag. This development led to production of a new type of swimwear liked by many winning swimmers of the world.



**F. Rattle Snake Heat sensing**

The heat sensing capabilities of Rattle snake has helped in development of stick for visually impaired and night vision camera.



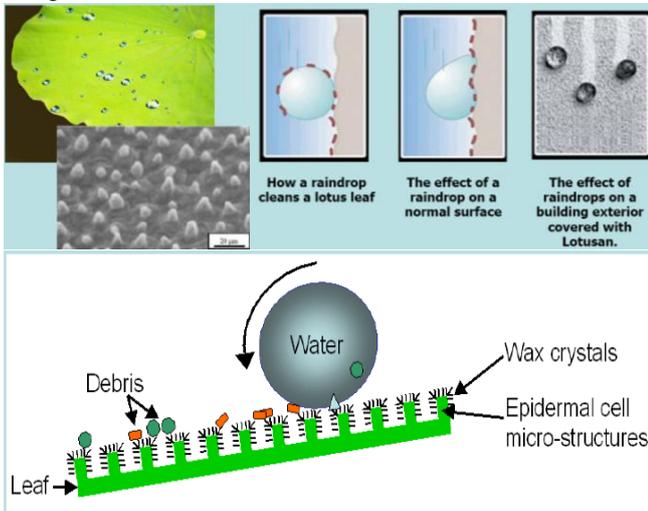
**G. Optical Camouflage**

Retro-reflective Projection Technology (Transstudio Tachi Laboratory, University of Tokyo) requires the use of clothing. In the following example a person is wearing a hooded jacket made of retro-reflective material, made of thousands of small beads that reflect the light precisely according to the angle of incidence. This helps in creating an illusion of ‘seeing through the individual’.



**H. Lotus Effect**

Lotus effect is the self-cleaning property of the Lotus leaf. Lotus flower emerges clean from swampy waters. Lotusan paint has adopted these properties and it enables buildings to be self-cleaning. Nature can influence humans in ways outside predetermined design problem. We need to look at it with fresh eyes and open mind to find solutions/ applications in the ways that were not tried earlier and find fresh and innovative design solutions.



Water forms droplets on the tips of the epidermal protrusions of the Lotus leaf and collect dirt and pollutants as it rolls down the leaf. Same quality has been adopted in the Lotusan Paint

**I. King Fisher**

King Fisher is the source of inspiration for the Bullet Train



**III. EXAMPLES OF ARCHITECTURE INSPIRED BY NATURE**

Following are some of the architectural examples that have been inspired by the Nature:

**A. Eiffel Tower**

**Source of inspiration**-Thigh bone or the Femur bone, **Material of construction**- Exposed iron, **Resemblance**- The outward flares at base resembles the upper curved portion of femur. The internal wrought iron braces closely follow design of original trabeculae within femur. **Strengths**- Can withstand bending and shearing effects due to wind. Ventilation problem solved.



Efiel Tower

Femur Bone

**B. Waterloo International Centre:**

**Source of inspiration**- Pangolin, **Material of Construction**- Steel & glass, **Resemblance**- The glass panel fixing that makes up the structure mimic the flexible scale arrangement of Pangolin. **Strengths**- Ability to move in response to the imposed air pressure forces when trains enter and depart.



**C. Eastgate Centre Harare:**

**Source of Inspiration**- Termite mound. **Material of Construction**-Concrete, **Resemblance**- The building is designed with a unique ventilation system, which draws outside air and cools or warms it depending on temperature. **Strengths**- Temperature remains regulated all year round without Using conventional air-conditioning or heating system.



**IV. NINE PRINCIPLES OF BIO-INSPIRATION**

Janine Benyus, a biologist, author and innovation consultant, in her book *Biomimicry: innovations inspired by nature* gave nine principles for Biomimicry which can be easily used in architecture. These principles can be used as a base for working out design strategies for our buildings:

- 1) Nature runs on sunlight.
- 2) Nature uses only the energy it needs.
- 3) Nature fits form to function.
- 4) Nature recycles everything.
- 5) Nature rewards cooperation.
- 6) Nature banks on diversity.
- 7) Nature demands local expertise.
- 8) Nature curbs excesses from within.
- 9) Nature taps the power of limits

A comparison of manmade systems and the systems of nature reveals the following facts

SN	Natural Systems	Manmade System
1	Linear	Cyclic
2	Complex	Simple
3	Inter-dependent and Symbiotic	Mono Functional and Disconnected
4	No Waste	Produces Waste
5	Uses Solar Energy	Uses Fossil Fuel Energy
6	Overall Development	Unidirectional Development
7	Use Local Resources	May Use Global Resources
8	Re-generative	Extractive
9	Adaptive to Changes	Does Not Change

The comparison clearly indicates that the systems of nature are cyclic and work in close loop thereby they do not disturb the ecology. The systems of nature are also very adaptable to the environmental changes and result in zero waste. This clearly indicates if similar systems could be adopted for the modern buildings, the buildings might produce similar results as the nature itself.

**V. INSPIRATIONS FROM VERNACULAR ARCHITECTURE**

Just like the living organism have been evolving to adjust to the changing climatic condition, the artesian world over have been modifying their habitat. These buildings have really not been designed but have evolved from generation to the generation to suit the changes in climate and to keep themselves comfortable.

**A. Ventilation System**



*Hawa Mahal, Jaipur*

*Hawa Mahal* is truly a ‘Wind’ Palace, having number of small and large window having wider opening towards the wind side (outside) and small towards the living chambers of the queens and ladies (inside). The window design invited warm outside wind inside and while passing through smaller section became cool thereby made comfortable living inside, in the era on ‘No Electricity’. The artesian actually used the ‘Venturi Effect’ without knowing the principles. They applied what they experienced and are beneficial.

**B. 7.2 Courtyards**

Entire world that falls under hot and arid region has provided courtyards in the buildings. Same has been done very efficiently in the buildings of Rajasthan, be it the palaces *havelies* or the residences. There could be one or more of the courtyards in a building. Most of the residences did not have any opening on the outer façade. This helped in cutting down the harsh sun and effect of sand storms. These courtyards provided indirect light to the rooms placed around them. They were also the place for outdoor living and were the places for the women folk to stay in privacy. The courtyards also acted as place to ventilate the building through the chimney effect. Due to its size and number of floors of spaces around it, the courtyards used to remain in shade and cool.

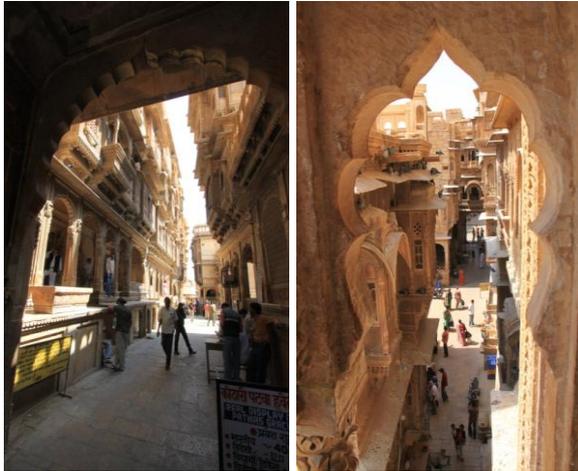
There are examples available from round the world. Given here below are examples from Jaisalmer, Rajasthan.



*Courtyards in the Havelis of Jaisalmer, Rajasthan*

**C. 7.3 Mutual Shading**

Buildings in hot and arid regions used to be closely placed so that one building cast shade on other to keep the temperature inside low. This system has also been followed around the world in similar climatic conditions. Normally no side setbacks are left and buildings are built touching each other. Lesser exposure also helped in lesser heat intake.



The mutually shading lanes of Jaisalmer

**D. Overhangs**

All exposed surfaces of the buildings would have large projections or large number of projections to create more of shaded surfaces to cut down heat intake of the interiors.



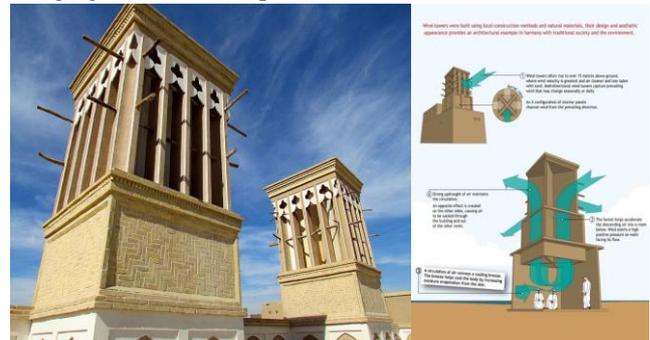
Jaisalmer Havelis have projections (known as Jharokha) on all exposed faces.



Padmnabhapuram Palace, Kanyakumari, Tamilnadu, is an example from hot and arid region where in addition to large overhangs giving shadow, verandah is added on outside to utilize the cool breeze and verandah became outdoor living space for the males while courtyard is still utilized for women folk.

**E. Wind Catchers**

Wind Catchers have traditionally been used as an element to cool down the interiors in buildings. These were very popular in UAE and Saudi Arab world and were helpful in bringing the indoor temperatures to the comfortable levels.



Typical wind catchers and principles of work.

**VI. CONCLUSIONS**

Nature provided ample examples that show that the species have survived in the harshest of the environment for centuries, be it plant life or the animal life. A closure review of these examples show that the species developed skills for thermo regulation, light management and water conservation. The species have also been surviving in the varied and changing climatic conditions- harsh cold to harsh hot, rainy to bone dry. A closer look explains the mechanism of their adaptability in varied climatic conditions. The species could survive without any external aid and modify themselves in the changing climatic conditions. The skills of different species are directed to different climatic conditions. Some have done it for thermal regulations some for water harvesting and some for regulation light conditions. All these regulations can be adopted in our modern buildings. Nature has always been a source of inspiration for structural stability. Applicability of these inspirations has been utilized by modern designers as is ample clear from the examples discussed. Similarly the vernacular architecture evolved through the generations has adopted techniques to combat different climatic condition.

Authors have proposed to use the inspirations from nature and vernacular building coupled with the modern technologies such as AI to make our modern structures more environments friendly and less energy consuming. Although the earlier example are of buildings and species living close to the ground surface, the inspiration can certainly be used in modern even high rise buildings if we take basics of their skills and use the modern technology for their applicability. For example due to increasing wind velocity at higher levels in high rise buildings, it becomes difficult to open windows for getting natural ventilation. AI can be used to sense the wind velocity outside the building to regulate the opening of window accordingly. For cutting down light and heat inside a building, exposed glass/window surface could be regulated to a desired programmed level. Similarly suitably located light shaft, a modified version of courtyard, could be used to light the interiors of large buildings, which can also be a used for ventilation through shaded shaft.

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