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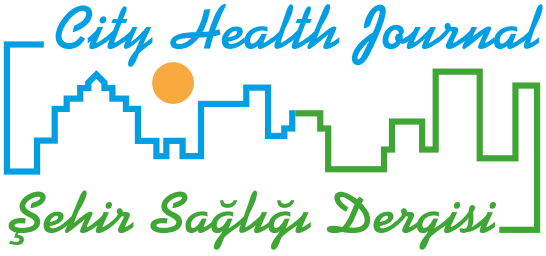
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ARAŞTIRMA / RESEARCH ARTICLE

Architectural Design Based on Carbon Footprint for Sustainable Cities

Sürdürülebilir Şehirler İçin Karbon Ayak İzine Dayalı Mimari Tasarım

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Abstract

After the industrialization of architecture, the increasing carbon footprint of the built environment requires greater consideration of small eco-design principles in architecture. Because of their role in design, architects have a decisive role in all stages of the life cycle of buildings. Therefore, for a built environment project that aims to contribute to the reduction of carbon footprint, it is of great importance to consider the direct/indirect greenhouse gas emissions originating from every stage of the life cycle of buildings. Thus, architects can make a great contribution to the sustainable architecture process by using the available options regarding material supply, energy flow, land use and ecological factors in their projects. In this study, architectural applications/eco-design methods that can be used for low environmental impact and contribute significantly to the reduction of global greenhouse gas emissions (carbon footprint) are discussed.

Keywords: Eco-design, Climate Change, Carbon Footprint, Sustainable Architecture, Built Environment.

Özet

Mimarlığın endüstrileşmesinin ardından yapılı çevre kaynaklı karbon ayak izinin giderek artması, küçük karbon ayak izini hedefleyen eko-tasarım ilkelerinin mimaride daha çok dikkate alınmasını gerektirmektedir. Çünkü tasarımdaki rolleri nedeniyle mimarlar, binaların yaşam döngülerinin tüm aşamalarında belirleyici bir role sahiptirler. Bu nedenle karbon ayak izinin küçültülmesine katkıda bulunmayı hedefleyen bir yapılı çevre projesi için binaların yaşam döngülerinin her aşamasından kaynaklanan doğrudan/dolaylı sera gazı emisyonlarının dikkate alınması büyük önem taşımaktadır. Böylece mimarlar, malzeme tedariki, enerji akışı, arazi kullanımı ve ekolojik faktörlere ilişkin mevcut seçenekleri yapacakları projelerde kullanarak sürdürülebilir mimarlık sürecine büyük oranda katkı sağlayabilmektedirler. Bu çalışmada, küresel sera gazlarının emisyonunun azaltılmasına (karbon ayak izi) önemli oranda katkı sağlayan çevresel etkisi düşük mimari uygulamalar/kullanılabilecek eko-tasarım yöntemleri tartışılmıştır.

Anahtar Kelimeler: Eko-tasarım, İklim Değişikliği, Küresel Isınma, Sürdürülebilir Mimarlık, Yapılı Çevre.

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1. INTRODUCTION

Natural ecosystems are cyclical, stable and productive areas that can produce maximum output using minimum matter and energy. On the other hand, artificial ecosystems such as cities that have maximum material and energy requirements using natural ecosystem services are linearly progressive, unstable and inefficient. Because of this process, exceeding the carrying capacity of our planet has become "unsustainable" (Türe & Türe, 2021a). In order to make this effect measurable and visible, the "Ecological Footprint" indicator has been designed. The "Carbon Footprint" parameter, which expresses the amount of greenhouse gas emissions (GHC), has the largest share in this indicator (Türe, 2013). It is now a scientific fact that the large carbon footprint resulting from fossil-based energy consumption is the main cause of global warming and climate change (Eggleston et al., 2006). This situation has brought with it international initiatives (Kyoto, Paris, Sustainable Development Goals and EU Green Deal etc.) including legal sanctions for the production of goods and services with smaller carbon footprints of all sectors (Türe & Türe, 2020; Türe & Türe, 2021b).

The construction industry is also responsible for approximately 40% of world energy consumption and 1/3 of global greenhouse gas emissions (carbon footprint) during the building life cycle (Wang & Tan, 2012). This situation necessitates a holistic approach to life cycles in order to reduce the environmental impacts of buildings, especially all greenhouse gas emission sources (Türe, 2014a). The role of architects in design is decisive in all life cycle stages of buildings. Thus, the importance of architectural projects based on small carbon footprints has increased in order to reduce the negative environmental impacts caused by constructions. However, the success of this process requires not only architects and architectural design, but also all sectors and actors related to construction to adopt small carbon footprint-oriented building technologies and innovations (Türe, 2014b).

Planning the buildings according to eco-design principles will contribute to both the reduction of the carbon footprint and the construction of buildings that are resistant to climate events. In this study, architectural applications/eco-design methods that can be used for low environmental impact and contribute significantly to the reduction of global greenhouse gas emissions (carbon footprint) are discussed.

2. METHODOLOGY

The eco-design approach in the low-carbon built environment is the application of architectural and design principles to ensure positive social and economic development while minimizing ecological and environmental impact in their projections. The material of this study is the buildings designed with low carbon footprint and environmental impact, and the method is to evaluate the gains of these buildings throughout their life cycles according to eco-design in the light of relevant literature information (Bennett, 2007; Monahan & Powell, 2011; Türe, 2017; Fenner et al., 2018; Türe & Ar, 2019; Sipahi & Kulözü-Uzunboy, 2021).

3. FINDINGS AND DISCUSSION

The increasing carbon footprint of buildings after the industrialization of architecture requires a closer look at the architectural design process and a re-evaluation of eco-design principles.

3. a. Architectural design and ecology

Unfortunately, it is seen that the effects of architectural design and applications on the environment have been ignored in the past. Because the ecological and environmental effects of the design have not been fully taken into account in architecture. For this reason, many applications have been made with unsustainable architectural design principles. At the end of the twentieth century, with the understanding of the power of design and its importance in terms of sustainability, an architectural design movement that makes use of ecological processes and functions has started.

Since its emergence, the science of ecology has been the basis of understanding the processes in nature, managing environmental resources and sustainable development. Expectations to find solutions to environmental problems in order to protect the ecosystem have increased the search for sustainable design and application based on ecological knowledge. Thus, while ecology knowledge provides information and guidance to this process, the creative potential of eco-design has begun to offer sustainable solutions to environmental problems.

The increasing interest in the concept of sustainability due to ecological and environmental problems in the world has found a response in the field of architecture as well as in many disciplines. All buildings, artificial landscapes

and built environment elements in the world are products of architectural design. The increase in the environmental effects of buildings, especially the carbon footprint, brings with it a new definition of architecture (ecological architecture) that takes into account the climate and the local environment in the architectural design process (Sevim & Özipek, 2019).

The eco-design approach is to apply architectural and design principles in a way that will ensure positive social and economic development while minimizing the ecological and environmental impact in its projections. Thus, it can create an interface that inevitably connects culture and nature with material exchange, energy flow and land use options. In addition, turning the design into a product always requires benefiting from an ecosystem.

3.b. Carbon footprint assessment in architecture

Carbon footprint assessments in architecture require preliminary assessments that consider every stage of the building's life cycle, starting from the design stage, and can shed light on the environmental performance of buildings holistically. For this, the following are necessary;

- Understanding the effects of the construction industry on climate change by researching and determining the effects of the built environment on the carbon footprint,
- Understanding and adapting to the effects of extreme weather events related to climate change on the built environment,
- Using eco-design methods and tools to build healthy, safe and durable structures that are compatible with the ecosystem.

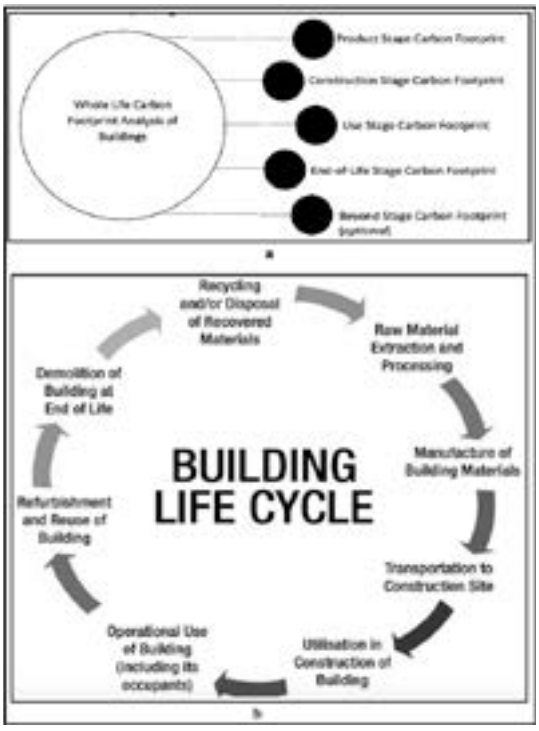
For a built environment project that aims to contribute to the reduction of carbon footprint, it is of great importance to analyze and consider direct/indirect greenhouse gas emissions and carbon sequestration capacities at all stages of the building life cycle (Table 1).

Table 1. Greenhouse gas emission sources and capture capacities of buildings (Srinivasan & Lakshmanan, 2013)

EMISSION SOURCES IN BUILDINGS	• Energy Use • Material Use • Water Use • Land Use • Transportation Use • Chemical Processes • Construction Processes • Fugitive Gas Leakage • Storage And Distribution • Waste Processing • Other Sources
CARBON CAPTURE CAPACITY OF BUILDINGS	• Sequestration • Capture and Utilization • Other Sinks

The carbon footprint analysis of buildings is the sum of the greenhouse gas emissions and removals associated with a building project over its entire life cycle (Čuláková et al., 2012). For this reason, architects should consider each stage of the building life cycle separately in their designs and choose the products and services to be used in these stages with the lowest possible carbon intensity (Figure 1a-b).

Figure 1a-b. Life cycle stages to consider for carbon footprint analysis of buildings (Srinivasan & Lakshmanan, 2013)



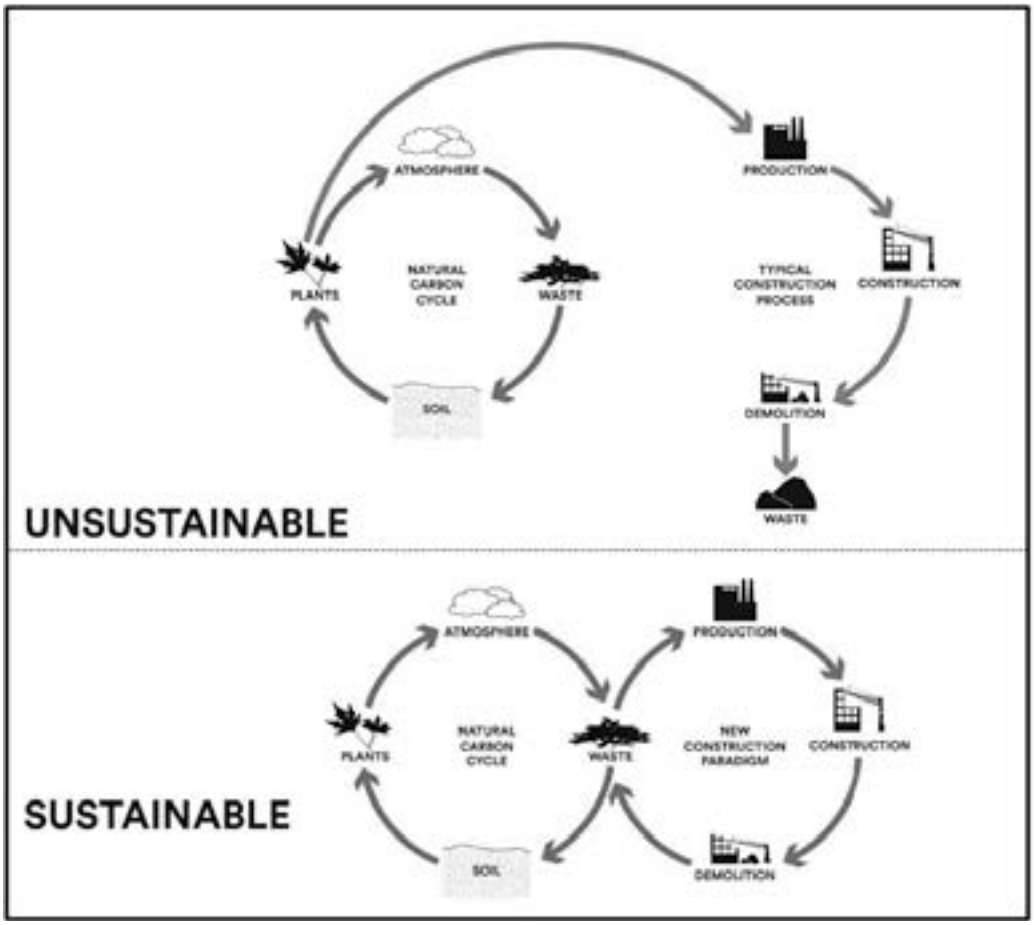
The main carbon footprint sources that architects should consider in the building life cycle in their designs are summarized in Table 2.

Table 2. Major greenhouse gas emission sources contributing to the carbon footprint in the building lifecycle

Product Phase	Construction includes processes from the extraction and refining of raw materials to the manufacture of construction products. Emissions from raw material supply, transportation and manufacturing are included.
Construction Phase	It includes the processes from the factory door of construction products to the practical completion of construction works. Includes emissions from transportation and construction installation process.
Usage Phase	It includes the processes from the practical completion of construction work to the demolition or demolition of the building. It includes emissions from use, maintenance, repair, replacement, refurbishment, operational energy and water use.
End of Life	It starts when the building is decommissioned and no longer used. It includes emissions from demolition, transportation, waste treatment and disposal.

In the light of this information, it is important for architects to design by choosing products, methods and services that can be included in the natural circular carbon flow in ecosystems, reducing the linear carbon flow that occurs during the life cycle stages of buildings. (Fig. 2).

Figure 2. Carbon cycles for a sustainable built environment (Srinivasan & Lakshmanan, 2013)



4. RESULTS

For a built environment that aims to contribute to the reduction of carbon footprint; direct/indirect GHG emissions and carbon sequestration capacities at all stages of the building lifecycle need to be analyzed and taken into account prior to the project. Particularly, the following principals are important to the adoption of eco-friendly building:

- Site analysis for effective orientation
- Passive cooling design
- Use of high thermal insulation
- Controlling heat gains
- Use of energy efficient equipment and appliances
- Reduction of water demand and consumption
- Ongoing house performance monitoring and optimization

As a result; to reduce the carbon footprint of built environment practices and minimize their impact on the climate:

- A clear goal should be defined
- A carbon budget should be determined and followed throughout the project
- The natural ecological conditions of the land (climate, aspect, watershed, soil, biodiversity, etc.) should be taken into account at the maximum level
- In practice, the project based on eco-design that will have the least impact on the environment should ensure the use of materials and energy demand
- Materials and energy sources with low climate impact should be selected
- All emissions must be balanced.

For these reasons, it is of great importance in terms of sustainable architectural practices that architects consider each stage of the building life cycle separately in their project designs and prefer low-carbon products and services.

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ARAŞTIRMA / RESEARCH ARTICLE

Biophilic Design Concept And Different Examples In The World

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Abstract

As being home for millions of people and various species, cities has a remarkable role for sustaining ecosystems. After the effects due to dramatically increasing migration rates in urban areas are being clearly observed, design approaches have changed from anthropocentric to ecocentric perspective. The transition take place due to necessities. Population boost in urban areas due to numerous job opportunities eventually caused adverse impacts on the environment which indirectly affects public health and economy. Therefore in the 60's and 70's design approaches evolved into environmentally focused approaches. By the end of 80's growing environmentalism ideology is spread its scope and formed a new well-known term sustainability. Sustainability covers environmental, social and economic aspects. Getting into more details in economic aspects, a new term biophilia pops up. Biophilia then, having been used as a design ideology and can be applied in different scales varying from buildings to regional scale. Biophilic design in building and urban scale are applied to protect all elements of ecosystem including but not limited with plants, animals, insects and humans. Main objective of biophilic design is to contribute sustaining the ecosystem and urban life.

Keywords: Biophilia, Biophilic Design, Sustainability, Urban Design.

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1. INTRODUCTION

Considering cities completely different from the nature is a wrong approach since cities are also home to ecosystems. Even the largest cities can include significant amounts of species. Image of a city generally occurs in people's minds as full of grey buildings, cars, and roads. Despite the truth that a city includes all the things that appear in mind, cities are also home to species which are essential contributors to ecosystem. In the rapidly urbanizing world, conserving ecosystems in cities and even improving them are the main concerns. At this point the term sustainability gets involved and seeks for optimized conditions in the scope of environmental, social and economic aspects. Going deep into environmental aspect, another phenomenon biophilia comes up. In this essay, biophilic design in public scale towards achieving sustainability goals is criticized.

2. SUSTAINABILITY AND BIOPHILIA

2.1. Sustainability

Sustainability is an outcome of environmentalism. At the late 1980's environmentalism popped up and eventually the idea was expanded and became sustainability covering greater content. In the changing world, population has been boosted, CO_2 emission rates and the number of species that became extinct has been increased (Ayres, 1999). The reasons behind all these consequences are rapidly growing urban areas and consuming behaviors of the society (Tezangi, 2014).

Yeang et al (2010) defines sustainability in his dictionary as "Balancing a growing economy, protection for the environment and social responsibility".

2.2. Biophilia

The term biophilia is firstly introduced by Erich Fromm as love to living things. Afterwards, Edward O. Wilson's book named Biophilia boosted popularity towards biophilia and biophilia became a well-known subject. As getting well-known, biophilia was studied and considered as a subsection of environmental sustainability. Later on, the idea of biophilia is considered to be an appropriate design style which is a compatible approach in terms of reducing adverse effects of human activities that critically damages environment.

3. SUSTAINABLE URBAN DESIGN

Sustainability is a tool that encourages development in environmental, social and economic aspects. Environmental sustainability aims creating an alternative for the activities that damages environment. Reducing dependency on fossil fuel using vehicles, increasing walkability of people, green and protected public areas in the city are examples for the environmental pillar of sustainable urbanism. In terms of social urbanism, public spaces that are available to host different activities are the main applications. Economically, sustainable urbanism is for creating business opportunities and employment for residents (Tezangi, 2014).

Sustainable urban design must be done by following some principles. Main principles and the reason why we need are explained in the table by Tezangi (2014).

Table 1. Principles of Sustainable Urbanism (Tezangi, 2014)

Principles	What We Need	Why We Need
Density	Harmony Balance Varieties Mixed Uses	Reduce The Length of Walk Reduce Car Ownership and Use Reduce Carbon Emmision Reduce Energy Consumption
Accessibility	Transportation Sustainable Walkable Public Areas	Encourage Walking Corridor Encourage Cycling Reduce Car Dependence
Biophilia	Natural Systems Open Spaces Green Cities	Green Visual Relief Provide Habitat Civic Gathering

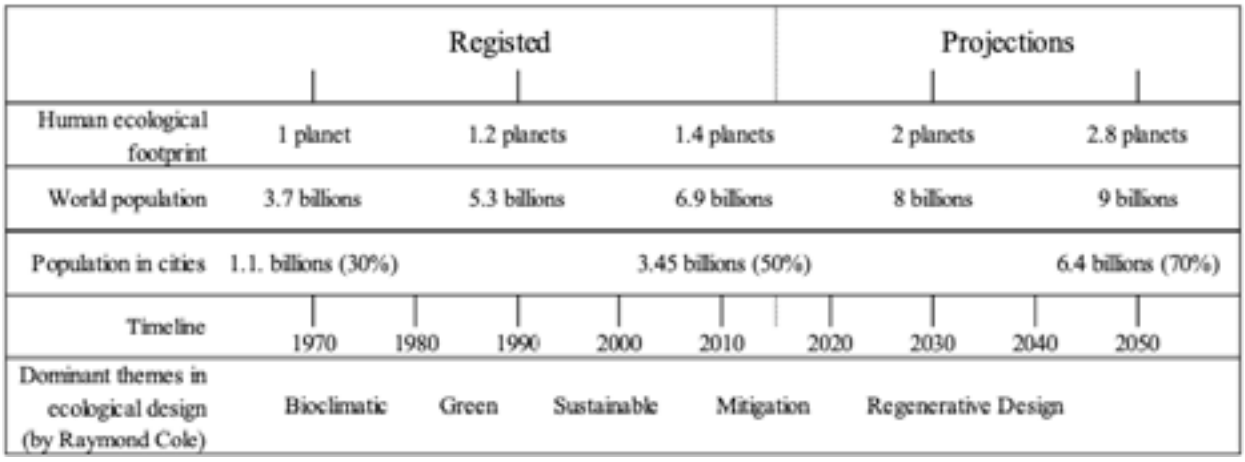
As stated in the Table 1, biophilia is a tool to reach sustainability goals. Comparing it with sustainability, biophilia is more ecocentric while sustainability is more anthropocentric approach. Therefore biophilia mostly focuses on environmental and social perspective since environment and society is composed of living things. Economic feasibility and outcomes are not strictly followed. However some biophilic design works may lead economic return directly or indirectly.

4. BIOPHILIA: ITS PAST AND FUTURE

The term biophilia is firstly used by Erich Fromm as an encountering idea of necrophilia. Initial step of biophilic design has taken in the late 60's as ecodesign idea. Ecodesign aimed focusing design mainly from an environmental perspective. Eventually, environmental perspective has come up with some green approaches. Development of these green approaches took place in 70's. Ecocentric design idea is also an outcome of global policies. Due to the oil crisis in 70's, fuel dependency was questioned and environmentally friendly approaches were being looked for. Questioning had impact on some authors and encouraged them to publish books like 'Silent Spring' (Carson, 2002), 'The Limits to Growth' (Meadows, 2004) and 'The Population Bomb'(Ehrlich, 1968). The books impacted more people and questioning came up with a broader perspective and branches.

By the time people were blaming some third parties on the adverse ecological impact in the world, it was accepted that the ecological crisis was due to human activities. After that, the term sustainability became a phenomenon which is expected to be a solution to humanbased impacts. Environmental aspect is determined one of the bottom lines of sustainability. Sustainability, especially environmental sustainability became a well-known subject. As getting well-known, biophilia was studied and considered as a subsection of environmental sustainability. Later on, biophilia was evolved into an architectural term. Some designers, planners, biologists, psychologists and many others have different expertise like Stephen Kellert, Timothy Beatly, Douglas Farr, Edward Wilson are leading individuals in terms of biophilia and biophilic design. Biophilic design has been started to being applied in different scales on buildings, blocks, streets, neighborhoods, communities and regions.

Figure 1 Dominant design themes and human-resource relationship (Dias, 2015)

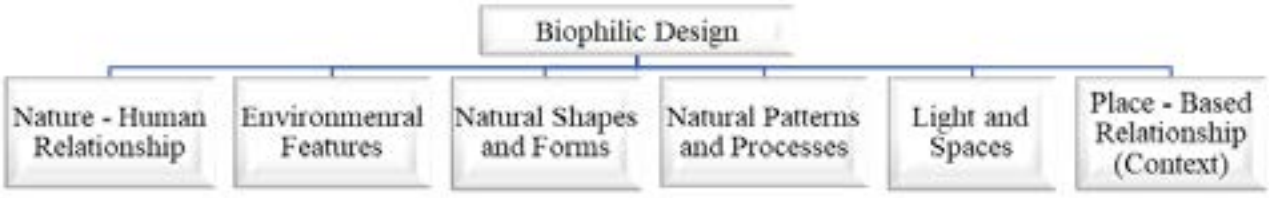


As seen in Figure 1, dominant design themes has exposed to some changes over the time. The reason why the themes were changed might be broading persepective of global issues. In the initial phases, solution was thought to be about environment only. However by the time, social and economical perspectives has been included as parts of possible solutions and human factor is also considered.

5. BIOPHILIC DESIGN

Kellert et al (2008) explains biophilia and design concerns under the headline of biophilic design. Concerns must be considered when applying biophilic design are:

Figure 2 Kellert's elements of biophilic design (Sadek et. al, 2018)



Nature is able to sustain itself. However due to some human activities such as use of fossil fuels in greater amount, nature that is home to limitless number of living creatures are adversely affected (Daly, 1994). Water pollution endangers water ecosystem and may lead some species to become extinct (Collen et al., 2013). Therefore a new concept must be developed. Instead of antropocentric approaches, more ecocentric approaches should be preferred. The main goal should be design for and with nature.

Nature in its purest form, doesn't have buildings and highways. They are the element which are relatively new for the nature. Because in nature, there is no buildings but trees. Trees can be considered as key elements of the environment that are able to provide all basic needs like sheltering, food, protection against predators and cure for sicknesses (Heerwagen, 2009).

6. BIOPHILIC DESIGN IN URBAN SCALE

Since cities include densely settled human population, with the population increase in cities environmental impacts are increasing like deforestation, greenhouse gas emissions etc. Thus, biophilic design may prevent all the human based effects. Biophilic design in urban scale can be achieved by some applications in different scales.

6.1. Strategies for Integrating Biophilic Design in Urban Scale

One of the leaders of the biophilic design idea, Timothy Beatley claims that there isn't exact definition for biophilic cities. On the other hand, urban biophilia can be defined in various forms.

Figure 3 Biophilic Design (Kellert et. al, 2008)

Scale	Biophilic Design Elements
Building	Green rooftops
	Sky gardens and green atria
	Rooftop garden
	Green walls
	Daylit interior spaces
Block	Green courtyards
	Clustered housing around green ares
	Native species yards and spaces
Street	Green streets
	Urban trees
	Low impact development (LID)
	Vegetated swales and skinny trees
	Edible landscaping
	High degree of permeability
Neighborhood	Stream daylighting, stream restoration
	Urban forests
	Ecology parks
	Community gardens
	Neighborhood parks/pocket parks
	Greening grayfields and brownfields
Community	Urban creeks and riparian areas
	Urban ecological networks
	Green schools
	City tree canopy
	Community forest/community orchards
	Greening utility corridors
Region	River systems/floodplains
	Riparian systems
	Regional greenspace systems
	Greening major transport corridors

6.2. Dimensions of Biophilic Urbanism

However, biophilic design goals can't be achieved just by applying the elements in Figure 3. Since biophilia is a broad content there are some aspects that are either enabling biophilic design to achieve its goals or disabling success in urban scale. Therefore, biophilic design must be considered according to some dimensions that Beatley (2010) explains:

See Figure 4. For detailed explanation.

- Biophilic Conditions and Infrastructure
- Biophilic Behaviors, Patterns, Practices, Lifestyles
- Biophilic Attitudes and Knowledge
- Biophilic Institutions and Governance

Figure 4 Dimensions of Biophilic Design (Beatley, 2010)

Biophilic Conditions and Infrastructure
--Percentage of population within a few hundred feet or meters of a park or greenspace;
--Percentage of city land area covered by trees or other vegetation;
--Number of green design features (e.g., green rooftops, green walls, rain gardens);
--Extent of natural images, shapes, forms employed in architecture and seen in the city;
--Extent of flora and fauna (e.g., species) found within the city;
Biophilic Behaviors, Patterns, Practices, Lifestyles
--Average portion of the day spent outside;
--Visitation rates for city parks;
--Percent of trips made by walking;
--Extent of membership and participation in local nature clubs and organizations;
Biophilic Attitudes and Knowledge
--Percent of residents who express care and concern for nature;
--Percent of residents who can identify common species of flora and fauna;
Biophilic Institutions and Governance
--Priority given to nature conservation by local government; percent of municipal budget dedicated to biophilic programs;
--Existence of design and planning regulations that promote biophilic conditions (e.g., mandatory green rooftop requirement, bird-friendly building design guidelines);
--Presence and importance of institutions, from aquaria to natural history museums, that promote education and awareness of nature;
--Number/extent of educational programs in local schools aimed at teaching about nature;
--Number of nature organizations and clubs of various sorts in the city, from advocacy to social groups.

Figure 5 Enablers and Disablers of Biophilic Urbanism (Newman et. al, 2011)

Enablers	Disablers
Innovative and adaptive frameworks	Planning frameworks (business as usual)
Leadership by planning authorities	Lack of quantiative/financial analysis of BU (rather than qualitative)
Social pressures - community forums	Cultural stagnation
Local and state government policy able to be informed by BU metrics	Control issues (e.g. At local government level there are internal struggles about control and how things happen)
Demonstration sites e.g. New Delhi (UHI), Ulrich (health benefits)	Lacck of information at the level of the decision makers (e.g. Buildings, town planning)
Community gardens and associated community groups	Lack of research on local, holistic systems
Corporate donations and sponsorship	Benefits/costs fragmented
Supportive local governments that are connected to the need of community	Regulations/planning permit requirements
Availability of vacant lands to be used as biophilic elements	Lack of integrated planning
Growing level of education, experience and exposure to nature in cities	Lack of rigorous cost-benefit analysis using a systems approach
A lot of good work being driven at grassroots level	Level of social disconnection to natutal environments

In such a variant scale, real life applications may differ in terms of both size and concept of the project. Renewal or redesigning of the buildings can be a design approach for contributing sustainability and biophilia concepts while planning and designing in the urban scale from the very initial step can be another approach. In this paper, some case studies in building scale and urban scale are examined.

7. CASE STUDIES

7.1. Building Scale Biophilic Design Approaches

7.1.1. Kickstarter Headquarters

The story of renovation of Kickstarter Headquarters is one of the best examples of renewal of buildings using biophilic design. Kickstar, a known crownfunding organisation set its headquarters in an old pencil factory that is located in Brooklyn, New York. The pencil factory wasn't being used for a very long time. The old factory was renewed and transformed from a dark and abandoned factor into a place that is nature filled space, with a total green and edible roof garden. The project was designed by Architect Ole Sondresen. Ole Sondresen highlights that "The existing building was deep, dark and partially below grade, which meant it had very little daylight or potential for fresh air." (Ole Sondresen) In his remarks after designing the project he emphasized on the importance of having an environment appealing to workers, stating, "The outside spaces were designed for work and leisure alike. I think a lot of designers make the obvious mistake of designing the outdoor spaces as a place to 'get away', I strongly believe the feeling of getting away from work is passé and that one can make any work environment a place one wants to go to and not get away from."(Ole Sondresen).

Characteristics of the Project

- ✓ The project was created for commercial purposes.
- ✓ Design by architect, Ole Sondresen
- ✓ Year Completed; 2014
- ✓ Total Project Area 29,000 sq ft
- ✓ It is a two story central courtyard with a rain garden.
- ✓ It has a rooftop garden with a total area of 8500 square foot.
- ✓ A reconstructed space to promote a dynamic work environment.
- ✓ Has plenty of green spaces

7.1.1.1. Biophilic Characteristics of KickStar Headquaters

Various biophilic patterns can be seen in this project as shown in **Figure 3** and **Figure 4**. Even though not all biophilic patterns are present in this project, some of the available patterns are;

- Non-Rhythmic Sensory Stimuli – P3
- Material Connection with Nature - P9
- Connection with Natural Systems – P7
- Prospect & Refuge – P11 and P12

Figure 6 Biophilic Patterns in KickStar Headquarters (Side View)

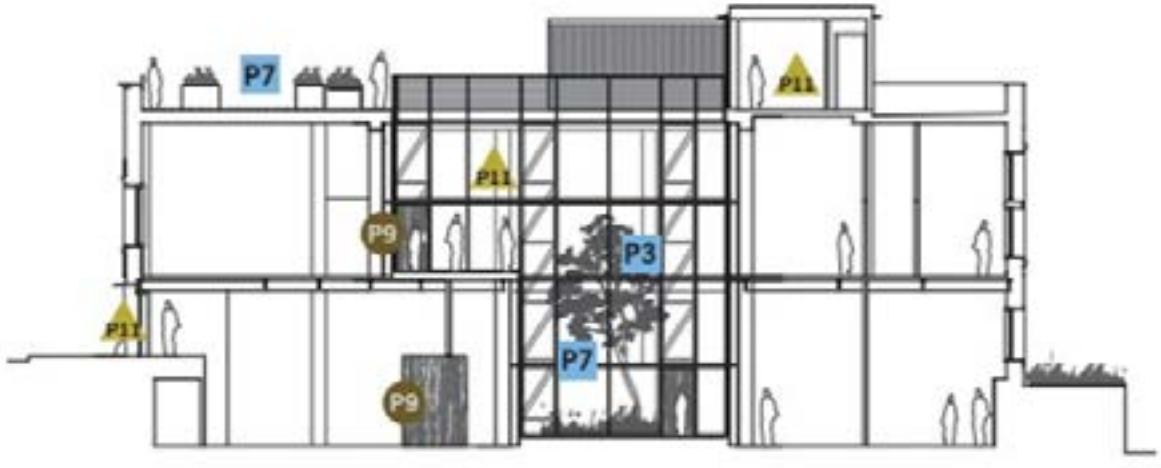
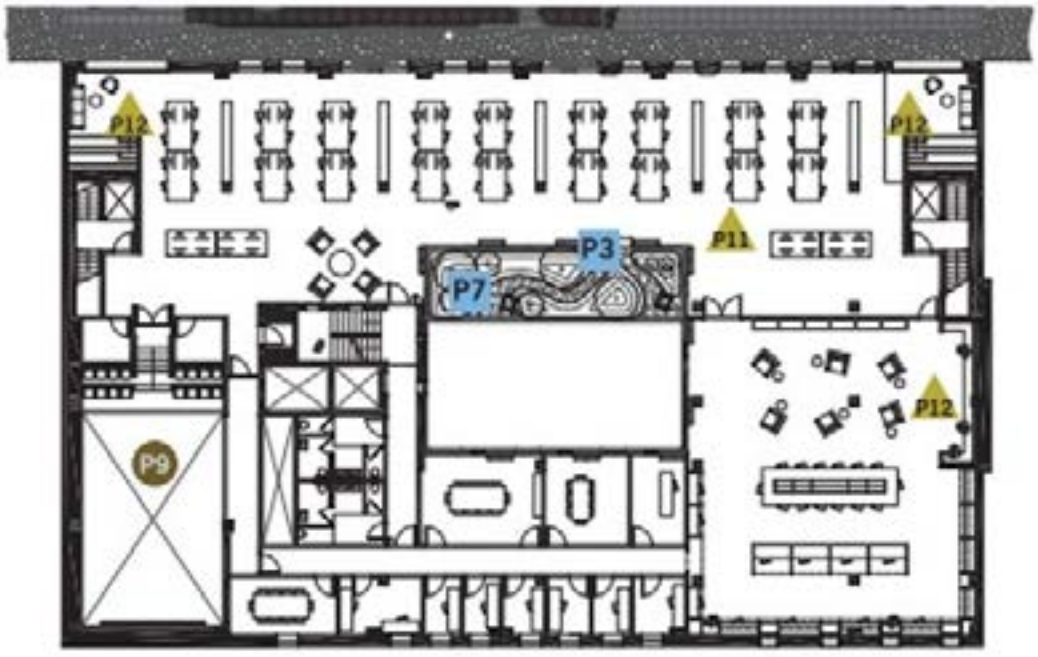


Figure 7 Biophilic Patterns in KickStar Headquarters (Top View)



7.1.1.1.a. Non-Rhythmic Sensory Stimuli

The project has various native landscapes which meet the non-rhythmic sensory stimuli pattern of biophilic design. The workers are able to get a direct view of the landscape. "Every space, except the blackbox theater, is designed to have either a direct or oblique relationship with at least one of the courtyards or the rooftop."

Figure 8 KickStart Headquarters (Sondresen (n.d.)

7.1.1.1.b. Material Connection with Nature

In comparison to the alternative construction materilas, timber production can be managed in a relatively sustainable concept which is plantation forests (Evans and Evans, 1997). The use of natural materials such as wood is observed in this project. "Barns in this area were constructed of a medley of woods as the settlers would clear the land for the fields and use the different species of trees for what they served best. For instance, hardwoods like oak were used for the structure, rot resistant woods like hickory and cedar were used for the siding, and so on."

Figure 9 KickStart Headquarters (Sondresen (n.d.)

7.1.1.1.c. Prospect & Refuge

Understanding that Kickstarter needed an office with an assortment of spatial conditions to respond to office and occupant needs, the designers distributed a mix of open office floor plans and small, sheltered work and study spaces throughout the three floors.

The building geometry supports a hierarchy to the prospect condition, with a variety of unimpeded views over a distance for surveillance and planning.

Kepuithy Boarding House

Keputih Boarding House is a dormitory located in Surabaya, Indonesia. It was an award winning project in the World Architecture Festival in 2016. It has been biophilically designed to overcome Indonesia heat by use of spatial opening and nature. The openings and panels allow natural lighting and air to circulate the main spaces, giving a sense that the house is “breathing”. With the installation of the panels, the house appears to “breathe”, just like any living thing, as the panels allow an abundance of natural lighting and aeration into the house. In addition, Andy and his team also built spatial openings that aim to optimise the flow of sunlight and breeze into the house although the openings are not too large in dimension. (City Scapes) Figure, shows and outer view of the boarding house.

Figure 10 Keputih Boarding House (Source: Indonesian Design)

7.1.2.1. Economic Analysis of Biophilic Design

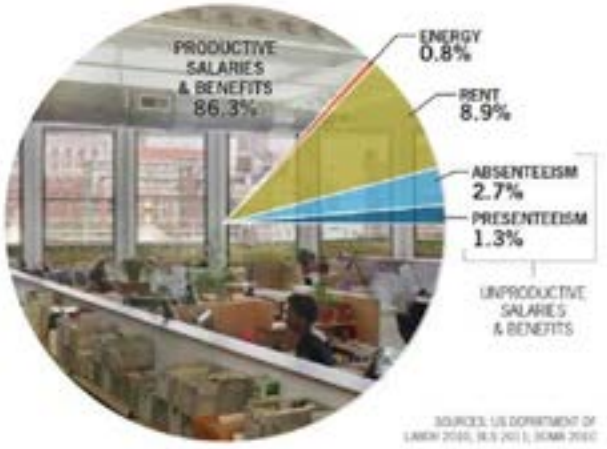
It is always very important to analyse the economic feasibility of applying biophilic design into buildings. The access to nature is vital for humankind, and when people are derived from its benefits, there may emerge economic consequences, mainly health and societal costs. Municipalities especially for public use purposes create the access to parks and views to nature to have a cost-effective strategy to reduce the impact of social problems. We can now quantity in currencies the economic analysis of biophilic design application.

People tend to pay more so as to have good views such as views of water and green nature. A study conducted in Ohio, United States, showed that good landscaping aesthetics increased rental rates by 7% (Laverne & Winson-Geideman, 2003). They study also stated that the prices of houses with landscapes were 5% more that houses far away from nature. The same applies to houses designed using biophilic design whereby they tend to more expensive than houses that don't have biophilic properties. Benson et al. in their article state that prices of properties near the lakefront added 127% more value to the house (Benson 1998). This is actually not something surprising since people are willing to pay more for properties that have biophilic characteristics.

However, besides its cost biophilic design actually saves a lot of money in the economy after a long period. Terrapin Bright Green, a consultancy company did a study on the economic benefits of applying biophilic design is buildings, either a new or a renewal project. They came up with various results which are stated in this paper.

Employees tend to miss work more in working places where there is connection to nature. This amount to almost 10% of employees missing work more in offices not connected to nature. There are also some financial losses due to absenteeism and presentism of employees. This definitely affects the economy of the company and the country at large. Thus, if biophilic design is applied the productivity of the workers will also increase. The productivity savings in this case were astounding: absenteeism decreased by 15% after construction was completed. Employees looked forward to coming to work and voluntarily tended to the natural features in the office (Romm & Browning, 1994). This can be improved by making the working environment more natural. The employees should not feel far away from nature. This is explained in Figure 11.

Figure 11 Productivity in work places (US Department of Labor, 2010)



In the last decade, American psychologists have aggregated the five strongest requirements for basic functioning that, if neglected, can trigger worker comprehension problems and dissatisfaction in the office space, which mainly aim at increasing the productivity of the workers, thus more income to the economy (Kellert, 2008).

These are:

- Need for change (varying temperature, air, light, etc.)
- Ability to act on the environment and see the effects
- Meaningful stimuli (stagnant atmospheres cause an onset of chronic stress) o One's own territory to provide safety, an identity, and protection • View to the outside world

Recent studies have also shown that exposing children to nature reduces the possibility of getting ADHD. ADHD (Attention-deficit/hyperactivity disorder)is a brain disorder marked by an ongoing pattern of inattention and/or hyperactivity-impulsivity that interferes with America, with over 5.2 million children being diagnosed with ADHD (Scheffler et al., 2007). Biophilic design of cities will provide children access to parks and nature which will reduce the medication intake by 10%. This could save almost $228 million (Scheffler et al., 2007).

Patients with a view to nature, instead of a wall, are more likely to experience hospital stays that are 8.5 percent shorter, with fewer negative observational comments from nurses, and significantly fewer strong, post-surgical painkillers. Biophilic Design applied in hospitals helps in decreasing the average stay of in-patients by 0.41%. "In 1984, Roger Ulrich pioneered a seminal study to measure the influence of natural and urban sceneries on patients recovering from gallbladder surgery. Some patients were provided with views to nature, whereas others looked at brick walls. With all other variables equal, his findings revealed accelerated recovery rates and reduced stress for the patients who had views of nature. On average, patients whose windows overlooked a scene of nature were released after 7.96 days, compared with the 8.71 days it took for patients whose views were of the hospital's exterior walls to recover sufficiently to be released—a decrease of 8.5% (Ulrich, 1984). The reduction in the average was found to reduce hospital costs by $93 million dollars (Machlin & Carper, 2007). In 1993, Wal-Mart decided to use biophilic design in one of their stores, which attributes such as enhanced indoor air quality, natural landscaping and daylighting. According to Tom Seay, who is a former Vice President of Wal-Mart, they had remarkable results in this stores (Romm & Browning, 1994).

Other studies have shown that retail customers tend to want to buy from places surrounding by nature and natural features such as shopping malls and etc. Actually prices of things in such places have been estimated to be 25% more expensive compared to shopping malls and business that have no access to nature (Edwards & Torcelli, 2002). For example daylighting in retail stores have more possibility of attracting customers that those which don't have daylighting.

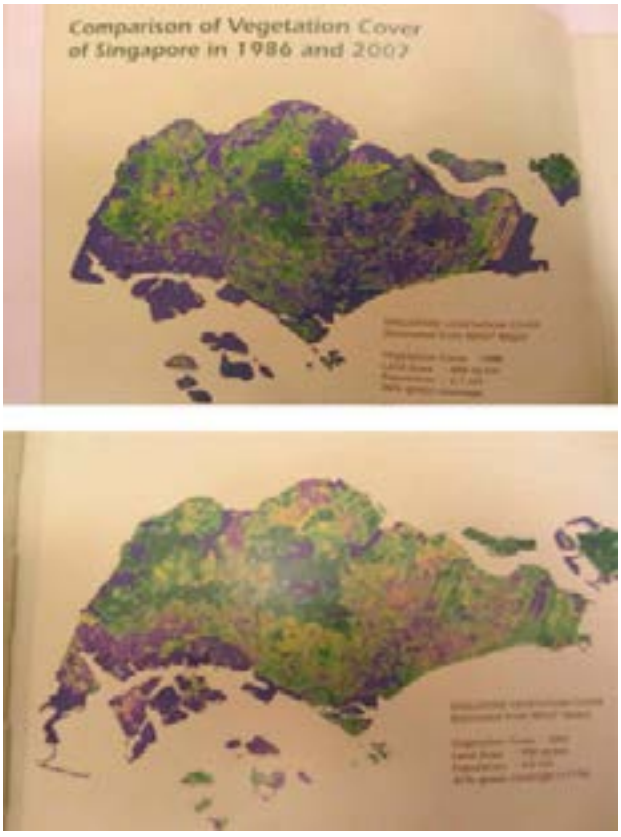
It is estimated that living near vegetated landscapes can result in the reduction of crime rates by 7 percent. New York City, for example, would save $1.7 billion in incarceration costs. Scaling similar calculations for adding access to nature in 12 public housing developments in Chicago, the paper asserts that the city would save nearly $162,265 in incarceration costs from violent and property crimes (Elzeyadi, 2011).

7.2. Urban Scale Biophilic Design Approaches

7.2.1. Singapore

As many eastern countries, Singapore has a great ecological site. Singapore has been working on the garden city concept for a long time about 4 decades. Singapore includes almost all biophilic design strategies in all scales. Government initiatives contribute to Singapore's garden city goals. In Figure 6, change of vegetation in all over the city is shown (Newman, 2014).

Figure 12 Vegetation map of Singapore in 1986 and 2007 (Newman, 2014)



Singapore City Council and Urban Planners has the key role on application of biophilic approaches in urban scale. Starting from early 1960's Singapore has been evolved into a garden city which makes it home to various species. Singapore is now has more than 350 parks and uninterrupted pedestrian passages between those parks. The uninterrupted park connectors enable city residents to reach public green spaces easily. Priority of green areas and habitats of living creatures provide best fit for native and other kind of species. Now there are;

- 2145 native vascular plant species
- 384 bird species
- 109 reptile species
- 85 freshwater fish species
- 318 butterfly species
- 125 dragonfly species
- Over 400 spider species
- 29 amphibian species
- 35 true mangrove tree species
- 12 seagrass species
- 255 hard coral species
- 50 sea anemone species
- Over 200 sponge species
- Over 68 echinoderm species
- Over 30 sea fan & sea whip species (Chan, n.d.)

Thanks to biophilic design methods varying from building scale to urban scale, Singapore managed to provide exclusively pleasant urban living spaces for its residents, visitors and other members of the ecosystem. Some biophilic approaches applied in Singapore are:

Figure 13 Arcadian Road in Sigapore

Figure 14 Gardens by the bay

Figure 15 Park connector

8. CONCLUSION

Biophilic design can be considered as a part of sustainable approaches in different scales for urban design. Scale of approaches or biophilic design may vary from street level to regional level. Therefore the are many biophilic design elements to be applied. Considering biophilic design as an approach towards sustainable urban design, inputs and outputs must be evaluated in detail. Since sustainability consists of environmental, social and economic pillars, each pillar must be satisfied thorough design. KickStart headquarters can be named as one of the best example of integrating nature into buildings while Singapore is an admirable urban case. On the other hand, in urban scale, urban design guidelines of Singapore and such cities and processes that the cities past thorough can represent a concrete example for urban designers to design towards sustainability goals which eventually make living spaces more livable. The positive change in Singapore in the last few decades is a result of sustainable development. In the environmental aspect of sustainability, biophilic design methods contributed its welfare significantly. Thanks to considerable investments and public initiative, Singapore successfully handled to develop its own garden in the city, or city in the garden. Since cities are home to all species as they are for humans, protecting the ecosystem and improving the conditions for all living creatures can be possible by applying biophilic design approaches.

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- The Journal shall be an academical journal including the scientific studies, researches and analyses conducted for developing the health and wellbeing of the people living in cities. This international journal shall provide contribution to strengthening the governance among the parties included in the making and implementation of policies in regards to the topic of city health and health environment. It shall be a journal as a reference source for the decision support mechanisms on the topics of formation of health cities.
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