https://doi.org/10.33261/jaaru.2022.29.1.003 *Association of Arab Universities Journal of Engineering Sciences (2022)29(1):16–30*

Association of Arab Universities Journal of Engineering Sciences
مجلة اتحاد الجامعات العربية للدراسات والبحوث الهندسية

"Earthen Architecture Between Systematic and Non- Systematic System"

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Published online: 31 March 2022

Abstract: Earthen architecture has emerged as a system that has multiple systems embodied in its architectural and urban productions. These productions showed their relationship with sustainability and its considerations (environmental, economic, and social), but it was not clear to what extent these systems are related to sustainability, and from here the research problem emerged to be represented by **(the lack of a clear perception of the systems of earthen architecture and sustainability indicators within these systems).** The goal of the research is to be determined by building a theoretical framework for sustainability indicators within the main earthen architecture systems. The research hypothesis was determined by (sustainability indicators within the systems of earthen architecture were fully achieved, but indicators of economic consideration were more achieved within the non-systematic system at the expense of the systematic system). To solve the problem and achieve the goal, the research was divided into two parts: the first was concerned with identifying the systems of earthen architecture and indicating sustainability indicators within them and so that the second part was concerned with testing these indicators within samples that Associated with the main systems of the earthen architecture to verify the research hypothesis and to clarify which considerations were the most influential within the system. The research found that the main systems of earthen architecture are the systematic and non-systematic system, both of which are designed according to sustainability considerations. However, the indicators of economic consideration emerged to be achieved within the non-systematic system more than they were achieved within the systematic system of earthen architecture.

Key words: Earthen Architecture, Systematic system, Non-systematic system, Sustainable Architecture.

1. Introduction:

Earthen architecture is one of the most prominent subjects related to sustainable architecture as it depends on the earth's natural resources in construction such as clay, wood, and reeds of all kinds, stone and other natural materials. This architecture has proven its efficiency in achieving dimensions of sustainability environmentally, economically and socially, throughout history and up to the present time. Therefore, many studies that specialize in Earthen architecture have emerged and focused on specific aspects such as historical aspects, as these studies have documented evidence of earthen architecture in many regions of the world to this day to benefit from previous experiences and invest in enhancing the contemporary earthen architecture. While other studies have exposed the potential of natural earth materials and methods of their use in building through various building types that are a reflection of the context of the natural environment, such as clay architecture, wood architecture, and stone architecture, which sometimes appears in the form of buildings with clear engineering systems based on

advanced planning while appearing on the other side as buildings of a random nature, relatively lacking in advanced planning. Hence the importance of the research has emerged to get knowledge of the specificity of the Earthen architecture in these two directions. The research problem is determined by (The lack of knoeledge about systems of earthen architecture and sustainable indicators within these systems), The objectives of the research are to identify indicators of sustainability in the systematic approach of earthen architecture within the architecture of the engineer, and indicators of sustainability in the non-systematic approach of earthen architecture within vernacular architecture, and the research hypothesizes that (The considerations of sustainability (environmental, economic and social) are achieved within the systems of the earthen architecture, but the economic consideration of sustainability is achieved more within non-systematic systems than the systematic systems.).

2. Framework of the earthen architecture:

This axis is concerned with defining the specificity of the Earthen architecture from the doctrinal and historical, with its structural patterns, aspects. It also includes the sustainability considerations, that associated with the buildings of the earth, are represented by the environmental, economic and social consideration, and specifying the systematic and non-systematic, structural, technical and methodological, aspects of earthen architecture. This axis ends up with the conclusion of the two systems' indicators.

2.1 The peculiarity of earthen architecture doctrinally:

the topic of the earthen architecture was doctrinally related to the topic of earthen reconstruction, which includes the material and moral aspects, as God Almighty said in his Holy Quran: {... He has produced you from the earth and settled you in it, so ask forgiveness of Him and then repent to Him. Indeed, my Lord is near and responsive." - Verse 61 Surah Hood [13]. The concept of earthen architecture was interpreted in Islamic law on the basis of the relationship that governs human with the environment, according to two principles, which are harnessing and moderation. The harnessing is intended by God Almighty to harness the components of the environment in order to help man fulfill his mission in the reconstruction of the earth, God Almighty says: {It is Allah who created the heavens and the earth and sent down rain from the sky and produced thereby some fruits as provision for you and subjected for you the ships to sail through the sea by His command and subjected for you the rivers}...Surah Ibrahim - verses 32 - 33 [14]. The moderation is linked to human benefit from harnessing the components of the environment in a moderate manner. Moderation was adopted as a method in the reconstruction of traditional Islamic cities and in accordance with the jurisprudential rule (no harm, no foul) [1] [48].

The concept of Earthen architecture is raised by linking it to the doctrinal aspect at different levels related to assessing the relationship between human and the environment on the two basis of harnessing and moderation as concepts governing this relationship, according to the jurisprudence rule (no harm, no foul), which is considered a central role in Islamic law that includes details of organizing life and govern the relationships of individuals.

2.2 The peculiarity of earthen architecture historically:

Earthen architecture has been interpreted historically on the basis of the use of natural earth resources and the employment of technologies that are appropriate to the local context for each region in terms of building materials and methods of implementation and at the global and local levels. Globally, shelters in caves, and cliffs are represented as the first examples of earthen architecture that have been transformed by repeated use in certain seasons into temporary seasonal shelters that are made of wood and covered with mud to provide waterproofing [33]. After the increase in human knowledge of the importance of agriculture, the need for settlement, which required the creation of more stable shelters with various requirements as they developed gradually. They were called "hole shelters" or "hole house", which were environmentally suitable, and required a little bit of planning [24].As for the technique of implementation, it is clay blocks or a primitive type of clay brick that is formed in baskets; it is called the construction of turtles [34]. The differences in the shape and choice of materials were based on the local environment where the stones were used in the places where they were readily available, while in other places wood and organic materials were used because they were more abundant. The place where wood or stones were not available, the clay was used. Wood-based buildings have adopted trellis and plaster technology, which is a mixture of woven wooden strips that covered with mud. Additionally, the construction with wooden frames, which are sometimes built on a stone base as an insulating basis that protects the wood from moisture, water, mold and insects.1930's Great Depression was a severe worldwide economic reduction that took place mostly during the 1930s, beginning in the United States, and it leds to the revival of construction on earth and this concern was limited to building public and a few schools during the thirties, but due to economic change, frequent crises and lack of energy, this led to a new evaluation of the construction of the earth and the attempt to support it from various aspects.

Thus, the historical earthen architecture appeared according to models that have adopted building materials and implementation techniques as basic factors in their existence as functional and planning patterns have evolved from a temporary shelter in one space that collects several functions without prior planning, and by the gradual development to the needs of individuals and the advancement of civilization, patterns with clear functional

isolation advance planning has emerged. As for building materials and implementation techniques, they were mainly dependent on the geographical specificity of each region. Materials such as clay, stone, wood, reeds, papyrus, wicker, straw ... etc. While implementation techniques varied from simple technology needless of experience in implementation to technology depends on skilled labor.

2.3 The peculiarity of Earthen architecture as structural types related to the natural context:

Earthen architecture has been interpreted as structural types related to the natural context of each region represented by climate and topography of the earth that directly affects the elected building materials and technologies, so many structural patterns have emerged and will be discussed according to the environmental, economic, technical, structural and aesthetic aspects.

2.3.1 Clay architecture:

The architecture of clay buildings depends on raw clay as a basic building material, with the possibility of introducing other natural materials such as wood, stone, straw, animal waste ... etc., whether during work stages or in the structure of the structural construction. Environmentally, this pattern does not adversely affect the environment, as it is completely sustainable. After the end of the age of the building or its demolition, it returns to the earth, it maintains optimum moisture levels inside the space, a heat-resistant material, with high efficiency in sound and heat insulation, recyclable and cannot be left under rubble. Economically, the advantages of clay as a building material are summarized as a material that is generally available in most construction sites. It does not require high consumption of transformative energy. Technically, clay in construction has weak mechanical resistance and does not stand up to tensile forces, subject to exposure to water due to the capillary action of water transmission, which makes its application somewhat difficult and requires extensive precautions to protect it from future defects such as adding industrial fasteners such as cement, lime, asphalt emulsion or natural stabilizers like straw or rice husk. Structurally, clay material without reinforcement is not earthquake-resistant, and in the case of height for several floors, clay buildings will face the problem of wind resistance, while aesthetically familiar and generally accepted, since it provides a sense of contact with the natural world [7] [27].

2.3.2 Wood architecture:

wood structures depend on wood as a basic material, Environmentally, wood has the advantage of being a structural material that can bear both pressure and tensile strength, by increasing the section of wood, it increases the time of resisting fire, and it can be painted with anti-combustion materials, its thermal and sound insulation is better than stone It is earthquake-resistant, especially soft species like bamboo and leaves less damage to the population if it falls. Structurally, it can be used as a structural element or as an internal or external packing material and also in floors and ceilings [10].Technically, wood defects arise as a result of exposure to weather factors, the most prominent of which are the points of contact of the branches with the trunk and represent a weak point in the wood because of the possibility of its separation during work and it can be removed with special machines for this purpose. Other defects are mold, and sheltering insects in the cases of water exposure and moisture as a result of decaying. Wood becomes traumatized, when it is cut down and dropped to collide heavily on the ground, and trees become ageing, so the heart of the tree becomes hollow. Parts of tree wood damage as a result of leaving the tree for a long time without cutting it in time. Economically, wood is a cheap building material if it is available at or near the construction site. It is also a material that can be used in multiple uses as support or complementary elements. As for aesthetics, the employment of wood in construction enhances an individual's sense of belonging to the place as a natural substance [45].

2.3.3 Stone architecture:

Building with stone is one of the oldest building systems, structurally characterized by durability and rigidity, its efficiency in the foundations, resistant to water, moisture, mold and insects, needs less maintenance than clay and wood. Technically, its disadvantages are heavy weight, prone to collapse in earthquakes if adopted without reinforcement. Environmentally inefficient in thermal and acoustic insulation. Economically, it is inexpensive if it is available on site and does not need skilled labor. Types of stone are sedimentary rocks such as sandstone and slate, and volcanic rocks such as granite and basalt, which are distinguished by their acceptable natural appearance [46].

It appears from the above that the earthen architecture includes different building types that depend mainly on the available natural resources with the possibility of intromission industrial materials at the level of the building material or the implementation technology or the level of the structural construction, as the technologies differ in various aspects such as the environmental, economic and technical aspect of labor and the machines required to implement the technology .these technologies differ in the structural aspect on the level of durability, earthquake resistance, the ability to create large areas and implement shapes with straight or curved lines. Regarding the aesthetic side, some technologies create walls that do not require external or internal finishing because of their acceptable appearance, unlike other techniques requiring finishing as an aesthetic factor and also to increase the durability of the walls.

2.4 Sustainability considerations in Earthen architecture:

Earthen architecture has been interpreted as a system linked to environmental, economic and social considerations, as follows:

2.4.1 Environmental consideration:

Earthen architecture is considered a realization of the environmental aspect of sustainability by offering environmental advantages of building with natural earth materials, which are represented by preserving heat in the winter season, maintaining lower temperatures in the interior spaces during the summer, and contributing to reducing heating and cooling costs resulting saving energy. The adoption of earthen architecture is a necessity to achieve sustainability in all its dimensions, especially the environmental dimension through: protecting the environment, reducing climate change and carbon emissions, reducing the consumption of natural resources, improving the quality of the internal environment, reducing waste and construction waste [35]. Also, the earthen architecture provides recruitment for the capabilities of the building material that affect the quality of the internal environment and thus the health and comfort of users, through the properties of the balance of temperature and humidity of the building material, which affects the ratio of the need to rely on industrial means to provide the requirements of the environment such as cooling and heating that resulting consumption of energy and resources. As for the quality of the external environment, the adoption of natural building materials reduces the energy consumption needed to manufacture industrial building materials such as cement, iron, and plastics, and reduces the proportions of construction waste represented by construction waste and non-recyclable demolition waste [47].

2.4.2 Economic consideration:

earthen architecture has emerged as an economic system as a result of lower building costs, lower maintenance costs, higher building value, increased productivity of skilled cadres and maintaining their presence in the labor market, providing employment opportunities for the local population, supporting the economy and limiting the flow of funds out of the country [36]. While the relationship between natural building materials and the economic aspect was represented by the geographical distribution of resources and employment, as the preparation of construction materials, their distribution, marketing and assembly at the site represent activities that provide employment opportunities and support the local economy, with the need to avoid the central production of building materials in urban centers at the local level because that It leads to impoverishment of rural areas and enrichment of urban centers only. On the international level, relying on imported building materials or imported manufacturing technology underestimates the economic situation of the country and thus creates a gap between the reality of the local economy and other countries [47].

2.4.3 Social consideration:

The social consideration of sustainability has emerged within the Earthen architecture as it relates to the human being as a beneficiary and producer of this architecture, it is an architecture that provides more physical and psychological health, improving learning environments and healing environments, increasing user productivity and achieving aesthetic satisfaction [36]. The social consideration of earthen architecture is also highlighted by the relationship between the elected building materials and the social aspects, by identifying the social problems associated with the election of the type of building material where these problems are low income, inequality, rapid population growth, and increased conflict between individuals in the collection of resources, services, and job opportunities. Often the poor (those with low incomes) choose inappropriate materials or use the elected materials without organization and coordination, which leads to creating technically and aesthetically flimsy buildings that express poverty. The problem of inequality between slum housing and housing for the wealthy that are technically and aesthetically sound structures at the level of elected materials and the organization of the construction process in design and implementation, and as a result of these apparent social differences occurs conflicts, so the election of building materials has an impact on social aspects through conflict prevention or underestimated. Strengthening the social aspect of the Earthen architecture system is achieved through criteria (enhancing social relationships, equal distribution of materials and equipment, relevant to local culture, social acceptance of the project) [47].

Earthen architecture represented as an integrated system that includes considerations of environmental, economic and social sustainability consistently, leading to one another. Environmental consideration criteria of earthen architecture are represented by improving the internal environment and protecting external environment, reducing the effect of climate change and carbon emissions, reducing the consumption of natural resources, and Reducing the waste and construction waste. While the criteria for economic consideration are represented by the low costs of operating the building, lower maintenance costs, high building value, increasing the productivity of skilled cadres and maintaining their presence in the labor market, providing employment opportunities for the local population, supporting the local economy and limiting the flow of funds out of the country. As for the social consideration, it may be summarized by the criteria for enhancing social relations, equal distribution of materials and equipment, relevant to local culture, and social acceptance of the design.

2.5 The Systematic system peculiarity of earthen architecture (engineer architecture):

Many architects have defined the term architecture and these definitions have varied according to the aspects that they dealt with. Some definitions focused on the physical aspects of architecture and considered them an integrated engineering system consisting of multiple systems linked together, as stated in the McGraw-Hill Dictionary of Scientific & Technical Terms: "A field that deals with the technological aspects of buildings, including the properties and behavior of building materials and Its components, base design, structural analysis, environmental systems analysis and design, and construction Management and building Operation" [23].While others focused on the formal and structural properties of the building blocks and their impact on the user's feelings, such as Lee Corbusier definition: "Architecture is the perfect play of blocks visible under the light. Employing stone, wood, and concrete, with these materials, buildings and palaces are built, this is construction and creativity, but when it connects to my heart and makes me the happiest is architecture". Architecture was considered by some as one of the most prominent reasons for the establishment of civilization, such as Ibn-Khaldun's definition: "It is the construction industry and is one of the civilization urbanization industries that a person needs in shelter and housing." While some definitions included physical and aesthetic aspects, such as Vitruvius's definition of architecture as: "utility, durability, beauty" [41].

The above definitions are shared by a focal point represented by the fact that architecture is created by the architect, it is the architecture of the engineer, some of which define the architecture from the scientific side and focus on the physical aspects such as formal features, structural constructions, and the interlocking engineering systems to form the building. While other definitions consider it as a comprehensive system that combines science and art, it includes material and spiritual aspects. Architecture is a scientific art of building construction that meets multiple conditions surrounded by the architect to achieve the material and moral needs of the user in the best possible way.

2.5.1 The Systematic system peculiarity of earthen architecture at the structural level:

Systematic system peculiarity of earthen architecture is manifested within the structurally constructed architecture on the basis of identifying two types of development in the field of building materials and technologies. The first development represents by the type of treated natural building materials, as this type depends on developing treatments that enter the raw material between the stage of extraction as raw material and the stage of its use in construction, intending to improve its properties and increase its efficiency to the building requirements. The most prominent of these materials are stone, clay, and wood. These treatments include leveling stones, molding processes for forming clay, adding materials to strengthen clay, cutting wood and treating them with materials to increase their resistance to moisture and mold [42]. As for the second type of development of the structural aspect, it is represented by manufactured building materials, where innovations in the chemical and mineral industries contributed to providing new alternatives of building materials that proved effective in expanding the horizons of construction options. New materials have emerged, such as all kinds of metals, concrete, glass, and plastics, due to the variation in their properties and their uniqueness in different dimensions; this led to the architect thinking about the necessity of creating formal languages that fit with the nature of the new materials. Also, the development of engineering science in the era of engineering and during the twentieth century, and the building materials that were created have had a great impact on changing design concepts in architecture. The most prominent types of manufactured building materials are metals such as iron, steel, aluminum, copper and titanium, as well as concrete, glass and plastics [25].

It appears from the above that the development of building materials in the engineer's architecture is necessarily followed by the development of implementation techniques, and it is in two phases, the first of which is the adoption of natural raw materials after being subjected to treatment processes to increase their efficiency in construction. As for the second stage, it is represented by the manufacture of alternative building materials as a result of the development of chemical and metallurgical industries, as these materials changed design concepts and through which new formal languages are created in architecture such as metals of all kinds, concrete, glass, and plastics.

2.5.2 The Systematic system peculiarity of Earthen architecture at the level of the design process:

The design process in the engineer's architecture is the part that connects theory with practice, and the approaches adopted in this process have varied, some of which have adopted the design as a product stemming from the creative imagination in which the practical steps disappear, including The design is no longer an organized process with sequential and inter-step steps leading to specific decisions based on scientific foundations, as in the following table:

Table 1: explains the principles of the design process within the systematic system of Earthen architecture. Source: The researchers.

The design process within the systematic systems of Earthen architecture	Experimental approach	The design process expresses the form as a final product that cannot be analyzed into its initial items because it depends on the principle of trial, error, and innate intelligence of the designer without adopting a method with specific steps [2].
	Systematic thinking approach	The design process represents a set of strict rules that must be adopted by the designer without regard to the privacy of the individual and the identity of the community as a result of the rule of applied mathematics and the designer's impact by the technological production of the machine [6].
	Probability approach	The design process relies on the material and non-material forces affecting design, which gave multiple results as the design possibilities as a result of the emergence of many theories that transformed science from deterministic and assertive reality into the inevitable and non-specified reality [11].

2.5.3 The Systematic system peculiarity of earthen architecture on the level of sustainability dimensions:

Interest increased in achieving sustainability through architecture after the energy crisis in 1970's, and that was by the architects' focus on methods of achieving it and dealing with it as a scientific method that is achieved according to specific steps subject to certain criteria with scientific conscious. Environmental sustainability is achieved in the architecture of the engineer through passive design strategies, which is designed treatments such as directing the building with the best guidance, designing the shape of the openings and their projection according to the prevailing climate, and other treatments such as thermal insulators, sun and insulating glass breakers, and all kinds of treatments that do not consume energy [3]. The efficient design is based on technological techniques that have evolved, such as solar cells, gray water recycling systems, energy efficient devices, smart sensors, etc.Three types of sustainable buildings emerged, namely, passive energy buildings, zero energy buildings, and positive energy buildings. They are buildings whose sustainability range between reducing energy consumption and having their total annual energy consumption be zero, or buildings that generate more energy annually than they consume. The dimensions of sustainability are the environmental dimension, the economic dimension, and the social dimension, which represent criteria by which assessment of the amount of sustainability achieved in the building. In general, environmental sustainability is achieved through protecting the environment, reducing climate change and carbon emissions, reducing the negative impact of buildings, avoiding persistent lack of natural resources, improving the quality of the internal environment, and reducing waste.As for economic sustainability, it will be by lowering the costs of operating and maintaining the building, increasing the value of the building, enhancing marketing, increasing the productivity of skilled cadres and maintaining their presence in the labor market, and high returns on investment.Social sustainability is also achieved by ensuring health and a decent life for individuals, improving learning environments and healing environments, increasing user productivity, social equality in the distribution of resources, providing opportunities to find work, providing opportunities to obtain public, health and educational services, achieving collective security and protecting people from crime, and esthetic Satisfaction [26].

It appears from the above that the engineer's architecture deals with sustainability as a scientific method based on specific steps starting from the design stage through the implementation, operation and maintenance of the building, until the end of the building's life through recycling, by environmental, economic and social considerations that work as criteria through which the building's sustainability is assessed It also serves as goals that are necessary to reach to serve human generation today and in the future.

2.6 Non-systematic system peculiarity of earthen architecture (vernacular architecture):

The definitions of vernacular architecture varied according to the aspects that are focused on, and are mentioned in various terms such as: (Traditional Architecture Popular Architecture. Local Architecture. Environmental Architecture. Human Architecture), and some express it through the meaning of the building material used in it, such as Mud Made Architecture [4].

Some definitions focused on building method, building function, and formal considerations, such as Ronald Bronskill's definition: "A building designed by amateurs without any design training, where the individual is guided by a series of agreements that have been built in his area and which represent building norms. The building function is the dominant factor with little presence of aesthetic considerations.Other definitions of vernacular architecture focused on the goal, the composition method and the formalities, such as the definition of Frank Lloyd Wright: "vernacular construction is a structure that responds to the increasing actual needs, and is installed in the environment by people who know its suitability for the local environment better than others. It is a primitive form of design that lacks smart thinking but best of all academic endeavors that are self-aware of the environment" [44]. The definition of vernacular architecture has also been put forward from aspects of the functional type, the owner, the type of technologies and the goal, such as the definition of Paul Oliver: "vernacular architecture consists of dwellings and all other buildings of the people, with regard to their environmental contexts and available resources. It is built by the owner and the surrounding community like the relatives and neighbors, by using traditional techniques, that are designed to meet specific needs and absorb the values, economics, and cultural lifestyles they have produced " [22]. Others have defined it as a tool that validates the principles that underpin sustainability as a definition (Steenkamp&Whitfiled, 2011): "It is a tool for transferring skills, vocational training, community participation and improving sustainability."On the other hand, the definition of vernacular architecture on the level of the materials used and the local context was presented as a definition (Bourdier& Minh-ha, 1996): “Homemade, woven, locally grown and not intended for the market” [16]. It was also defined from the aspects of the approved knowledge, and the impact of the local context on both sides of culture and traditions, as well as the choice of the building material as it is "a kind of non-engineering engineering, which brilliantly relies on the accumulated knowledge and experiential experience in the construction. It represents the traditions and the historical background of the local area, most of which are made of clay, wood, and stone " [36].

The foregoing shows that the definition of vernacular architecture has been raised from several aspects represented in focusing on the job, the impact of the local context on the choice of building materials and techniques, formal considerations, goals, what it reflects of the cultural and historical specificity of the region and its achievement of the dimensions of sustainability. It is a non-engineering functional architecture that is built by local builders without resorting to the architect, through the accumulation of experimental experience in implementing solutions, and represents an automatic response to the needs of individuals without prior planning.

2.6.1 Non-systematic system peculiarity of earthen architecture at the structural level:

Vernacular architecture depends on the natural resources of earthen available at the site (such as mud, wood and reeds of all kinds, stone, papyrus, wicker, straw and also animal waste) without the need for manufacturing processes or complex techniques [12]. As for construction techniques, they are chosen according to several factors, the most prominent of which are climate and culture. In general, in Bedouin settlements, dwellings are temporary, where lightweight building materials such as bamboo, palm leaves and leaves are used to facilitate transportation. As for permanent housing, they are made of clay, wood, stone, straw and animal waste, and are relatively stronger and more durable. Houses in river basins, such as the Amazon Basin in South America or the rainforests of Africa, are built on tree tops or on raised platforms supported by bamboo wood from below. In areas with strong winds, the roofs are tilted in the appropriate direction for the winds to blow. Rainy housing has conical or inclined surfaces to facilitate rain water. in Cold climates, the building block is larger and is encapsulated with materials to prevent heat loss, while the building block is light and has large openings in hot and humid climates to ensure natural ventilation and reduce humidity problems. Building technology is influenced by the local culture represented by customs, traditions, religious beliefs and cultural symbols, and by experimenting techniques as structural solutions, it is confirmed that their success is transmitted by individuals as an approved technique with the individual differences remaining between housing and another [8]. The construction is dependent on the handcraft by the owner and the surrounding community, such as relatives and neighbors, as the construction team in traditional European societies is headed by a carpenter or building chief and represents his role as that of the engineer or contractor. While traditional non-European societies, community participation in the building was an activity for all individuals, thus allowing skills to be passed on from one generation to another [37].

The Process of choosing building materials and techniques in vernacular architecture comes as an automatic response to the fixed (environment), and changing (economic, social and cultural) conditions, through the users themselves by passing on successful solutions and building skills from one generation to another, without the need for an architect.

2.6.2: Non-systematic system peculiarity of earthen architecture at the level of the design process:

Despite the relative lack of prior planning in vernacular architecture, however, it depends on the design and implementation on the principle of learning through trial and error. It gradually develops by testing, design and

construction solutions in response to a specific need, and then it is transferred between individuals if it proves worthy as successful solutions. This is done through collectively agreed rules represented by customs, traditions and religious beliefs, according to the specificity of each region, and applied effectively by all members of society alike [31]. The term vernacular architecture refers to the construction methodology that indigenous people use to build shelters using resources and conditions that prevail locally. Building knowledge and skills are developed through trial and error and delivered to future generations through local traditions. Some studies have also indicated that vernacular architecture is a sustainable architecture over time because it is adjustable through trial and error to meet the needs of society using local materials and technologies emerging from the natural environment and surrounding culture. The adoption of the approach of trial and error in vernacular architecture provided the opportunity to unleash a myriad of ideas and solutions implemented by the local population through craft and innate intelligence, which led to the accumulation of practical experience over time and finding designs comfortable to live and sustainable to the present time. The method of trial and error was not only limited to the design and implementation process but also extended to the selection of the building material. For example, not all types of soil are suitable for making clay bricks, where locals know by trial and error where to get good soil. One of the reasons for the success of this approach in vernacular architecture is the population continuing to retry the experiment until a suitable solution is found, and they are also able to adapt to the constantly changing circumstances of the environment. They were helped by the availability of materials locally, which reduced processing and transportation costs to the site [30].

The method of trial and error in vernacular architecture comes at several levels, starting with the choice of building material, through design and implementation, and ending with the actual use of the building that determines the success or failure of the experiment. This happens through the continuation of the retry by population and their ability to adapt within changing circumstances, in addition to the availability of materials locally without the costs of manufacturing and transport, which facilitates the adoption of this approach.

2.6.2 Non-systematic system peculiarity of earthen architecture at the level of sustainability dimensions:

Vernacular architecture influenced the thoughts of many architectural pioneers and it was the focus of their intellectual interests, due to its success in meeting the spiritual and material needs of its users, and the strong link between local popular architecture and the environment. It is called environmental architecture because it is closely related to the local environment [21]. Environmental architecture means architecture that is in line with human needs and requirements and that reflects, the past, present and future, in addition to its homogeneity with the natural environment of man, and therefore environmental architecture deals with three axes: “the axis of the social environment, the axis of the natural environment, and the economic axis". Vernacular architecture is considered a necessary source to revive the movement of modern architecture, the architecture of time and space, as its material product reflects the reality of time and the place in which it is located, it has a certain shape and features using simple environmental items during a specific time period in a specific geographical region. An image of collective creative activity, which is built with the collective efforts of the population and with the knowledge of craftsmen, and develops according to the needs of its users. This nature mirrors the environmental, social and civilizational components, as it stems from the environment and is compatible with it financially and humanly, by making optimal use of its environmental and economic potentials [5]. Folk construction relies on the innate intelligence of ordinary people to construct buildings that are not only low-cost but also familiar to the indigenous people. This is especially important in third world countries where people lack capital, so their housing crisis can be resolved through their participation in the design of their community.In addition, vernacular construction has proven to be extremely beneficial in times of calamities such as wars and natural disasters, when IDPs are returned to their homes and they recover better from painful experiences [29].

According to the foregoing, it shows that vernacular architecture is a realization of the dimensions of sustainability with its environmental, social and economic dimensions, and these dimensions are distinguished by their intertwines in the popular construction as a construction stems as a response to the conditions of the surrounding environmental with its various dimensions.

Conclusion: At the end of this axis it is necessary to determine a procedural definition of each of the systematic and non-systematic systems in earthen architecture, to select the samples associated with each system.

Systematic earthen architecture buildings are those buildings in which the engineer has a presence from the initial concept stage, information gathering, design and implementation stage through pre-planning.

As for the buildings of non-systematic earthen architecture, they are those buildings that are implemented by trial and error by the local population from the stage of selecting building materials, design, implementation and use. They are buildings that can be modified on more than one level according to the actual needs of the user.

2.7 Theoretical framework:

Accordingly earthen architecture include two systems represented by (systematic and non-systematic). First one can expressed by architecture of engineer which depends on identified steps starting from design process,

implementation process, operation and maintenance, while second one can be expressed by vernacular architecture in which there is relatively no prior planning relying on the spontaneous consideration and have multiple variables derived from these consideration as showed in table (2).

Table 2: Indicators of sustainability at systems of earthen architecture. Source: The researchers.

Vocabulary	Indicators	Possible Values	
Sustainability strategies in the systematic and non-systematic system of Earthen Architecture	*Environmental consideration*	*Directing the building to the best orientation*	*A1*
		. Combining artificial and natural materials to increase thermal insulation efficiency and structural durability	*A2*
		Openings design, direction.	*A3*
		Adopt thermal insulators.	*A4*
		Sunshades or terraces.	*A5*
		Insulating glass	*A6*
		Solar cells	*A7*
		Smart sensors for light, temperature, motion	*A8*
		Interior and exterior finish with efficient thermal insulation materials	*A9*
		Treatments applied to the building material, or to the implementation technology, or to the structure to improve the properties of thermal and acoustic insulation, durability and earthquake	*A10*
		The need to maintain the building periodically.	*A11*
	Economic consideration	*Low Material Cost*	*B1*
		Low Labor Cost	*B2*
		Low Construction Machinery Cost	*B3*
	Social consideration	*Providing spaces for interaction and social networking.*	*C1*
		Improve learning and healing environments.	*C2*
		Social equality in the distribution of resources and employment opportunities.	*C3*
		Providing opportunities for public, health and educational services.	*C4*
		Harmony with the local cultural context	*C5*

		Achieving community participation in implementing the building	*C6*

3. practical application:

This part aims to test the reliability of sustainability indicators on the selected models represented by (The House of Earth and Light - USA) and (The House of rammed earth- France) as a models for the systematic system of earthen architecture and (The House of Pillar - China) and (The Reed House - The Marshes of Iraq) as a models for the non-systematic system of earthen architecture, For the following reasons:

A- Its structures have been totally or partially Implemented by using natural earth materials, which makes them classified within the earthen architecture buildings.

B- All samples classified within the residential type, to facilitate comparison between samples.

C- The variation in geographical location and construction period between samples to ensure that the largest possible number of them is scanned.

D - classified within the buildings that meet with the standards of sustainable architecture.

The research would examine theoretical indicators on these models to check following hypothesis: (Earthen architecture possess sustainability considerations (environmental, economic, and social) in its systems, but achieving these considerations differs in technical, constructional and operational aspects).

3.1 Models of systematic system of earthen architecture:

3.1.1 The house of earth and light - USA:

It is located in the Arizona desert - USA, designed by the architect Marwan El Sayed in 1998. Achieving thermal comfort was one of the designer's most prominent goals. The plan consists of three parts, the central part is represented by a block of transparent glass and steel that acts as a bridge between the other two blocks, as it floats over the valley (hanging block), this block contains the living room and dining room. The glass used in this part has low transmittance to harmful solar rays, and it is also subject to opening and closing degrees to take advantage of the cold valley breezes. While the other two blocks consist of thick load-bearing walls of rammed earth mixed with a ratio of Portland cement and a thickness of 18 inches, as it blocks the harsh desert sun, and contains the entrance, study space, kitchen, bedrooms and bathrooms. The dwelling with its contrasting blocks is roofed with a tent with a structure based on the tension system, and the fabric consists of three layers, the first layer is perforated fabric to allow light and air to pass through and is coated with a layer of polyvinyl chloride, and the second layer is a fabric of polyvinylidene fluoride which is dulled like a waterproof membrane and allows the passage of the light. While the last layer consists of non-woven fabric that is resistant to solvents and acids is suspended 6 inches away from the second layer to create a gap that enhances the thermal insulation. The tent extends outside the housing block to be a shade of 6 feet in the southern façade to protect it from the sun and rainstorms [38]. Fig(1)

3.1.2 Rammed Earth House - France:

These homes were designed by Jourda & perraudin partenaires in France in 1984 and were implemented by labor, the functional program for each unit: living room - two bedrooms - two bathrooms - kitchen - garage - private garden - private balcony - glass garden on the roof. The structural structure consists of load-bearing walls from ramming the earth into wooden molds, with a thin layer of concrete between each layer to provide lateral reinforcement to the walls and prevent erosion of the wall layers. The facades have been treated with balconies and the structure of the balcony consists of a concrete wall at the rear façade that holds the balconies on the first and second floors, and provides a transition between the interior and the private garden on the ground floor. The unit surface is designed in the form of a glass garden made of transparent polycarbonate supported by light steel trusses, supported by concrete trusses that extend to the outside of the building to protect rammed earth walls from rain, and to enhance heating during winter season by a thermostat controlled from inside [39]. Fig (2)

3.2 Models of non-systematic system of earthen architecture:

3.2.1 Reed House - Iraqi marshes:

Reed houses were implemented by using reeds to build roofs and cover them with mud to provide thermal insulation in summer and winter, while the walls were implemented by layers of compacted or woven reeds and covered with mud or plaster. This process is known locally as "claying", and it is performed by the local people. Reed houses are directed towards the prevailing winds, where the air enters through the holes of the reed mats that are fixed from ground level to the half height of the house and on both sides, to create air flow inside the house during the hot summer. While these openings are closed with a clay mixture during the winter to avoid cold air and provide thermal insulation. Also the reed hostesses were implemented entirely of reeds, sedge, and reed mats, they were made with meticulous attention to the aesthetic and environmental aspects, and are considered one of the most prominent tourist destinations in Iraq [32]. Fig (3)

3.2.2 Stilt House - China:

It is implemented by using mud and wood, raised above the water level on stilts of sturdy wood (with a concrete base under water) to avoid mold and dampness, stilt houses are spread in fishing villages in southern Chinese provinces, and are carried out by local residents. The stilt house includes an open balcony to fulfill the following needs: (family gathering for food and rest, preparing fishing supplies, storing fish, selling and drying it with salt, and household activities such as knitting and cooking), and the balcony has an environmental function as preventing direct sunlight and providing a transitional space between inside and outside to achieve thermal comfort. As for the openings, they were directed in the direction of the prevailing winds, and the adhesion of the units to each other reduces exposure to external weather conditions, the housing units cluster along a common wooden corridor extending from the land to the sea, and the common services (bathrooms and kitchens) are distributed along the wooden corridor to facilitate access to it as It is of general use, while fishing boats are tied down the units and accessed via wooden stairs (ladders) [15]. Fig (4)

Figure 1: The house of earth and light - USA. [20]

Figure 2: Rammed Earth House - France. [40]

Figure 3: The Reed houses - Iraqi marshes. [18]

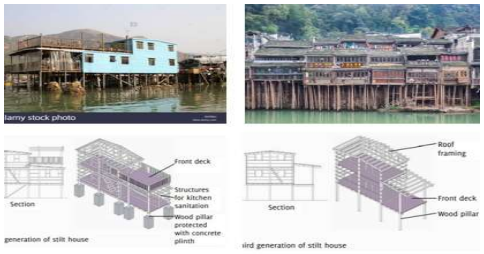


Figure 4: Stilt House - China. [19]

3.3 Measurement method:

In the following, the indicators reached in the theoretical framework from (A1) to (C6) will be tested within the four selected models, on the basis of their achievement or non-achievement on a scale ranging from (1-0). Where the value (0) represents the failure of the indicator, while the value (1) represents the achievement of the indicator

Table 3: Testing sustainability indicators on the selected samples as models for systematic and non-systematic system of earthen architecture:

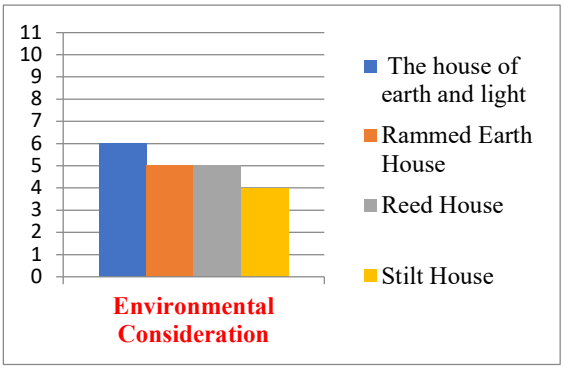
Possible Values	The house of earth and light	Rammed Earth House	The Reed house	Stilt House
A1	●	●	●	●
A2	●	●		
A3	●		●	●
A4				
A5	●	●		●
A6	●			
A7				
A8		●		
A9			●	
A10		●	●	●
A11			●	
B1			●	●
B2			●	●
B3			●	●
C1			●	●
C2	●	●		
C3	●	●	●	●

C4	●	●		
C5	●	●	●	●
C6			●	●

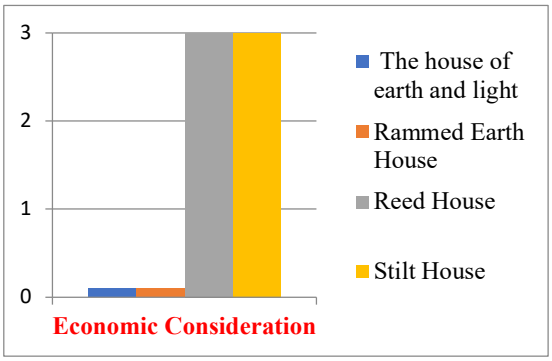
3.4 Results:

The results of testing sustainability indicators on the selected samples for the two systematic and non-systematic systems of Earthen's architecture showed the following:

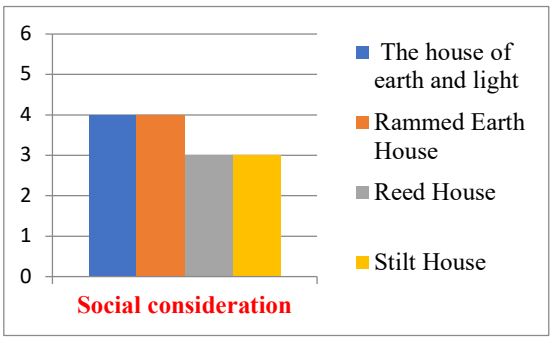
3.4.1 The Results of Environmental Consideration:



3.4.2 The Results of Economic Consideration:



3.4.3 The Results of Social Consideration:



-The environmental consideration has emerged in both the systematic and non-systematic earthen architecture systems, but the two systems differ in some aspects related to the nature of materials, their treatment method, implementation techniques and façades details.

- The economic consideration is achieved in samples of non-systematic system more than those with a systematic system, as a result of resorting to collective cooperation between the local population instead of labor in the implementation process and reliance on manual work and natural building materials available in site land, which makes the costs low or almost non-existent in samples of non- systematic system. While the cost increase in the systematic system samples, as a result of the industrial materials that are combined with the natural at the level of the building material, the structural structure and the details of the facades, as well as the increase in the required labor costs and the increase in the costs of modern construction machinery.

- In general, the social consideration has emerged in both the systematic and non-systematic systems of earthen architecture, but there are implicit differences in the indicators of achieving this consideration between the two systems.

4. Conclusions:

- Earthen architecture introduced with various aspects, some qualified it with a doctrinally peculiarity through the reconstruction of the earth, which includes the material and moral aspects based on the relationship between humans and the environment. While other dealt with it from the historical side as an architectural heritage that extended from ancient to present time, other studies, specialized in interpreting earthen architecture as natural building types that differ according to the circumstances of the natural context of each region, such as clay architecture, wood architecture, and stone architecture.

- Earthen architecture appears in different orders in buildings, including systematic and non-systematic systems. The systematic one depends on specific steps in design, implementation, and formalities. while the other appears in buildings, which are relatively lacking in clear planning.

- Earthen architecture is a system that possesses multiple considerations related to sustainability, represented by (environmental, economic and social). These considerations were reflected within the systematic system of earthen architecture, which is represented by the architecture of the engineer, and the non-systematic system, which is represented by vernacular architecture.

- The peculiarity of earthen architecture was represented within the systematic system of engineer architecture and the non-systematic system of

vernacular architecture in many aspects, The most important aspect is the structural aspects, principles and goals of design process and strategies for achieving sustainability, as many common points emerged between earthen architecture and the systematic and non-systematic systems, which strengthens the knowledge that clarifies the importance of Earthen architecture and its flexibility to appear in different systems.

- The peculiarity of the systematic system of Earthen architecture appears within the engineer architecture on the basis of identifying two types of development in the field of building materials and technologies, the first type of development represented with natural treated building materials, as this type depends on the development processes that enter the primary material between the stage of extraction as raw material and stage of use in construction, with the aim of improving its properties and efficiency to the construction requirements. The most prominent of these materials are stone, clay, and wood. while the second development type represented by manufactured building materials, where innovations in the chemical and mineral industries contributed to providing new alternatives to building materials that proved effective of construction options. It is possible to invest these materials and enter them as supportive or complementary elements with natural building materials.

- The peculiarity of the non-systematic system of earthen architecture within the vernacular architecture is structured through the selection of building materials and techniques as an automatic response to the fixed (environment), and changing (economic, social and cultural) conditions. Where users depend on themselves without the need for an architect, by passing on successful solutions and building skills from one generation to another.

- Sustainability considerations overlap with each other in order to achieve formal and planning characteristics aimed at serving humanity at the present time and preserving natural resources for future generations. In earthen architecture differences appeared in these characteristics according to the architectural system, generally appears that the environmental and social considerations are achieved in both the systematic and non-systematic systems with implict differences in tecniques and treatment methods, but the economic consideration is achieved more in the buildings of non-systematic system, as a result of the lower costs of materials, labor and machinery.

5. Recommendations:

- The necessity of investing principles from previous and contemporary earthen architecture experiences and developing the existing capabilities to make a preliminary guide that developed earthen architecture and in a way that serves the society and meets its various needs.

- Study the potential of earthen architecture as a natural architecture based on the materials as clay, wood, cane of all kinds, stone, papyrus, and straw, to identify indicators that enhance the strength and durability of local materials and create a local earthen architecture that achieves dimensions of sustainability.

- Determining the successful aspects of vernacular and engineer architecture on the material and non-material levels to investing them in enhancing the performance of the Earthen architecture as a comprehensive system that works on several levels that achieving human harmony in the temporal and spatial context.

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عمارة الأرض بين النظام الممنهج وغير الممنهج

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نشر في : 31 اذار 2022

الخلاصة: برزت عمارة الأرض كمنظومة تمتلك أنظمة متعددة تجسدت في نتاجاتها المعمارية والعمرانية. أظهرت هذه النتاجات تعالقاتها مع الاستدامة واعتباراتها (البيئية، الاقتصادية والاجتماعية)، الا انه لم يتضح مدى تعالق هذه النظم بالإستدامة، ومن هنا برزت المشكلة البحثية لتتمثل بـ **(قصور التصور الواضح عن أنظمة عمارة الأرض ومؤشرات الإستدامة ضمن هذه الأنظمة).** ليتحدد هدف البحث ببناء إطار نظري عن مؤشرات الإستدامة ضمن أنظمة عمارة الأرض الرئيسة. تبلورت فرضية البحث بـ(تحققت مؤشرات الإستدامة ضمن نظم عمارة الأرض بشكل كامل الا ان مؤشرات الاعتبار الاقتصادي كان أكثر تحققاً ضمن النظام غير الممنهج على حساب النظام الممنهج). لحل المشكلة وتحقيق الهدف تم تقسيم البحث الى محورين: اختص الاول بتحديد أنظمة عمارة الأرض وبيان مؤشرات الإستدامة ضمنها، ليختص المحور الثاني بإختبار هذه المؤشرات ضمن عينات تتبع للنظم الرئيسة لعمارة الأرض للتحقق من فرضية البحث ولبيان أي الاعتبارات كان الأكثر تأثيراً ضمن النظام. توصل البحث الى أن النظم الرئيسة لعمارة الأرض تتبلور بالنظام الممنهج والنظام غير الممنهج وكلاهما مصمم وفقاً لإعتبارات الاستدامة، الا ان مؤشرات الاعتبار الاقتصادي برز تحققها ضمن النظام غير الممنهج بشكل أكبر من تحققها ضمن النظام الممنهج لعمارة الأرض.

الكلمات المفتاحية: عمارة الأرض، النظام الممنهج، النظام غير الممنهج، العمارة المستدامة.