

## **BIOMIMICRY IN ARCHITECTURE**

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**Abstract:-** This research aims to explore the latest holistic approach of one of the latest engineering technology in architecture –Biomimicry in reference to impact and influence it has on architecture as science and the society in general. Investigation will be done by analyzing economic, environmental and scientific changes that Biomimicry design may provoke. Methodology used in this article is comprised of previous theories and models in other articles, and also implications of the model for social and economic aspect. This study examines Biomimicry theory and presents a model which is most applicable to architecture. It is expected that this research will provide information on extend of impact that architectural design will have on mentioned areas and therefore create buildings that provide greater comfort to the inhabitants.

**Keywords:-** Biomimicry, sustainability, social inclusion,nature inspired design, smart materials.

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### **I. INTRODUCTION**

The need for analyzing process of biomimicry is multiple because it is being applied in almost every scientific and social field of work and research. Since architectural design is primarily done to satisfy basic human need for shelter, the manner in which it is done has a great social impact and vice versa. But manner in which biomimicry architectural approach will influence life of inhabitants of such architecture is still unknown. Trend of returning back to the nature in the sense of creating more nature friendly buildings is gaining momentum, with biomimicry being the most advanced in the line of holistic approaches to design.

It is important for architectural design to consider social aspects for it will ultimately influence people and behaviour, relationships and influences between entities and its environment. It is crucial for architects who follow biomimicry approach to have feedback from the users of products of architecture, in order to evaluate if this kind of design satisfies its basic function – to be used by the inhabitants. As some of us reflect upon the challenge of creating more equitable life on earth, our focus is shifting; from artefacts to systems, from transactions to relationships, from design as craft to design as thinking, from habits of destruction to a awareness of the need for resilience.

This research aims to summarize basic principles and advances in field of biomimicry architectural design and examine all dimensions that it will inevitable influence, environment, economy and science, in order to make a prediction on how will this kind of architecture affect the surrounding community or life of building inhabitants in general.

Methodology of this paper will be examination of latest researches and estimations in the mentioned areas. Each dimension, environment, economy and science, will be inspected in reference to the manner in which it will influence human living.

It is expected that this research will provide information related to the magnitude of change that biomimicry design will have on human living. Also it will identify areas of economy, science and environment that architecture needs to take into consideration in order to improve its performance and create nature responsible buildings. It will provide information on how biomimicry design can create architecture with maximum comfort for the inhabitants with the least impact on the environment, while being economically efficient.

### **II. METHODOLOGY**

In order to define quality ideas we used qualitative descriptors in our data presenting. Using the method of in-depth interview we didn't have any limitations. Our only goal was to explore new perspectives about biomimicry in architecture. We conducted interviews successfully and rated all candidates. Review of all candidates was done thoroughly and objectively.

Our questionnaire is made up of three sections, which are defined in variables. Questions aim to inspect relation between defined variables and sub variables. The first two sections have five questions each while the last section has four questions.

Since this is a new field of research in architecture and is still almost completely unfamiliar even to the local professionals, each question is answered with a multiple choice of positive or negative (YES/NO). Survey sample was done on 100 respondents. These answers are evaluated on a percentage basis for each question indicating how many of which each question contains.

### III. THEORETICAL BACKGROUND

#### 3.1. Related definitions about the topic

We can partly understand the definition of the term biomimicry from the literal translation of word biomimicry, bios - life and mimesis - to imitate. Among the first definitions of biomimicry is that it is an "innovation inspired by nature" (Benyus, 1997). She stated that "*Biomimicry is the conscious emulation of life's genius.*" Biomimicry is also defined as "*mimicking the functional basis of biological forms, processes and systems to produce sustainable solutions.*" (Pawlyn, 2011)

Biomimicry is a relatively new discipline in architecture and engineering, developed in the last thirty years, in practical and philosophical sense. Development in technology and material science enabled growth and implementation of ideas of Biomimicry.

There are visible proofs in contemporary design that using nature, as source of ideas, can lead to the higher level of sustainability. Biomimicry definitions indicate that a radical approach to design is inevitable.

#### 2.2. Historical evaluation of the idea

Since the very beginning of human existence we have fought to control, use, dominate and gain independence from nature. Our struggle began ten thousand years ago with the Agricultural Revolution, when we liberated ourselves from hunting and gathering and learned to stock food to last longer. Scientific Revolution increased the momentum of the process but it was not until Industrial Revolution, when machine replaced man, that humans felt ready to dominate the world. We were finally able to create internal comfort in any climate, travel long distances in a short period of time, produce food independent of natural conditions. The consequence of it, from architectural perspective, is that an office building in New York looks exactly the same as an office building in Moscow or Singapore. By alienating ourselves from our immediate surroundings and therefore from respective cultures, we believe that we have gained our autonomy from nature. But, at what price?

Despite the technology, modern gadgets and machines that have undoubtedly made our lives easier, at least in the short run, we are still inseparably bound to the laws of nature.

*The most irrevocable of these laws says that a species cannot occupy a niche that appropriates all resources--there has to be some sharing. Any species that ignores this law winds up destroying its community to support its own expansion.* (Benyus, 1997)

At a current world population of 7 billion and growing, with present unsustainable habits, scientists have concluded that we have used almost all of our ecological supplies. Man must go back home, back to the forest. Once the modern science started examining the creations of nature it was obvious that all that we so proudly believe we've created with our unprecedented ingenious, has already been made in nature, only in a much more elegant, smarter way, with no damage to the planet.

*Our most clever architectural struts and beams are already featured in lily pads and bamboo stems. Our central heating and air-conditioning are bested by the termite tower's steady 86 degrees F. Our most stealthy radar is hard of hearing compared to the bat's multifrequency transmission. And our new "smart materials" can't hold a candle to the dolphin's skin...*(Benyus, 1997)

Humbled with the cognition that our co species, in comparison with we see ourselves as superior, function with natural limitations in harmony, homo sapience finally understood that we should examine the nature not to abuse it but to become, once again, a part of it.

The concept of sustainability, green or eco-friendly has become a catchphrase in almost every scientific field in the past few decades. Although biomimicry shares the same good intention with green design of preserving the planet, it aims to go one step further and create not only a more sustainable but even regenerative

'living building', materials and machines that not only do not harm the nature but exists in perfect symbiosis with it.

The best known biomimicry invention is the airplane which first took off in 1903. However, it was Leonardo da Vinci in the 15<sup>th</sup> century who tried to imitate the bird flight and construct 'flying machine'. Though the concept of imitating nature is quite old it is not until 1960s that the term biomimicry appeared in scientific literature, especially being popularized in the 1980s in material science and production. In 1997 when Janine M. Benyus published a book called "*Biomimicry: Innovation Inspired by Nature*", biomimicry became well known. She devised a set of questions useful to measure our designs and innovations against in order to determine the level of biomimicry (Bob & McLennan):

- Does it run on sunlight?
- Does it use only the energy it needs?
- Does it fit form to function?
- Does it recycle everything?
- Does it reward cooperation?
- Does it bank on diversity?
- Does it utilize local expertise?
- Does it curb excess from within?
- Does it tap the power of limits?
- Is it Beautiful?

Today Biomimicry is widely studied in material science, in automotive industry in engineering and architectural design.

### 2.3. Fundamental theories and models about the topic

To understand the theory of biomimicry we must look at the other theories that had been developed with similar objectives, such as nature based design. Natural processes and unity of eco-system is what architecture should aspire. Basis for realization of the biomimicry theory are technological achievements, biotechnology and nanotechnology. If we look at the biomimicry from sociological aspect we can say that is absolutely inclined to nature and human needs. Biomimicry is not only "a new way of viewing and valuing nature" it is also a new way of valuing human needs. It is based on following frameworks:

**1. Sustainable Development** and green design concepts is the foundation of biomimicry. Architectural professional accepted the fact that as a society's economic status improves, its demand for architectural resources — land, buildings or building products, energy, and other resources — will increase. This in turn increases the combined impact of architecture on the global ecosystem, which is made up of inorganic elements, living organisms, and humans. The goal of sustainable design is to find architectural solutions that guarantee the well-being and coexistence of these three constituent groups. (Kim, 1998)

**2. Theory of Natural Capitalism** is a new business model that involves four major and synergistic elements (P., Lovins, & Hunter Lovins, 2000)

**Radical resource productivity** - Radically increased resource productivity is the cornerstone of natural capitalism because using resources more effectively has three significant benefits: It slows resource depletion at one end of the value chain, lowers pollution at the other end, and provides a basis to increase worldwide employment with meaningful jobs.

**Ecological redesign** Reducing the wasteful throughput of materials—indeed, eliminating the very idea of waste—can be accomplished by redesigning industrial systems on biological lines that change the nature of industrial processes and materials, enabling the constant reuse of materials in continuous closed cycles, and often the elimination of toxicity.

**Service and flow.** This calls for a fundamental change in the relationship between producer and consumer, a shift from an economy of goods and purchases to one of service and flow. In essence, an economy that is based on a flow of economic services can better protect the ecosystem services upon which it depends.

**Reinvestment in natural capital.** This works toward reversing worldwide planetary destruction through reinvestments in sustaining, restoring, and expanding stocks of natural capital, so that the biosphere can produce more abundant ecosystem services and natural resources.

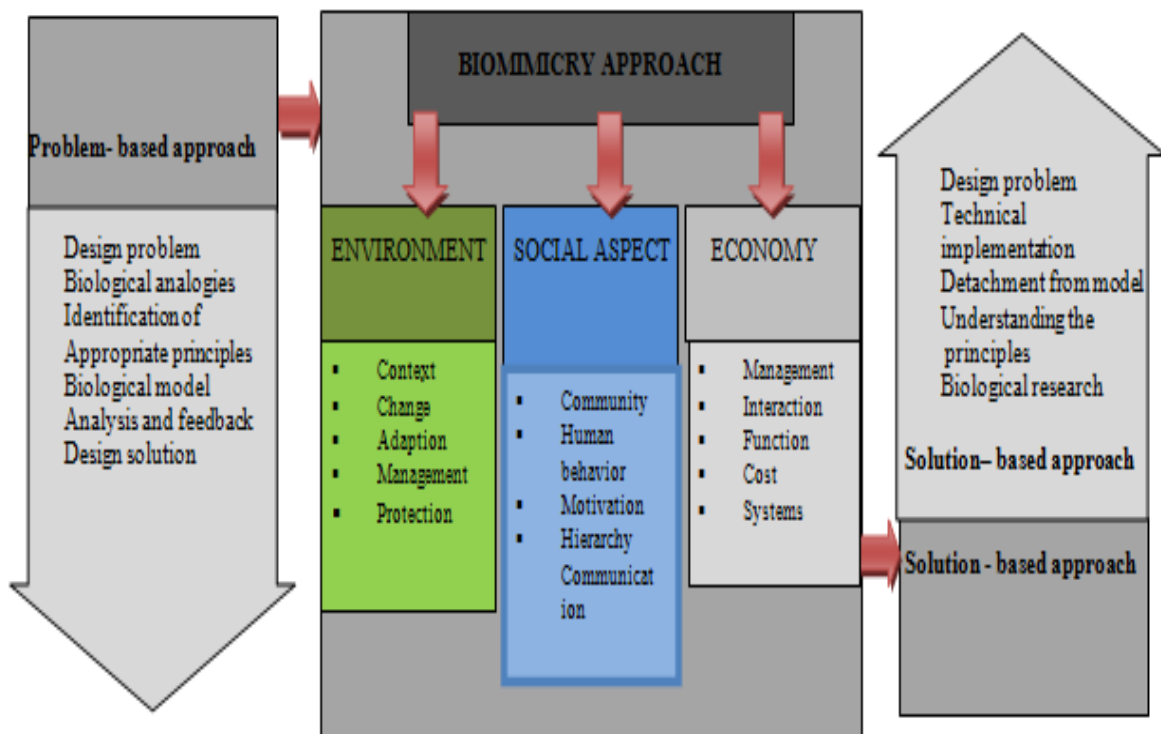
**3. Cradle to Cradle or Regenerative Design** is a holistic economic, industrial and social framework that seeks to create systems that are efficient and essentially waste free. It promoted the idea of industry protecting and enriching ecosystems and nature's biological metabolism while also maintaining a safe, productive technical metabolism. It is based on three fundamental ideas Waste Equals Food, Use Current Solar Income and Celebrate Diversity. (Strandesen& Bjorn)

Biomimicry theory differs from other theories which are bio-oriented. Very often design approaches that are bio-assisted are classified under the theory of biomimicry. Biomimicry in design is in many ways different from what it is in other theories. What makes biomimicry different from other theories is quest for solutions in nature. Biomimicry is natural symbiosis of form and process where nature is not only a source of aesthetic value.

**2.4. Proposed Model**

With the Industrial Revolutions mankind has alienated itself from nature and fully indulged in the blessings of, at that time, emerging modern technologies. We are creatures of making and acquiring; most of the lessons from Biomimicry pertain to the manufacture of physical things. We remember the conch shell, made as strong as ceramic without heating the ocean. Spider silk tougher than nylon filament made without waste or petrochemicals.

These examples and others have inspired designers and manufacturers to think differently. But stepping away from physical things we realize that this type of design will have great impact on economy, environment, science and technology, and consequently it will impact the lives of people – social impact. However if, as our study **suggests**, biological functions and processes are less reliant on energy, then the implications could be very significant.



**Figure 1. Biomimicry approach model**

Since concept of biomimicry approaches to architectural engineering and design is relatively new, there are numerous approaches to the matter each with its own benefits and drawbacks. Specific principles of ecosystem biomimicry for architecture have been deduced through a comparative cross-disciplinary review. It can be concluded that the incorporation of specific principles of biomimicry in architectural design we should reach high level of sustainability. All articles emphasised that understanding of biology and ecology into architectural design will be significant in the creation of a built environment that contributes to the health of human communities.

| No. | Variables     | Sub variables   | References   |
|-----|---------------|---|--|
| 1   | ENVIRONMENT   | 1. Context<br>2. Change<br>3. Adaption<br>4. Management<br>5. Protection                | (Benyus, 1997)<br>(Pawlyn, 2011)   |
| 2   | SOCIAL ASPECT | 1. Community<br>2. Human behaviour<br>3. Motivation<br>4. Hierarchy<br>5. Communication | (Holbrook, Clark, Moore, Overson, Penick, & Smith, 2010)<br>(Cole & Brown, 2009)<br>(El-Zeiny, 2012) |
| 3   | ECONOMY       | 1. Management<br>2. Interaction<br>3. Function<br>4. Cost<br>5. Systems                 | (Global Biomimicry Efforts an Economic Game Changer, 2010)<br>(Koho, 2012)                           |

Table IV Variable Sub-Variable Table

### Interview Questions And Biomimicry In Architecture Survey

In order to evaluate how biomimicry in architectural design influences environment, economy, and science, and accordingly make evaluation on how this kind of architecture affects the surrounding community or life of building inhabitants in general, please fill out the following survey.

1. Do you think that the context in which the building is designed affects biomimicry design?
2. Does biomimicry change the environment?
3. Does design approach need to be adapted to the immediate environment in which it is constructed?
4. Is biomimicry design architectural management of natural resources?
5. Is biomimicry design the best solution for protecting the environment?
6. Can biomimicry architectural design enhance sense of community and social belonging?
7. Do you think that human behaviour is in any way affected by the built environment?
8. Can biomimicry design improve communication within the inhabitants of such buildings?
9. Is biomimicry architecture available only for a certain social hierarchical group?
10. Do you think that biomimicry architectural design can be a positive motivator in social sense?
11. Is economy in any way affected by management of biomimicry architectural design?
12. Is interaction between science and biomimicry design influenced by the economy?
13. Is cost of the building affected by its function and therefore by the subject of imitation from the nature?
14. Are there any systems in the nature that can be used as models for building economy?

#### 3.1. Data

Process of interview was carried out by selecting the interviewees and conducting the interview. We made in-depth interviews as a qualitative research technique with the focus group of people who have professional background who work in the fields of sustainable and environmental architecture. We interviewed architects, civil engineers and specialist for engineering material and technology.

We interviewed 10 people and collected data for seven days. On the very beginning we made selection of interviewees by their professions. Despite of professional background we had two different types of interviewees. First group of interviewees work in practice and they are constantly exposed with environmental problems. Second group of interviewees are academicians and they based their knowledge through the theoretical facts. We made selection inside of focus group because of better understanding of final data's.

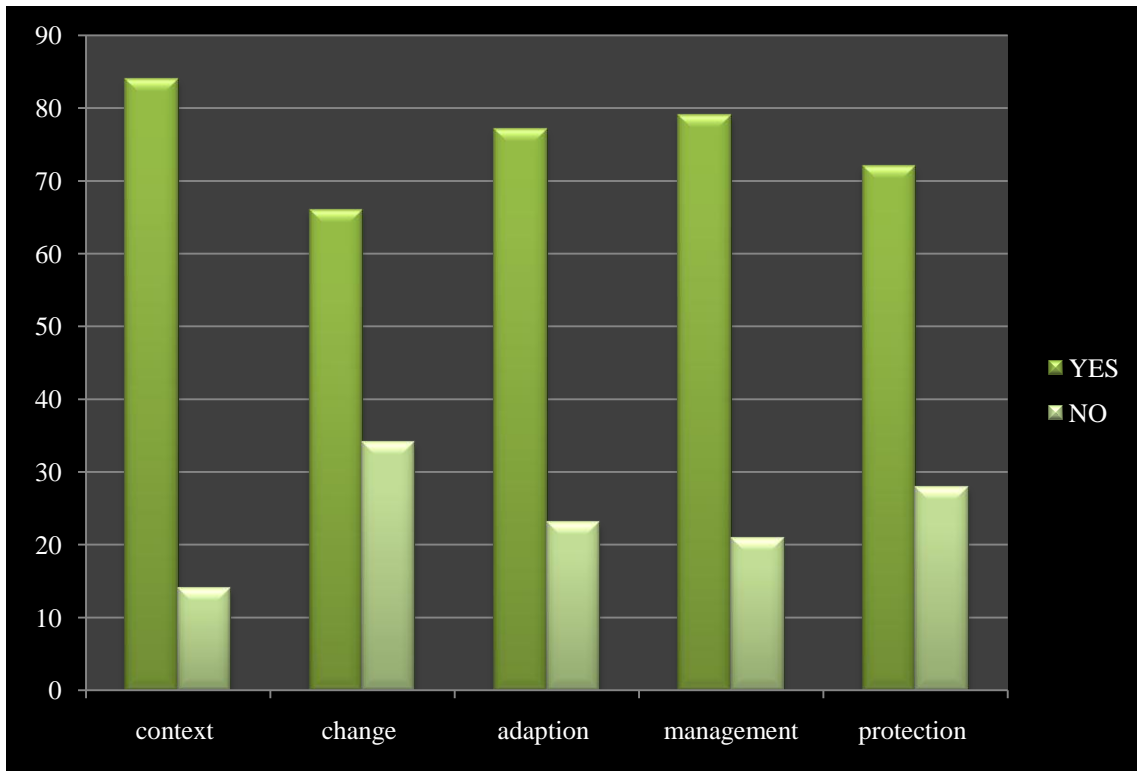
## IV. RESULTS

### 4.1. Interview Results

#### ENVIRONMENT

The prevalent feeling was that biomimicry can change built environment in a positive way and that responsible environmental effect is presented by biomimicry design.

“Nature inspired design can be seen as a windows for the sustainable future. The environment in which we build is our responsibility. Biomimicry has potential and can become new way of sustainability within design. Environmental inspired design can support architecture of new generation through biomimicry.”  
 (MajdaHodzic, architect in company, May 25, 2013)



Graph1.Survey results

**SOCIAL ASPECT**

Participants strongly felt that nature inspired design can enhance sense of community and social belonging.

“It is necessary to provide more assistance in implementing sustainable way of life in society. Biomimicry is the solution how we can improve society with this type of design. Biomimicry is positive motivator in social sense and we should strive to implement not only natural process in design but also in our life’s. It cannot be neglected that nature is perfect model for human comfort. “  
 (VesnaHercegovac-Pasic, academicians, May 25, 2013)

**ECONOMY**

Most participants agreed that biomimicry design is influenced by economy and that we should aspire for sustainable models in building economy.

“Economy has huge impact in every aspect in architectural design. It confirms our first steps in design process, location for building, material selection and especially technique that we will use. Emulating natural process and applying them in architecture, requires high technology and it is enormous challenge and huge economical investment. “

(Maja Halilhodzic, architect in company, May 20, 2013)

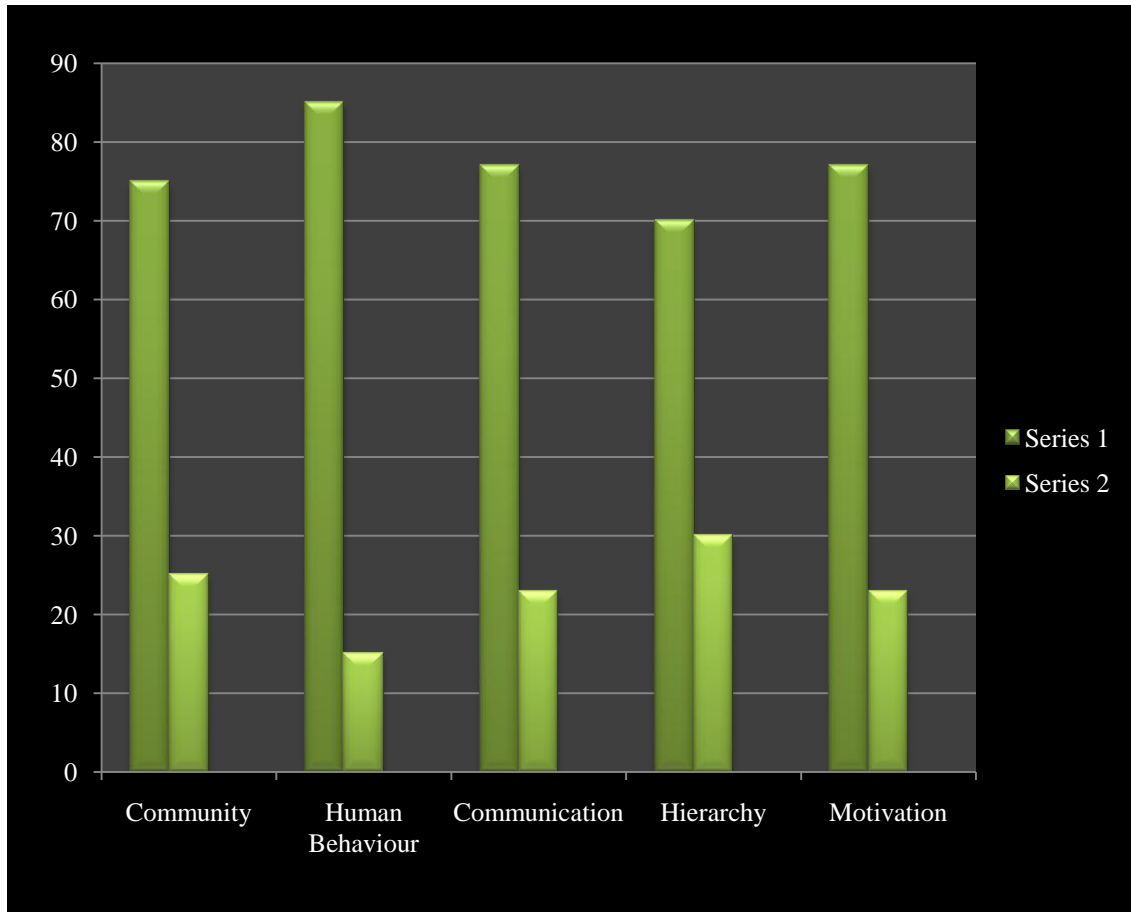
**4.2. Survey Results**

According to the results obtained from the first group of questions concerning environment and the impact of biomimicry architectural design on environment and vice versa, from our questionnaire, the following graph displays the results

In Graph 1. We notice that great majority of the architectural professionals circled the positive answers option, from which we can conclude that it is believed that implementation of biomimicry design has great impact on the environment and is one of the ways to improve sustainability in design and construction industry. The negative response to the change that biomimicry design will have on nature is under 35 % of the total 100 responses.

**SOCIAL ASPECT**

According to the results obtained from the second group of questions concerning social aspect of implementation of biomimicry design from our questionnaire, the following graph displays the results.



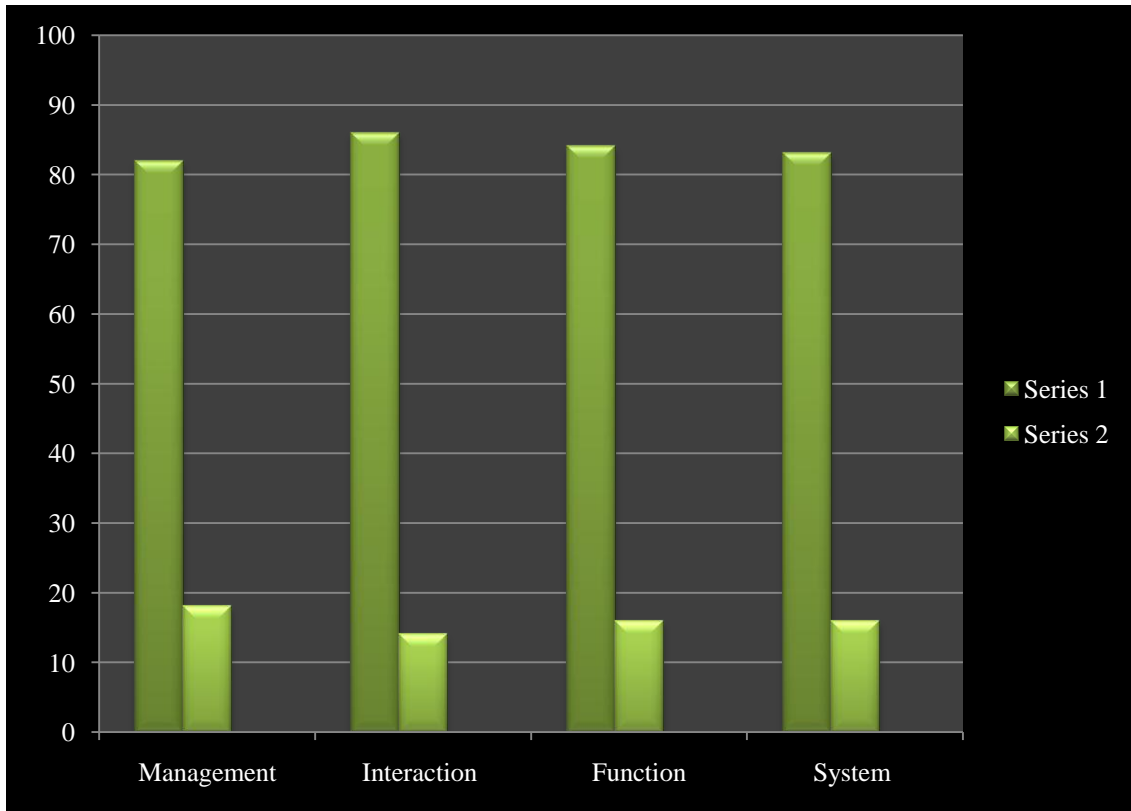
**Graph 2.Survey results – social aspects**

In the second segment group the participants were asked questions about the possibility and the extent of change that implementation of biomimicry design may have on social aspects of living. We can say with assurance, from Graph 2, that the level is quite high considering that over 80 % of participants answered positively to the question will human behaviour be influenced by biomimicry built design. Only 30 % answered negatively to whether biomimicry design is available to a certain hierarchy group, which means that most professionals believe that it is about design layout rather than expensive technology that this type of sustainable architecture is relying on. In addition to that 77% of participants believe that biomimicry design will be a positive motivator in social sense.

**ECONOMY**

According to the results obtained from the third group of questions concerning economic indicators of biomimicry architectural design from our questionnaire, the following graph displays the results.





**Graph 3. Survey results – economical aspects**

In the third group the targeted participants were asked how biomimicry design impacts economy and about economic indicators of biomimicry design. From the Graph 3 we can see that number 84% of participants believe that function of the building and therefore the system imitated from the nature will affect the cost of the building. In addition to that 83% of professional believe that even economic systems can be copied through biomimicry design. On the other hand only 16% of participant's claims that interaction between science and biomimicry design is influenced by the economy, while 82% of participant believes that management has a great role to play in the process of biomimicry architectural design.

## V. DISCUSSION

This paper, through literature review and results of our investigation, confirms the positive quest of Biomimicry, to help humans evolve, learn to adapt to the natural rhythms and cycles of the earth, to become sustainable in every aspect of human life.

The survey confirms that Biomimicry research is gaining momentum even among local professional in architecture, when it comes to environmental sustainability. Our literature review has shown many examples of scientist who are naming specific natural organisms that are able to perform in a way that is applicable to building systems. This is in positive relation with the results of our surveys and interviews where large majority of participants confirm that there are models in the nature that can be used as models for controlling certain functional systems within the building and therefore decrease the level of pollution caused by the construction industry.

When it comes to social effects that biomimicry has, our literature review indicates that learning about positive solutions and ways to take meaningful action are powerful ways to rejuvenate optimism. The integration of the concepts of biomimicry can accomplish these two goals simultaneously. Though biomimicry is not a familiar term to many, and there has not been formal integration of this concept into education or environmental science, this survey demonstrated the potential positive social impact of biomimicry. The interviews, as well as literature review indicates the impact that built environment has on social masses. Biomimicry designs are bringing us closer to our inborn habitat – the nature, and that it helps us integrate closer to nature has a positive social impact on the users of design.



In terms of Economy our literature has shown examples of businesses that are adapting the ideas of eco-industrialism because it gives credit to those who are trying and hope to those who want to keep this trend going. The survey confirms that nature has shown us that if you are not able to adapt then you will be edited out of the gene pool; humans are not immune to the laws of nature. If our extracting and polluting industries do not adapt, then there is no chance for human survival and no economy will flourish. When the resources are no longer there, neither are the products. It is time to bring back the interconnectedness of the world and for people to understand the earth's cycles, the processes and our part in them. Only then will we learn to move forward.

Our Literature has shown that the direction of sustainable development is Biomimicry design due to its positive implications not only on the environment but on economy and social development. Our survey and interviews confirm that local professionals recognize this fact and do indeed give great notice to it.

## **VI. CONCLUSION**

This paper can be used by the local government to develop local strategies by a set of global strategies. It can be used as guidelines for living well on this planet, drawn from deep patterns found in strategies across all life forms on the planet. Analysis of biomimicry design principles and its impact can be used as the framework for designing new cities, "remodelling" old ones, and in creating new systems based planning tools for governments.

Local companies can contribute in the paper for it underlines two important challenges that arise from this biomimicry analysis: (1) Recognizing the fields, problems and applications for which local biomimicry design has or can have an impact; (2) Understanding the basic steps required for a successful and deep fusion of biological and engineering knowledge.

Architectural and engineering professionals can understand from this paper that biologically inspired design is typically thought of as being problem based, that is, motivated by the desire to generate an improved or different solution to a particular technical challenge. The inversion of this approach is to take biological 'solutions' as a starting point and seek out particular technical challenges for which the system is appropriate. The paper suggests that solution-based approaches are much less widely employed. It seems wise to ensure that intellectual exchange between biology and engineering is bidirectional; we may be missing considerable opportunities by inadequate support of both perspectives. Interestingly, solution-based approaches may encourage the application of biological principles in ways that would not be immediately obvious when viewed from a problem-based perspective.

A clear message of our paper is that translating biological principles into human devices or processes requires considerable technical proficiency, which will inevitable have impact not only on science but as well as on economy, environment and social development. However, the paper also shows that pure technical achievements are not the sole arbiter of success, and in fact may not always be the most important factor. A reasonable perspective is that the success of biomimicry design and the magnitude of its impact one environment, economy and social development, depends most critically on establishing the appropriate analogy between the problem to be solved and potential biological model systems. The strength of this analogy will in large measure determine how appropriate the resulting principles are when extracted from biology, and this step deserves at least as much analysis as the subsequent attempts to understand and implement principle.

## **VII. LIMITATIONS OF THE RESEARCH**

Greatest limitation of our research is that Biomimicry is an emerging discipline and therefore still in developmental faze. Though the field of architecture has consistently been the most intrigued by biomimicry, and there are numerous commercial products and several individual buildings that have demonstrated lessons from nature. Yet, within the built environment, biomimicry is still in its infancy. Also there are only a very small number of building projects throughout the world that have truly integrated biomimicry at the macro scale. When it comes to local level, number of research and the very awareness is not developed, but obviously there is a positive attitude towards moving contemporary sustainable design towards biomimicry development.

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