

# Green Architectural Aspects of Urban and Architectural Heritage of Old Mosul City

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**Abstract**— The urban heritage is one of the most important features of urban character of any old city throughout history. It reflects the craftsmanship of ancient architects in dealing with the surrounding environmental conditions in order to meet their needs without affecting the surrounding environment. Green Architecture is one of the architectural concepts that emerged after the energy crisis of the 1970s. Many architects and urbanizes have been looking for a new building, based on the idea of crystallizing architectural designs that focus on studying long-term environmental impact while operating and maintaining the building. The research aims to identify mechanisms of traditional urban heritage to archives concepts and principles of Green architecture, and to achieve the goal of the research is by study and analyze the characteristics of green architecture and the most it's important environmental treatments, in the first part. While identification of green characteristics of traditional architecture in the context of local heritage of the old city of Mosul, in the second part. The research concluded that the urban and architectural heritage of the city of Mosul has adopted most of the principles and aspects of green architecture, even if primitive and modest.

**Keywords**—: *Green architecture, heritage, Mosul*

## I. INTRODUCTION

The concept of green architecture is based on an idea of a dynamic and effective integration of architecture as a physiological presence with surrounding natural environment, thus promoting the use of natural factors at a technical level in energy conservation or at the functional level in creating a healthy and comfortable internal environment for the human.[1]

The roots of the environmental movement date back to the early 19th century, when the industrial revolution was saturated with physical and spiritual needs of the human occupation of architecture. Ruskin sought to make evolution form a system compatible with the natural order. To countryside on adoption of self-sufficiency and revival of local manual skills, Lethaby called architects for understanding and insight into the beautiful system of nature. Geddes in Scotland, Fuller & Wright in America, Hassan Fathi in Egypt, and latest of them Roger & Foster in Britain, all sought to develop methodologies and ideas about the sustainable environmental trend but in completely different ways and forms. Design coupled with nature was replaced by low-energy design due to the problem of global warming. While Roger & Foster developed mature models of energy-efficient spaces, twentieth-century designers tended to improve environmental conditions of wider urban areas. In

general, Geddes & Fuller agreed to introduce Nature in Urban Areas is in direct association with human existence. Hasan Fathi and Wright have taken a different approach in using local materials and craftsmanship in their attempts to produce modern architecture outside traditional local structures. They have come to conclude that social sustainability and environmental design are very close to each other. Archigram in the 1960s has sought to reconcile the distinction between high technology and environmental solutions.[4]

Suit's work is the first among architects to demonstrate technical effort of ecology, James Wins led a group that tends to product forms of an explicit and implicit in local environmental and geological considerations, which it's clear on building with a realistic environment of corridors , light rain-like drizzle , interior gives the aroma of plants and coolness of breezes to the visitor's pleasure in rippling delightful paths, that this drama contains a sense of natural environment.[2]

At the end of 20th century, architecture was charming and attractive in the design of buildings, which is known as environmental design, Eco-tech environmental technology or Eco-cool, which adopted engineering and computer computing with the environment, buildings are no longer heavy and stable, but became light, extended and flexible. In this point of view, Roger pointed out that buildings must be like birds in changing their shape, appearance, and size in a way that harmonizes with the environment in all its environmental situations. This responsive design is what connects human and natural worlds effectively and successfully. As for Japanese architecture, the principle of the existence of architecture in harmony with nature is not a modern idea in search for inner space, the efficient use of energy and environmental response. The traditional ways of thinking about the spiritual connection between site and building, between the outer wall and forest environment still appear in the form and function of the building. Woodcutter hut to the greatest architectural monuments [3]

## II. THE FOUNDATIONS OF GREEN ASSESSMENT OF ARCHITECTURE:

Cheryl pointed out that green design adopts the vocabulary of (balanced, healthy, environmental, architectural characteristics) research on the building that respects the following six principles:[5]

1. Respect the characteristics of the site
2. Reduce power consumption.

3. Harmony with the climatic environment.
4. Economical use of resources.
5. Reduce waste and contaminants.
6. Use of building materials.

### III. CONTEMPORARY CONCEPTS ASSOCIATED WITH GREEN ARCHITECTURE

#### A. Study of Simon Guy 1997 "The social construction of green building":

The study examined contemporary concepts of environmental architecture and overall intellectual ideas competing in defining a clear definition of green architecture. The study also developed a comprehensive understanding of the environmental issues by their classification according to terms representing intellectual visions of these theories based on practical and practical development of these trends. The study classified the intellectual orientations of green architecture into five basic terms of green architecture: environmental - contemporary - aesthetic - ergonomic - social. Table (1) presents the details of these proposals according to the vision of each direction. [6]

#### B. Study Jerry Yudelson 2008 "The Green building Revolution"

The study pointed to the evolution of green buildings movement from 1960 to 1990 and resulting trends and organizations that worked on these directions. The study pointed out that the main objective of revolution towards green buildings is to change built environment by making buildings more energy efficient, raising health level of environment and making buildings more productive. In 1993, the United States Green Buildings Conference (USGBC) adopted leadership of this change through many of institutions that emerged from it. Including LEED in 2000 [Leadership in Energy and Environment Design]. The main foundation of its work is an improvement by adopting environmental contributions of the site, which are represented by the impacts of the site, a method of energy use, renewal of environmental resources and raw materials. Green architecture based on LEED are buildings that have the highest performance in reducing the environmental impact of the building itself on both surrounding environment and human health. The specifications defined by LEED in terms of improving the quality of the internal environment are: Improve the air quality inside building - Increase effect of natural ventilation - Activation of building with elements that improve ventilation - Use of non-toxic materials for finishing materials - Introduce designs of natural materials such as wood - Reduce chemical emissions during building occupancy - Provide convenient control for users of the building - Maintain thermal comfort specifications - and finally activate natural daylight in building and communicate with the landscape.[7].

#### C. Study of Edwards 2001 "Green Architecture" AD Architectural Design:

The study presented views of a number of leading architects and innovators of the movement of sustainability in architecture, which reflected a clear consensus in visions of intellectual with a slight variation in some of the contents and following is a part of their views: In his definition of

sustainable design, Lord Foster pointed out that he did much more but with an ecological concept and optimized use of energy conservation mean through building components rather than relying on energy-wasting mechanical services, even though these were limited and negative. [4, p32]. Jan Kopecky pointed out that the important features of the sustainable design are the optimal use of resources and long-term performance of building with these resources. Buildings must be self-sufficient in more than 80% of energy. He also pointed out that nature has been used as a medium on many levels. Natural structures have a lightness that is not possessed by human architectural product, it is lighter and more powerful. [4, p34]. Lord Rogers pointed out that sustainable design is designed to meet the needs of the present without depleting remaining reservoir of natural resources for generations. The greatest sustainability is achieved through the intelligent design of natural resource stewardship, increased efficiency through orientation and shape of the building, maximization of natural ventilation, regulation of thermal gain Solar energy. He also noted that nature is an important vector of environmental design by providing inspiration, information, and metaphor. [4, p36] Ken Yeang has defined sustainable design as an environmental design or design that interacts with natural systems in a biosphere throughout the entire lifecycle of building system, and the most important in sustainable design is architects' understanding of link between each system in nature and all these systems must be integrated as part of the processes of the built-in system. Nature should be observed and our systems should be ecosystems. [4, p60.] Thomas Herzog noted that sustainable design can be defined as a way of working to conserve our natural resources when using recycled energy forms (especially solar) as widely as possible, and the most important sustainability issues are to unify or integrate technology with the components of building by use of recycled energy in an acceptable manner, especially those that control possibilities of shape of the building there are five distinct possibilities that must be assumed to exist and deal with them positively:

- Learning from nature. Nature has implicit models and systems that can be used in the design of green buildings. Environmental design is an attempt to develop these systems and use them naturally.
- Using nature models, structures of nature are tested and reliable, shapes, configurations and even materials used in nature are all durable and sustainable.
- Make nature clear and tyrannical, as architects must bring the scenes of nature both inside the building or in its surroundings, or through the direct use of raw materials, nature is the source of tactical and visual and audio of joy and pleasure
- Adoption of nature in environmental calculations of the building, as this idea leads to similar elements that free designers from the task of assessing everything.
- Each part of nature is designed and shared in the overall design of building in the same manner.[4]

*D. Study of ALMusaed 2006 "Biophilic architecture, the concept of healthily sustainable architecture"*

The study referred to a green architecture called Biophilic architecture, which provides real and realistic opportunities to achieve environmental, moral, social and even economic benefits of nature. The principle of living architecture is to integrate with nature, leading to responses that reflect both health As well as the performance of human beings and mental and emotional conditions, by creating a friendly environment for more efficient buildings in the distribution of the energy area as well as developing an efficient manner in management of natural resources. This study indicates that the contact and proximity of building with nature makes its occupants more healthy and enhances physical performance of activities and activists in general, as the individuals concerned do not prefer to perform these daily activities of sleep and food and work in buildings with purely functional specifications, but in buildings with an environmental variety reflected on their feelings of reassurance, inspiration and comfort. [1]

## VI. ENVIRONMENTAL CHARACTERISTICS OF MOSUL CITY CLIMATE

### A. The climate of Mosul city :

Mosul is located on the northern side of Iraq ( $36^{\circ}$ ,  $19'$ ) north and longitude ( $43^{\circ}$ ,  $09'$ ) east, this means that the city is located in a warm moderate climate. Mosul is from hot regions where annual temperature increases to more than ( $18^{\circ}$  C) and this rate does not differ significantly from temperature prevailing in central and southern parts of Iraq, while the amount of rain delivered in the city (357.7 mm), and if taken Considering actual value of this rain as a result of high loss due to effect of summer heat and drought of atmosphere, the city lies within two regional ranges, which are closer to dry climates, including wet climates, warm desert climate, and the short grass climate. Analysis of the city's climate data shows that the average annual temperature is  $19.5^{\circ}$  C and the maximum temperature is  $43^{\circ}$  C in August, which is the hottest month of the year, the lowest temperature is  $7^{\circ}$  C per month January is the coldest month of the year. The highest absolute temperature was ( $51^{\circ}$  C) in July, and the ( $-11^{\circ}$  C) was the lowest temperature in January. The average daily relative humidity (3:00 pm) reached its lowest level in August at 13%, while the highest relative humidity (6 am) reached its lowest level in July (42.6%). The relative humidity was relatively high, with the daily average relative humidity (64%) and the highest (94%). [9]

### B. Methods of Natural Climate Control (Passive) in Traditional Architecture:

Traditional architecture has responded to harsh environmental conditions by using the following: [10]

- Exploitation of topography of land for housing purposes, such as housing in caves or dwelling underground or take refuge in slopes of mountains and highlands.
- The use of plant elements such as trees and gardens.
- Formation of compact urban build cluster with narrow traffic paths to allow shading of building facades, provide shade to passers-by, blocking cold winds and control to the local air movement.

- The opening of buildings inward, through the organization of internal spaces around the central courtyard, reducing area exposed to outside and impose a system of streamline between internal courtyard spaces and entire urban fabric.[10]

Natural treatments to climate adaptation in dry and semi-dry regions have been classified into two categories:

- Strategies that avoid or reduce heating (shade, protection).
- Natural cooling strategies through heat evacuation outside.[9]

## V. GREEN ARCHITECTURE APPLICATIONS OF TRADITIONAL ARCHITECTURE OF MOSUL CITY

There is a few basic application of Green architecture on formation urban and architectural heritage of old Mosul city, that appears in the structure of urban fabric and configuration, construction and details of traditional houses, as follow :

### A. Green architectural aspects of the urban fabric of old city:

The structure of traditional Arab city, which was formed in dry and semi-dry climates, is characterized by streets, narrow alleys(Col de sac), and sometimes with ceiling to shade its refreshing and climate-adaptive spaces, which are integrated with the local architectural style. It is a cohesive fabric that allows the cool air to be stored overnight by night radiation to the sky ,that keeps this cold air stagnant in urban space for 3-4 hours after the sunrise, which is increasing its temperature gradually, and combination reduces the thermal acquisition due to exposing the least amount of area of urban surfaces to outside, as well as repel the warm sand laden with dust.[9]

- Urban shade spaces :

The traditional urban fabric forms part of the solar radiation protection system. It includes as many residential units as possible, both horizontal and open to the inside, that fabric make reduces areas exposed to the sun. This urban shape is characterized by narrow streets, so it increases area of façade shades , and the guidance can take advantage of solar radiation in winter, the degree of enclosure of street and urban space (the relationship between width of street and height of buildings surrounding it) were also used to protect from winds of cold winter and hot summer winds that loaded with dust and sand. The narrow and twisted paths of urban movement reduce hours of solarization for facades and prevent wind from pulling cold air collected at night, and sometimes roofing

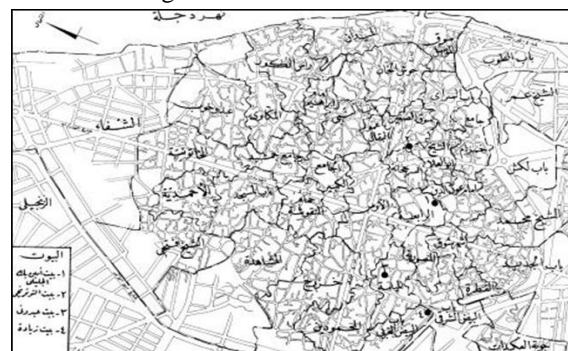


Fig. (1) the urban fabric of Mosul



paths of movement to ensure shading throughout day, so that pedestrians can follow their movement in urban fabric, this is what we are familiar with in traditional markets in particular, as well as the use of vault (Qantara) component, which offers a shaded space within residential alleys where there are various activities, and that depends on the height of the vault, depth, and direction. [11]fig. (1)

When conducting measurements in the city of Mosul and comparing them with types of fabric, the differences in temperature of external air between modern and traditional urban fabric ranged from (9-3 ° C). The decreasing of surface areas of urban spaces exposed to outside in the urban cohesive fabric implies that the reduction of surface heat exchange between the inside and outside, which leads to conservation of energy in an internal environment away from the harshness of external climate.[9]

- Flow or fluidity space:

The efficiency of fluidity space is reflected in the spatial configuration of Mosul city with its urban and architectural aspects. The traditional paths takes primary role in air flow of entire urban fabric, Path is a linear road that sometimes narrows, sometimes explodes and sometimes ripples through its meandering, that creates wide variety of high pressure for air shaded cold and rushing to spaces of residential units that overlooking it, which take place through clever details that developed by Arab architect in according to creative way in which strong intensity of air clouds starting from residential houses gates, which are usually open day and night, air through a white curtain to the entry (mizwar) towards (majaz).

That semi-entry(majaz)is sometimes it may open to stairs, top floor or towards basement, which draws attention to presence of curvatures within it and contains seats to sit and perhaps to receive some guests or siesta during the hot afternoon, as well as to put water drinkers(meshrabia), to turn this beautiful detail into a candidate for fresh air, net and clean, no dust and air humidifier, high-precision system controlled by life requirements and laws sanctity of the house.[12]

### B. Green aspects of the spatial organization of traditional house building:

House in traditional Arab cities, whether in east Arab world or west, are built according to the principles of solidarity of

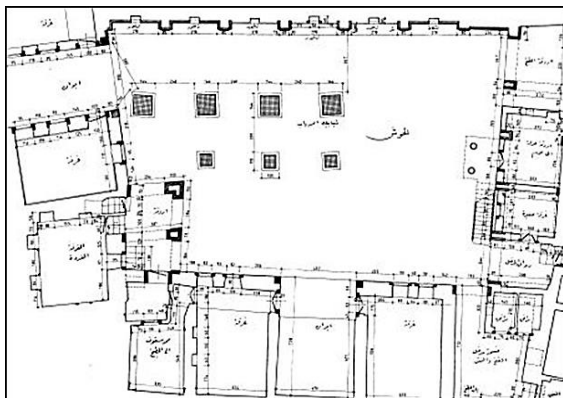


Fig. (2) internal central space- courtyard

- The Central space ( courtyard) :

A courtyard is an essential element of climate adaptation, it is a natural lighting collector and a good storage of cool, In the morning, the sun is still low and walls are so high that sun's rays cannot fall on the entire surface. The floor of the courtyard, thus maintaining air cooler for as long as possible [11]. It is worth mentioning that buildings with courtyard are essential adaptations of Mosul traditional heritage, in addition, the use of semi-courtyard ( Ewan), which represent an older style, have been adopted for climatic, structural and functional reasons. Building derives most of the ventilation and lighting elements, It serves as an air filter for dust and helps to store warmth in winter when entrances and openings are closed. The inner atmosphere is relaxed in summer when air currents are allowed to start after opening entrances and openings, and this positive role is enhanced by planting trees and flowers in it or in middle water basin. This is in addition to its social benefit, which is protected by residents of building from outside. It also agrees with human Arab needs for security. [9]fig. (2). The arcades (riwaq) that surrounding the central courtyard or external corridors usually reduce the impact of solar radiation of building through shadows generated by them or in front of a building, the transitional space which reduces climate variability between inside and outside. (9) The use of (Iwan), an outer space similar to open space in one hand around middle courtyard, and thus can create a space shaded ground, walls, and ceiling and be covered with pointed contracts rising above beams of wood, that may raise it from level of central courtyard and become a cold breeze in summer times. The presence of more than two (iwan)in north and south, make northern space is winter-use, while southern space is summer-use because it avoids high-temperature pressure in before sunrise time(12) fig. (3)

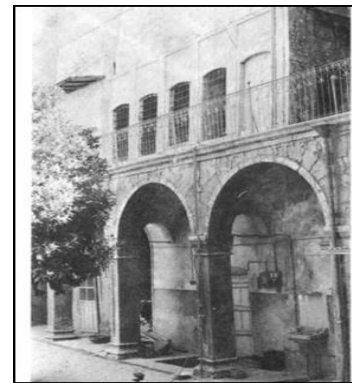


Fig. (3) riwaq around a central courtyard

### C. Green architectural aspects of building facades details :

- Elements of the building's cover:

Type of external walls is another level of environmental adaptation that regulates solar radiation, its constituent materials, thickness, color, and surface texture are the main factors in its assessment. The walls of external buildings form the building's crust, through which the greatest part of heat exchange is expressed. They are essential elements that cannot be protected from solar radiation. The use of elements of facades is the most

effective way of preventing access to solar radiation from reaching walls. Decorative formations when building with stone or brick, which forms a rough surface with additional shadows, or by constructional beams of some elements, which depend on the effectiveness of direction of the building and solar path [14]. Nature, quality and thickness of walls have a significant impact on the amount of heat leaking into the building in summer, and leaking it out in winter, [12]. Therefore, Mosul architect used thick built walls. The structural materials used in construction are non-engineered limestone, plaster for bonding and grouting, (noura) for foundations and bathrooms, marble for tiling, packaging, and framing of openings. Which are characterized by their slow delivery of heat on one hand, and their great ability to retain? Fig (4).

The slow heat conductivity reduces extreme heat pressure in summer because stones delay severe heat leak into buildings until temperature begins to decline in afternoon hours. The white color and soft texture of plaster help to reverse the sun. [9]. As for the storage or high thermal absorption of stone, it will help to deal with climatic conditions in winter, because it is a source of thermal radiation inside and outside the building during the night, reducing cold weather, and the use of stones works to increase thermal isolation of walls. The use of (mashrabia) is a distinct space outside the façades of outer buildings overlooking urban space. It consists of a split screen where small water jars (jarra) are placed to cool by evaporation caused by air movement, and control passage of light and air, reduce a temperature of the passing air. (14) The air passes through the wooden (Mashrabia) some of its moisture through wooden rails at night, and when it heated in a day by the heat of sun loses its moisture through for air passing through it. This technique is suitable for increasing humidity of dry air in summer, and cooling air and moisturize in times of need. [9]. fig(4)

#### D. Green architectural aspects of building construction and materials:

- The element of Ceiling:

The use of domes and pouch are commonly in the roofing of traditional buildings of the old city of Mosul, such as mosques, baths, etc., except for residential houses, which are domestically located and leveled from the upper surface, which is used for sleeping in summer. Unlike the horizontal surface, convection is less than interior spaces. The

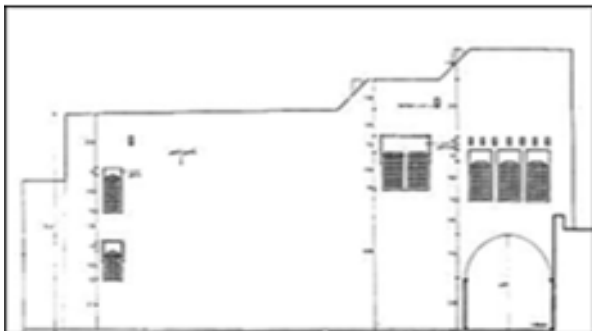


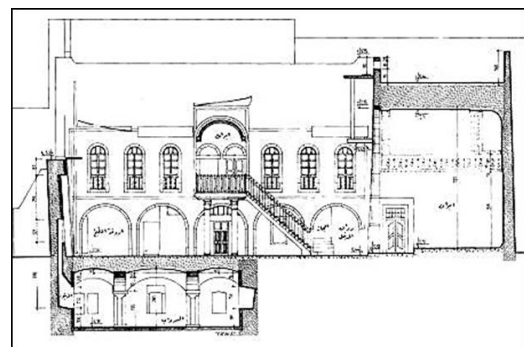
Fig (4) detail of external elevation

movement of air activates between the shaded part of dome or basement in sunny part, which helps to reduce the heat of surface, as well as the large surface area of domes and vaults compared to surface as it allows release of the largest amount of thermal radiation towards the sky at night [13]. fig.(5) The white flat surfaces have the same specifications as walls in reducing thermal loads of direct solar energy in summer, as well as the use of thermal insulators such as air gaps and debris of broken jars and plaster, which is not without a residential house in urban fabric of the old city of Mosul, which will raise the thermal capacity of roof to stabilize thermal is acceptable, environmental treatments for vaulted roofs, which are commonly used in the city, especially in public buildings, are to reduce heat pressure in summer because the surface is not fully exposed to sunlight. [9] fig (6)

The use of Hydration elements, the presence of water pond in the heart of traditional presence of water jar in net air or at bottom of sheds increase the evaporation of water and thus reduce the temperature of the air, which generates cool air inside the house in summer. The Fountain, It has a distinctive architectural character of a traditional house in Mosul, from which water (salsbil) flows. The presence of the fountains in walls opposite the fountain's axis, where air current with water spray moisturizes the atmosphere [13].

- contact with the earth (basements):

The height of inertia of land is indisputable, with the depth of (8-6) meters, the temperature of soil will be fixed [15], that is why ancients were building their villages and cities underground, The underground or semi-underground structures offer a comfortable interior environment. Experimental studies have shown that the temperature in such structures is stable at 30 ° C when the earth's surface temperature is 40 ° C [16]. Some of these are used by the family for different purposes, some of these were used for a



Fig(5) section of construction details



Fig (6) detail of inside elevation

siesta in summer(rahra). They were used as a store for grain and fuel, and some of them were used for knitting and weaving, there is rarely a dwelling in the city without a basement, to provide adequate ventilation and reduce convection in summer, it was provided with (badger)pastures to reach the top of the building, and its upper vents head to the north to catch the breeze of northwest wind.[9]. The use of (malqf): It is called in the whole of Iraq (Badkir), which is an aerial channel above the building and has openings corresponding to the direction of prevailing winds to catch cold air and push into the building, and helps to reduce dust borne by the wind. In order to flow an appropriate amount of air through the outlet, a carryout must be made, so airflow velocity increases by increasing intake of air from the carryout open.[15]fig. (8)

#### VI. CONCLUSIONS :

- The study defined green architecture as an architecture adapted to the surrounding environment, being integrated with all its determinants, filling its shortcomings and addressing its benefiting from the phenomena of this environment and its sources.
- The main objectives of green architecture are to reduce consumption of non-renewable resources and reduce waste resulting from the construction processes in buildings. A healthy environment for users to contribute to the performance of their functions in an optimal manner and increase their productivity.
- The possibility of applying sustainable green architecture in Mosul city in accordance with the techniques and principles derived from mechanisms to address environment and local climate and avoid the harmful environmental impact of building through the use of raw materials and means of reducing climate impact with elements similar to traditional elements.
- To define a clear definition of green architecture and its principles in order to increase the awareness of local architects about how to minimize negative effects on the environment, namely depletion of resources and energy consumption, and clarify role of engineers in applying green building concepts derived from our urban heritage and using renewable energies to reach real results that explain their role.

- To activate both solutions and recommendations that may contribute to the creation of sustainable green architecture in Mosul city through the development of new standards and formulas for green evaluation of buildings taking into account local architectural experience and the application of this system to contemporary buildings.

- The call for adoption of green building strategies is an invitation to deal with better environment and in an integrative way, considering that the perennial environment is a sacred right that must be preserved, maintained and protected in accordance with social, cultural and geographical characteristics, and the need to clarify concepts of green architecture and reasons that led to its emergence with the development of humanity to increase awareness of individual about the environment in general and the risks to environment as a whole as a result of human manipulation.

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