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Framework to Support Architectural Sustainability using Biomimicry (The Second Level)

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ABSTRACT

Through the study and analysis of the second level to Biomimicry, and try to exploit ways of the organism adapting with its environment, has been reached for the approaches. In this framework, research paper deals with an analysis for the main principles of environmental sustainability in the nature. Research proposed division environmental sustainability principles derived living organisms adapt with nature to four approaches. The aim of this research to submit a proposal for The methodological framework of using the second level of the Biomimicry levels to support architectural sustainability.

Keywords: Biomimicry - Sustainability

1. INTRODUCTION

Nature is an endless variety of living systems integrated closed, coexisting with each other without defect to the ecosystem, But when human intervenes , However does not have enough studies to conclude and devise solutions from nature to all areas of science and architecture. Can be said that nature is inspirational but it is also a part of our world which we can study more deeply – extracting creative solutions that we can apply today. Nature provides us with an amazing array of solutions for many complex problems that we face today, learn from nature is "Nature Simulation " and architecture can depend on this kind of approach.

Animals and plants are able to adapt to some of natural phenomena, and also have a lot of defensive means against a group of cruel climatic circumstances. So all organisms have been granted featured abilities to adapt to several environments on the earth surface whether by its shapes, functions of its organs , behaviour or the instinctive way and technique which is used in establishing their habitats [1].

Some animals show a skill in designing its habitats, its direction and choosing the location that is suitable for their life style and the condition of their environment; that could be considered as experiences of local construction which must be observed and studied [2].

It also may teach human, some lessons in the architecture design in what factors and environmental conditions taken into consideration. Human have made use of that lessons which he saw from how animals and plants adapt to its environment, that could be observed in Spontaneous examples used in building human`s habitats., Research proposed division environmental sustainability principles derived living organisms adapt with nature to four approaches, see Table 1. These approaches to employ the organism adaptation methods with its environment in the field of architectural sustainability. Research reviews of each approach and the secondary branches, through examples to the organism adapt. Then the architectural sustainability principles , which succeeded in their application and then architectural applications which can be employed where these styles and ways to adapt. Thus, the research had presented methodology to reach architectural applications compatible with the environment through the second level .

Table 1: Approaches to employ the organism adaptation methods

Skin of the organism	• Skin Color of the organism • Skin Composition of the organism
The structure form of the organism	• Skeleton of the organism • Openings Shaped of the organism
Shelter of the organism	• Shelter form of the organism • Shelter site of the organism • Shelter Construction materials of the organism
Biological characteristics	• Biological characteristics of the organism members

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2. WHAT IS BIOMIMICRY?

Biomimetics and Biomimicry are both aimed at solving problems by first examining and then imitating or drawing inspiration from models in nature.
Biomimetics is the term used to describe the substances, equipment, mechanisms and systems by humans to imitate natural systems and designs.
Biomimicry is an innovation method that seeks sustainable solutions by emulating nature's time-tested patterns and strategies, e.g., a solar cell inspired by a leaf. The goal is to create products, processes, and policies (new ways of living) that are well-adapted to life on earth over the long haul. Biomimicry has gained prominence as a method to reduce human's impact on our environment since Janine Benyus, a biological science writer, gave name and purpose to this innovative concept [3].
"Nature is my mentor for business and design, a model for the way of life. Nature's system has worked for millions of years. Biomimicry is a way of learning from nature."[4].

3. LEVELS OF BIOMIMICRY.

There are three levels of Biomimicry; Nature is the inspiration for the formation , Mimicry of how an organism behaves and ecosystem. The first level refers to a specific organism like a plant or animal and may involve mimicking part of or the whole organism. The second level refers to mimicking behaviour, and may include translating an aspect of how an organism behaves, or relates to a larger context. The third level is the mimicking of whole ecosystems and the common principles that allow them to successfully function, see figure 1.

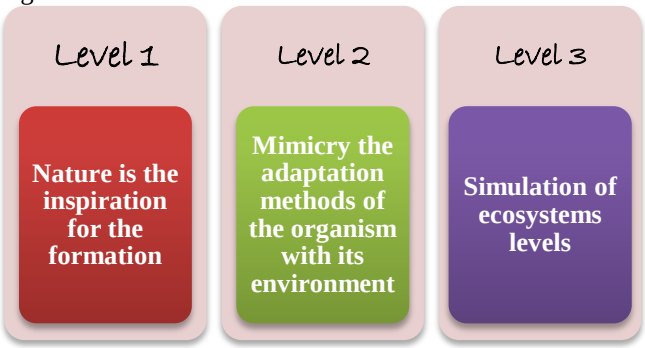

Figure 1: Levels of Biomimicry

4. THE SECOND LEVEL : MIMICRY THE ADAPTATION METHODS OF THE ORGANISM WITH ITS ENVIRONMENT.

A great number of organisms facing the same environmental conditions that humans face, but these organisms try to solve their problems within limits of energy and material availability, and continue to development the solutions even with the change of the Challenges of the around environmental conditions .

In behaviour level Biomimicry, it is not the organism itself that is mimicked, but its behaviour. It may be possible to mimic the relationships between organisms or species in a similar way. An architectural example of process and function Biomimicry at the behaviour level is demonstrated by Mick Pearce's Eastgate Building in Harare, Zimbabwe and the CH2 Building in Melbourne, Australia, see figure 2,3. Both buildings are based in part on techniques of passive ventilation and temperature regulation observed in termite mounds, in order to create a thermally stable interior environment. Water which is mined (and cleaned) from the sewers beneath the CH2 Building is used in a similar manner to how certain termite species will use the proximity of aquifer water as an evaporative cooling mechanism [5].

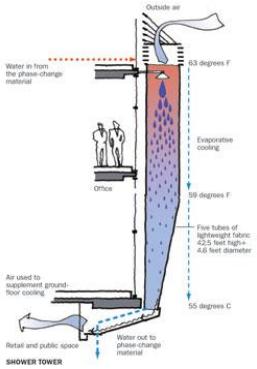

Figure 2: Sectipn in CH2 Building

Figure 3: Council House Two (CH2), Melbourne

5. THE METHODOLOGY TO REACH ARCHITECTURAL APPLICATIONS COMPATIBLE WITH THE ENVIRONMENT

The methodology to reach architectural applications compatible with the environment, includes the following steps:

- Study and analysis examples to the organism adapt.
- analysis for the main principles of environmental sustainability in the nature.
- Conclusion, the architectural sustainability principles.
- Proposal, architectural applications which can be employed where these styles and ways to adapt.

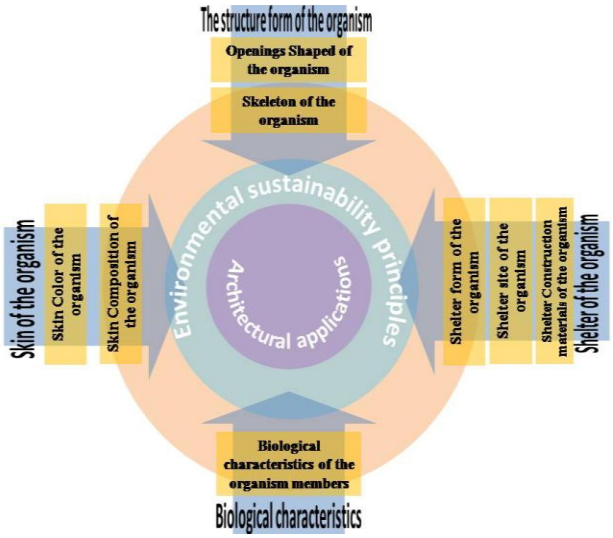

Figure 4: The methodology to reach architectural applications compatible with the environment

5.1. SKIN OF THE ORGANISM

5.1.1. SKIN COLOR OF THE ORGANISM

Desert animals have external pale and light reflective colours to provide itself with the first mean for the protection from direct sun rays. But, in the case of areas where plants and rocks animal takes in less heat from the environment, also help to make it less conspicuous to predators in the bright, pallid surroundings, see figure 5.

Figure 5 : Lizard Adaptation **[6].**

Environmental sustainability principles :

- ✓ The protection from direct sun rays

Architectural applications :

Paint buildings in bright and reflective colours working to reduce the acquired heat, thus reducing the energy used to provide thermal comfort ,as shown in figure 6

Figure 6 : Paint buildings in bright and reflective colours

5.1.2. SKIN COMPOSITION OF THE ORGANISM

The thorny devil lives in the central Australian deserts where obtaining water is a crucial task. "The thorny devil can gather all the water it needs directly from rain, standing water, or from soil moisture. Water is conveyed to this desert lizard's mouth by capillary action during cold nights; dew condenses on them and is drawn by capillary action along the grooves and eventually down to the tiny creature's mouth [7],[8], see figure 5.

Figure 7 : The thorny devil
Grooves on spikes of thorny devil lizard provide drinking water by drawing condensed dew to mouth by capillary action [9].

Environmental sustainability principles :

- ✓ Thermal insulation of external cover
- ✓ The provision of water needs

Architectural applications :

Passive Water Collection: Passive water collection in a building can provide water especially in dry arid climates without consuming much energy.

Thermoregulation : Water has one of the highest heat capacities amongst materials. Incorporating water into building facades can mean a passive, evaporative cooling system. This could eliminate or minimize the load on the building's air, see Figure 8.

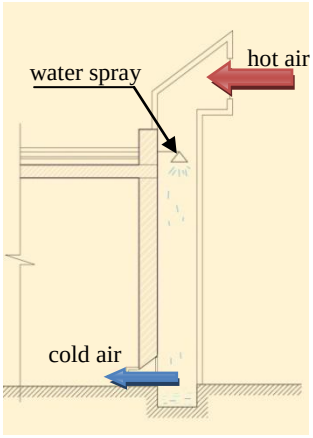

Figure 8 : Evaporative cooling system proposal

5.2. THE STRUCTURE FORM OF THE ORGANISM

5.2.1. SKELETON OF THE ORGANISM

The African ground squirrel and desert rats often use its huge tails to shade its bodies. It is the same with shading the final roof of the buildings which fronting the heated sun rays using shading separated ceilings. as shown in figure 9.

Figure 9 : The African ground squirrel and desert rats often use its huge tails to shade its bodies [10].

Environmental sustainability principles :

- ✓ The protection from direct sun rays
- ✓ Self-shading systems

Architectural applications :

shading the final roof of the buildings which fronting the heated sun rays using shading double ceilings., as shown in the figure 10.

Figure 10 : Roof Roof House, MALAYSIA, architect Ken Yeang [11].

5.2.2. OPENINGS SHAPED OF THE ORGANISM

A lot of animals in hot zones success in getting rid of excess heat which is formatted in its bodies in the summer by cooling system that are relied on the blood movement inside the body considering it as a heat conductor mediator from the body to heat radiated sun surfaces which are able to be cooled by external air and are also called as heat exchanger between the blood and surrounded air., Often the ear that contains tangled bloody small hairs and near from the skin represent the suitable heat radiator for the animals` body in hot zones. Thus, the distinction of the shape of **desert fox** by relative big ears which cool the blood which is flowed through it, is observed, beside achieving its role in increasing animal hearing ability [12], see figure 11.

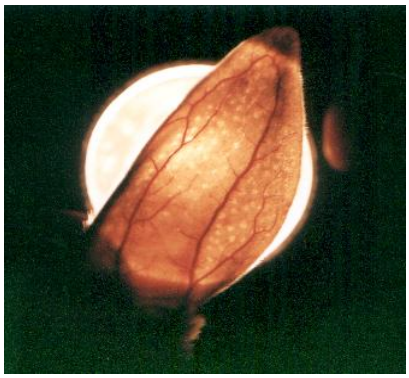

Figure 11 : large pores and the veins that run through their ear to help release heat and cool them down [13].

Environmental sustainability principles :

- ✓ Using a heat transfer to increase the efficiency of heat exchange and cooling

Architectural applications :

The same technique is used to cool engines efficiently by thermal exchange between the engine and the water as a heat conductor mediator to the external heat radiator which is cooled by thermal exchange with air. The same concept is used in cooling and heating the blanks of buildings, where a group of tubes that represent a heat exchanger through which a heat conductor liquid passes from and to machines of cooling and heating the building is buried by concrete slabs, see figure 12.

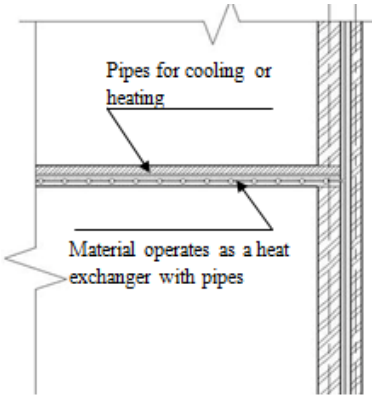

Figure 12: Pipes for cooling or heating

5.3. SHELTER OF THE ORGANISM

5.3.1. SHELTER FORM AND STRUCTURE OF THE ORGANISM

Some kinds of birds build its nests by heavy materials like the mixture of mud and straw. The entrance of the nest is located under side and directed up diagonally preventing sun rays and rains from entering. Nests also may be built vertically that looks like the buildings of multi storey apartments.

The nest contains two rooms, the first looks like a hall of entrance or thermal buffer zone, the second one is a protected place from external climatic circumstances which is suitable for hatchling. The broken shape of the entrance of the nest protects it from heated rays through day in the summer and decreases the effect of rains in the winter, see figure 13.

Figure 13 : Broken entrance of the birds` nests to protect the internal blanks from the sun [14].

Environmental sustainability principles :

- ✓ Protecting the important openings and blanks from external environmental conditions.
- ✓ Using thermal buffer zones.

Architectural applications :

Architects can design the building by thermal buffer zones principle, so that the presence in the vacuum, based on the exploitation during periods of the day, see Figure 14.

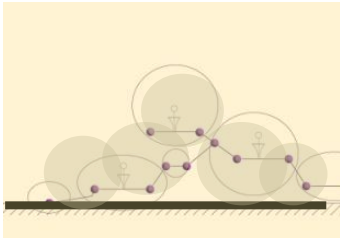

Figure 14 : thermal buffer zones principle**.**

5.3.2. SHELTER SITE OF THE ORGANISM

Animals make use of thermal gradation avoiding the high temperature of sandy earth affected by intensive sun radiation in the morning of those areas, as it reaches over than 70 ° C which is difficult for a lot of animals to live in or adapt to, as it results in lack of water in its bodies at a great rate [15].

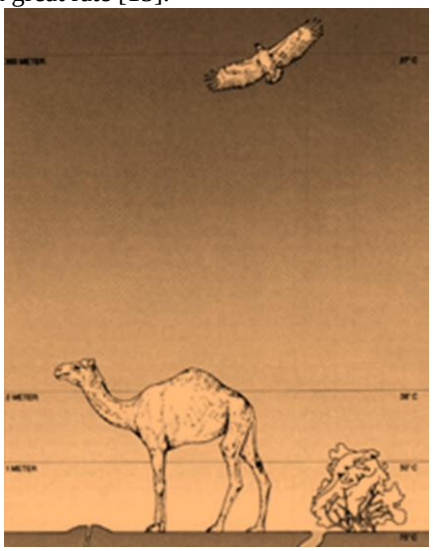

Figure 15 : The whereabouts of organisms during the day.

Environmental sustainability principles :

- ✓ Utilization from temperature gradation of air layers

Architectural applications :

Can design buildings warmer areas so that it is the ground floor, high above the surface of the earth to reduce acquisition radiated heat from the ground during the day and create a stream of air down the building, see figure 16.

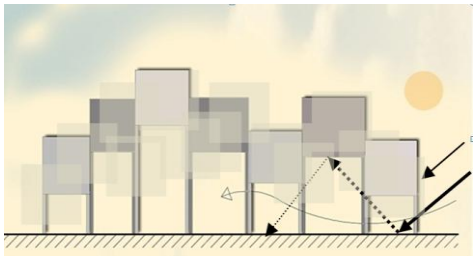

Figure 16 : Reduce the effect of sunlight reflected from the desert sands

5.3.3. CONSTRUCTION MATERIALS OF THE ORGANISM

The animal chooses the suitable materials of construction to achieve the features of thermal insulation for its habitat whether if it is fibril like straw in the nest of the birds to keep the temperature constant and to be suitable for eggs to be lied, or porous from dust and powder of curing woods like the habitats of the ants.

Some birds choose its habitats by making cavities inside the Cactus and the plants line the wall of that cavity as a reaction to decrease its lack of water with corky texture which birds exploit as an insulating material for its habitats. Thermal insulation materials that are used in construction are similar to the same spongy or light kinds [16], see figure 17.

Figure 17 : Bird Build Nest**.**

Environmental sustainability principles :

- ✓ Thermal insulation of external cover
- ✓ The means to conserve water

Architectural applications :

Use of materials for thermal insulation on facades can also design configurations on interfaces so that gives heat insulated .

Use all possible ways to preserve resources and energies existing the surrounding environment to project, see figure 18.

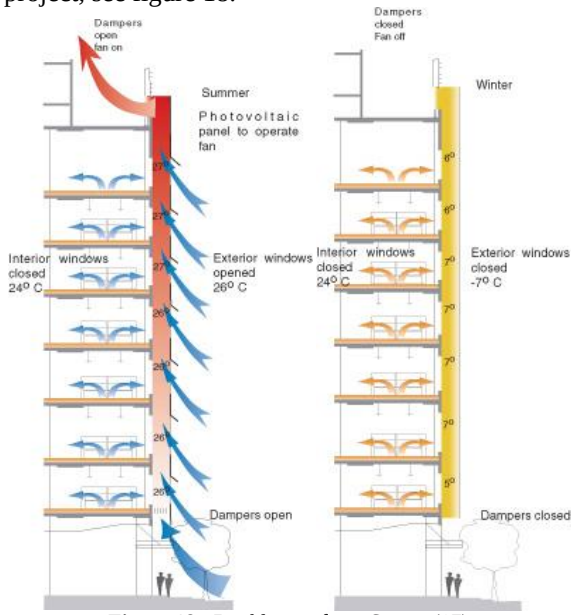

Figure 18 : Double interfaces System(17).

5.4. BIOLOGICAL CHARACTERISTICS

- Cooling by ventilation system in the nest of Termite settlement in hot zones is considered as a good example of cooling air system by carriage.
- In the middle of a group of branched tubes and pneumatic tunnels which are existed inside the nest.
- The top of the mound consists of a central chimney surrounded by an intricate network of tunnels and passages. Air travels through the porous walls into a series of small tunnels until it reaches the central chimney and rises up. When fresh air mixes with this warm air, the air cools and sinks down into the nest. This ventilation system constantly circulates the air and ensures that oxygen reaches the lower areas of the mound.
- The air goes down again to down parts of the nest to complete the organization of air cooling by utilization from the cold blanks of caves underground which the Termite digs under the nest to reach the level of ground water [18], see figure 19.

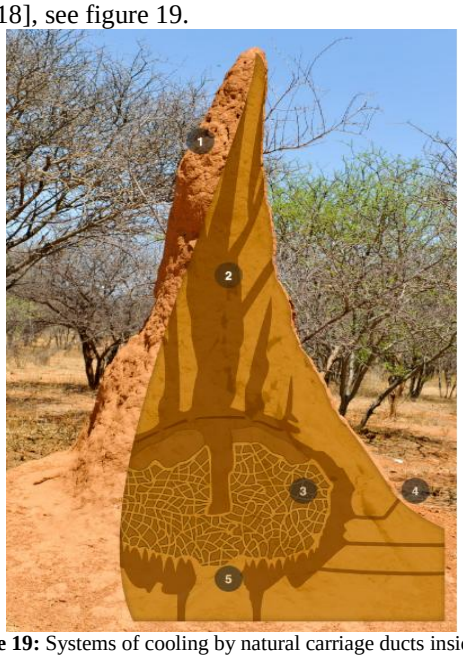

Figure 19: Systems of cooling by natural carriage ducts inside the Termite nest

1-The mound structure.
2-Central chimney surrounded by an intricate network of tunnels and passages.
3-The nest located at or below ground level. It's comprised of numerous galleries separated by thin walls.
4- At the base of the mound are several openings that the termites use to enter and exit the nest.
5- Air cooling by the cold blanks of caves underground.

Environmental sustainability principles :

- ✓ Cooling by ventilation by Natural convection currents (air physics)

Architectural applications :

That process is similar to the classical houses in desert areas in Iran,[19]. The hot air enters from the storm source and down directly to the blank of the basement which is near to a network of underground channels specialized in providing the building by water, where the temperature decreases and the blank becomes more moisture. Then the resulted air with moderated heat moves to the blank of the external yard of the building where the air is distributed all over the spaces around it. It is also noticeable that the system of air moving by natural carriage flows, inside the building in the morning in hot zones is totally relied on pulling the hot air from the top of internal blanks with the Providing of a source to supply those blanks by relative cooled air instead of it at the same time., if the distance between entrance and exit openings of air increases, the difference of the air pressure will increases and then the rate of airing by carriage as it is applied in the case of high blanks with top openings ad internal yard buildings of De Montfort university in England, where there is a stack ventilation to pull the air from the blanks like which is existed in Queen building.

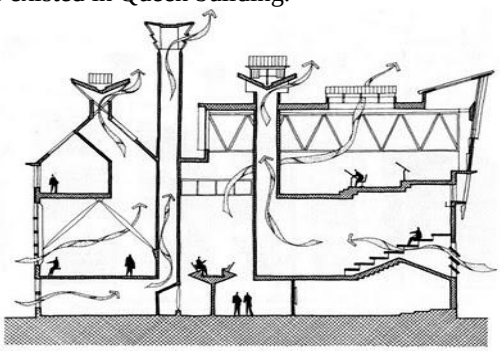

Figure 20: Queens Building - De Montfort University, Leicester - 1993 [20].

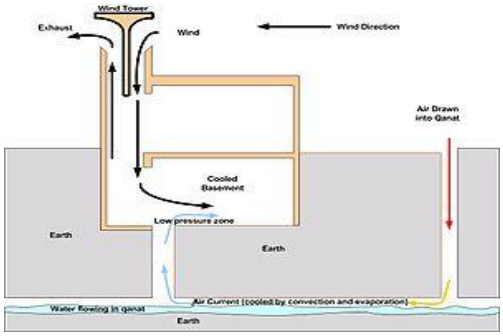

Figure 21: Section shows Iranian windcatcher, used for evaporative cooling of buildings .

6. HOW TO USE THE SECOND LEVEL TO INNOVATING ARCHITECTURAL APPLICATIONS?

After analysis the previous examples of living organisms adaptation ways, with the environment and conclusion environmental sustainability principles from nature, Then proposal architectural applications., Can answer a question How to use the second level to innovating architectural applications?., By using:

- Approaches for analyzing and studying Biomimicry (the second level) .
- Methodological framework of using the second level of the Biomimicry levels to Innovating architectural applications

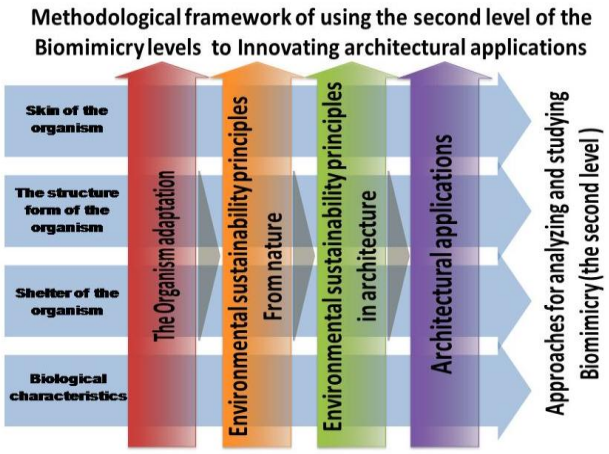

Figure 22: How to use the second level to innovating architectural applications?

Figure 23, proposes The integrated methodological framework of using the second level of the Biomimicry levels to innovating a new architectural applications

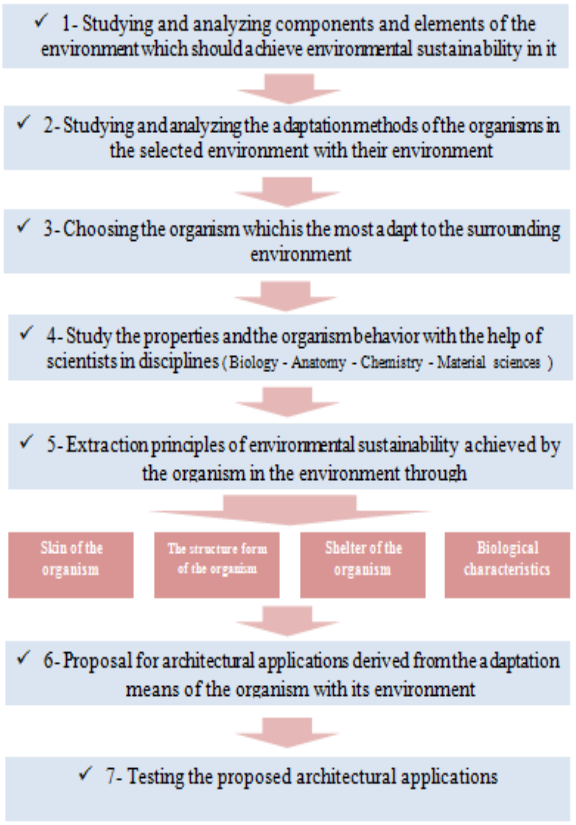

Figure 23: Diagram summarizing the presented methodological framework

7. Results and Discussions

- Nature is the perfect model and inspiration source for designing which could be analyzed and compared with specific design problems reaching some great solutions.
- The importance of activating measure role in architectural design and apply it on all levels of shapes, structural formation, biological systems and design conceptions.
- Nature's technology always very simple concepts and is highly efficient, healthy and cheap
- When all stages of the building design from the beginning of the idea to the implementation and occupancy. The importance environmental control sciences in fields of varied technical and natural sciences to create new imaginative ideas in architecture field.
- environmental design process of building with the solutions which are already applied living nature elements in the area.
- The concepts of natural sciences which are available in each region, through time, have also been introduced during research and are considered as an important entrance added to design and basis can beginning of it.
- The principles which apply energy saving systems and save the sources of water, energy and food for plants, and in animals habitats, such as insect colonies. This principles can be utilized in constructing compounds.
- Form/shape does really affect environmental performance and in nature find many beautiful shapes and simple. Without the costing and created by Allah for a reason, not in vain and thus give the highest environmental performance.
- The Environmental sustainability principles from nature have been classified to :
    - ✓ The protection from direct sun rays.
    - ✓ Thermal insulation of external cover.
    - ✓ The provision of water needs.
    - ✓ Self-shading systems.
    - ✓ Protection from solar radiation.
    - ✓ Protecting the important openings and blanks from external environmental conditions.
    - ✓ Using a heat transfer to increase the efficiency of heat exchange and cooling.
    - ✓ Using thermal buffer zones.
    - ✓ cooling by increasing prone area for ventilation.
    - ✓ Utilization from temperature gradation of air layers.

- ✓ Directing the entrances in the direction of the sun to achieve maximum heating.
- ✓ The means to conserve water.
- ✓ Cooling by evaporating.
- ✓ Waste disposal.
- ✓ Interaction with the surrounding climatic conditions.
- ✓ Utilization from saving energy process.
- ✓ Responsiveness and self adjustment with environmental variables.
- ✓ Cooling by ventilation by Natural convection currents (air physics).

- That as far as we go away from basic rules of Nature, as difficult it gets to sustain any system."Whether it is construction of a building - compound - greater or less levels
- Research concluded to **"The methodological framework of using the second level of the Biomimicry levels to innovating a new architectural applications to support environmental sustainability"** .

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