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# THE EFFECT OF NATURAL ENERGY SOURCES ON THE SUSTAINABLE FORM OF VERNACULAR ARCHITECTURE

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## ABSTRACT

*The Natural resources of each region are considered to be the main environmental influence on the traditional vernacular architecture that emerges naturally, considering that the physical appearance of the traditional architecture is based basically on the human interaction with the surrounding environment, his adaptation to it, and his best utilization of it. What really makes this architectural image special and significant is the integration of several aspects, which are; the environment, the aesthetics and the social character in a comprehensively complete way with the elements of sustainability. This research will look into two main aspects; firstly, the theoretical aspect that will review the importance of studying the effect of the characteristics of natural sources on shaping the elements of vernacular architecture, it will also inspect the importance of studying the nature and characteristics of these elements and their integration with environmental, social and esthetical sustainability standards. Secondly, the study will conduct a practical analyses of several vernacular buildings samples from the Levant region (Jordan, Syria, Palestine and Iraq) to study the effect of natural energy sources variations that were mentioned in the theoretical part of the study for analyzing and discovering the effect of these variations in enriching the sustainability within the vernacular architecture in each country, and their effect in generating the vernacular architectural form.*

**Key words:** Vernacular Architecture, Natural Energy Sources, Environmental Sustainability, Vernacular Architectural Elements

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# 1. INTRODUCTION

This paper aims to clarify the ways that natural energy sources contribute to shaping the form of vernacular traditional architecture within the Levant region, and define how vernacular architecture achieved sustainability through being environmentally responsive to a specific location in a specific period of time. Literature review on the topic showed a lack in scientific indicators about the effect of natural energy resources in creating the image of an environmentally responsive vernacular architecture within the Levant region. While there is a large body of literature regarding environmental sustainability in vernacular architecture in general, there are Limited studies regarding the effect of natural energy resources in creating the image of an: environmentally responsive vernacular architecture within the Levant region in specific.

Moreover, there are Limited studies about the character and image of vernacular architecture in the Levant region, which limits the researcher's field of study into specific categories and common prototypes of vernacular architecture in each country.

However, the research will look into what can be called the Vernacular form generator, as in; the factors that contribute in shaping the form of the vernacular architecture, and most importantly finding the direct link between these factors and the aspects that make vernacular architecture environmentally responsive, in other words; learn lessons from vernacular architecture and define how it achieved environmental sustainability in that specific period of time.

The most obvious limitation is working on a specific region, which is the Levant region. Choosing specific locations within the region to specify different case studies from different contexts to try and cover several conditions and their resulting architectural; form, like choosing different cases from Syria, Jordan and Palestine.

The first part of the methodology will depend on data collection in a descriptive research approach method in the theoretical part of the study. Then a qualitative, Case study, analysis and comparative research method approaches in the second more practical side of the study. Stages of research methodology: Reviewing the literature, identifying data, searching for data, collecting data through specifying case studies in specific locations within the Levant region (Syria, Jordan &Palestine), and Classifying the analyzing the findings in a comparative approach.

Vernacular architecture is a reflection of how many civilizations across the world historically lived in their local environments [1], it is a reflection of how cultures adapted and utilized the natural sources provided to them in a specific region, which resulted in generating a unique architectural image from one region to the other. While at the same time succeeded in providing the basic sheltering needs from the weather conditions, resolving climatic problems, integrating social functions and also added physical and aesthetical special appearance [2]. All of that is considered the prime motivators that resulted in the formation of different shapes of vernacular architecture across the world as a whole, and across different locations within a region, like the Levant region included in this study.

Vernacular architecture is the architecture that provides harmony to each element of its buildings, urban fabric, environment, building materials, culture, and climate [3], in other words; Vernacular architecture is sustainable, But is it is important to mention here that sustainability measures are different from time to time, our present time criteria for sustainability might be different from that naturally found in vernacular architecture, so we need to keep in mind that we are talking about a specific time in which those vernacular forms emerged and how conveniently they provided human comfort to their users within their context in the past so we can learn from vernacular sustainability experiences.

To be fully aware of how vernacular architecture is sustainable, this study will analysis how its elements and forms are climate responsive, in a way that brings human comfort to the users of its dwellings and its urban spaces. This is why the urban fabric tissue and the corresponding single building designs are significantly different from one climate zone to other [4], and therefor this study will focus on how natural energy sources that are found naturally in the environment have the major effect on how the vernacular architecture – environmental responsive forms are generated.

## 2. DEFINING VERNACULAR ARCHIETCTRE

The word "vernacular" comes originally from the Latin word: Verna, which means the traditional or the local. Vernacular architecture is the architecture that prevails at the whole society in a specific time with respect to its culture and context. 80% or maybe more of the total buildings in the world are considered to be vernacular [5]. Many terms had been used to refer to vernacular architecture, as Rudofsky mentioned in his book Architecture without architects [6]; "It is so little known that we don't even have a name for it. For want of a generic label, we shall call it vernacular, anonymous, spontaneous, indigenous, rural, as the case may be." Oliver [7] proposed defining vernacular architecture as the successful result of an architecture that corresponded rationally to the available local building materials, climate conditions and cultural needs. He also mentioned that there isn't really any clear definition of vernacular architecture, though it can be possibly a mix of architectural and human in relation to time, geography and history. Another famous author on vernacular architecture defined the vernacular architecture as the result of the total integration of many variables such as; society, culture, environment, building materials, and geographic location; as it is the product of processing all those variables together [8]. Many literatures had been addressed to vernacular architecture and its correspondence to the climate, in this regard, vernacular architecture had been described as the natural integration of the architectural form as a part of its natural surroundings as the passive strategies used in the naturally occruing forms – thanks to tradition and culture- are very helpful at achieving human comfort for the users [9].

## 3. DEFINING SUSTAINABLE ARCHITECTURE

As has been mentioned in the introduction, readings and literature led to the assumption that vernacular architecture is sustainable, as the vernacular architecture can produce buildings that can integrate sustainable architectural principles. Although sustainability might be considered a highly new concept, but in fact it is not, sustainable architecture of today is referenced to many vernacular examples of the past [10]. This research will look into how vernacular architecture applied sustainability aspects into their buildings, to do so we firstly need to identify sustainability and its principles, then look into the natural energy sources to come up with more understanding to this theoretical part of the study.

Sustainability had been defined by a large body of literature, maybe the most common definition we can come across when searching for "sustainability" or "sustainable developments" is the one published by the world commission on environment and development -WCED- back in 1987 [11]; "development that meets the needs of the present without compromising the ability of future generations to meet their own needs. " Sustainability is defined as the full integration between the nature and the human to sustain continuity and place making [12].

Phillip Sutton defines sustainability as a way of improving the quality of life and providing means of survival and continuity, he also mentions the full integration of the three aspects of sustainability as he says sustainability is a way of fully integrating the environment, society and economics together to sustain a better life [13]. It is clear now that sustainability

revolves around three main pillars which are the basis of any sustainable design strategy, and are – as mentioned before by Sutton; The social, the economical and the environmental pillars [10].

Within the context of what had been explained, it is evident that vernacular architecture achieved the three pillars of sustainability, the involvement of the culture and the society are what defines the social pillar, the usage of local materials and building techniques may define the economic, but the environmental pillar is much more diverse and complicated. The next part of the study will provide more understanding to how it was achieved based on the environmental sustainability aspects focussing on natural energy forces and how they are integrated within vernacular architecture to provide means of obtaining human comfort.

## 4. TYPES OF NATURAL ENERGY SOURCES

There are certain types of natural energy resources that are concerned with the resulting architectural form within a specific context, which are; the sun, wind, humidity, water [8], and finally the natural building materials found within the surroundings of the given context. Each of those factors contribute directly to the architectural forms generated.

The Sun factor is one of the main natural energy sources that man had to adapt with in order to reach comfort in his dwelling, as it is considered the main source of heat with in all climate zones. In order to design a building, the orientation of that building to the sun must be well studied in terms of defining the location of the sun at each hour of the day in all days and all seasons, especially summer. As well as taking into consideration the sun radiation that's being reflected from the neighboring structures and surfaces, or with hold the reach of it, which contributes into creating a special microclimate. Therefore, it is very important to find the perfect orientation to well utilize the energy of the sun [8]. This utilization would contribute into bringing passive heating, passive cooling and natural lighting into the dwelling.

Through good architectural design, buildings can insure a natural ventilation through two main principles that rely directly on the wind as a natural energy resource; firstly, through differences in air pressure that occurs due to different air velocity which makes the air flow from the high pressure area to the low pressure area. Secondly, the natural convection forces which depend on the difference between the air density – due to different temperatures- where the hot lighter air moves up and the colder denser air comes down creating natural air circulation. The Third factor is the Humidity – or the water-, the water is very important for increasing humidity especially if we are trying to achieve human comfort within dry hot climate zones [8].

The final factor is the natural materials –local- found within the surroundings, and as vernacular architecture had been defined by those local materials specified to a certain region, it is very important to find the link between how the vernacular buildings expresses those materials in their forms, and how they best utilize those materials to best achieve comfort to their users by methods of construction. And as local materials cost less and are naturally available, which consumes less energy in the process off delivering them to the site of construction –both economic and environmental pillars of sustainability-, it is more sustainable to use them than to use materials from elsewhere.

Local builder's self-helped themselves into developing the best building construction technologies to achieve comfort with the local materials available, for example; the usage of brick and adobe in several regions worldwide provided insulation in hot arid climates [14]. The techniques used in traditional vernacular architecture are interesting as they are considered sustainable by their nature [15].

## 5. THE EFFECT OF THE CHARECHTARESTICS OF NATURAL SOURCES ON SHAPING THE ELEMENTS OF VERNACULAR ACHITECTURE

This part of the study examines some of the most famous vernacular architecture elements within the Levant region (Jordan, Palestine, Syria & Iraq), as a result of an architecture that responded to the natural energy forces in the surrounding context and utilized it to achieve environmental sustainability and deliver comfort to its users.

The elements and features of vernacular architecture found in the Levant region are vast, in respond to the sun factor, the most common feature is the type of ceiling applied to the roof of the building, many traditional buildings use a vault like structure that gives both extra height and slope to the building, these vault structures are famous especially in the villages of Jordan (Figure 1), Syria and southern parts of Turkey (Figure 2).

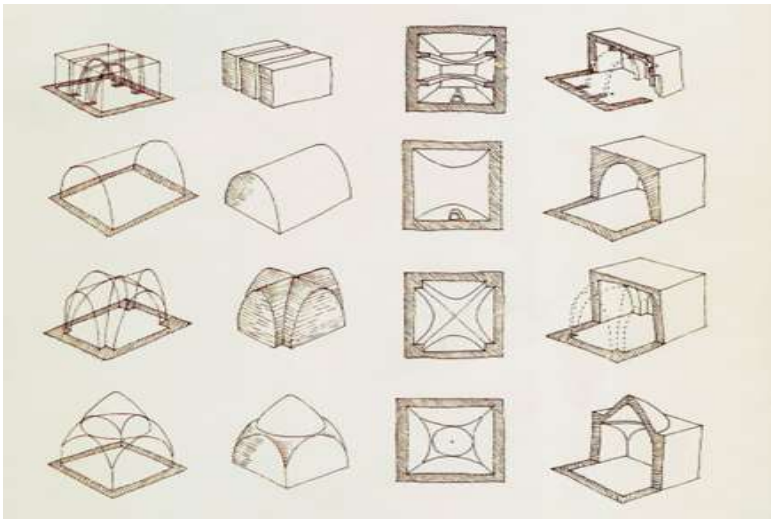

**Figure 1** Traditional forms of vault structures in the vernacular Jordanian villages. [16]

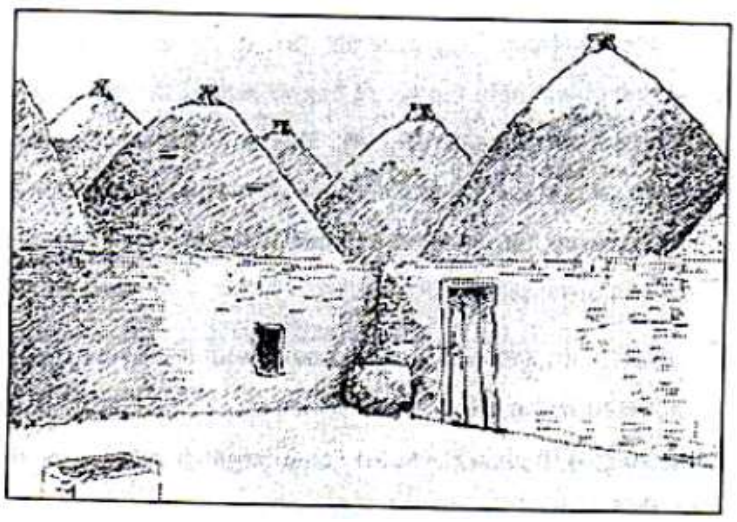

**Figure 2** Beehive dwellings of Harran Village – East southern Turkey – Note the usage of vaulted like domed roofs and the top opening which goes back for more than 200 years. [17]

Perpendicular on the roof - which means that the heat absorbed by the non-shaded part travels through the roof into the shaded part and then into the indoors, this process usually takes up a long time due to the big time lag found in the materials used, in a way that the heat

usually doesn't travel indoor as the process is reversed once the source of heat –the sun- is gone by the end of the day [19].

Vaulted roofs also help increase the height of the building which contributes in generating natural convection currents indoors passively [8]. Some of the interesting additions to this feature are adding an opening at the top of the domed roof which helps get rid of the excess hot air when it naturally rises up by convection [17]. Moreover, curved roofs help increase the speed of the wind passing above them which makes the pressure inside the buildings decrease, this creates different pressure zones on the outside and inside of the roof, thus, naturally makes the air flow from the high to the low pressure which helps obtain passive cooling through natural ventilation (Figure 3), this effect in physics is called the Bernoulli principle [19].

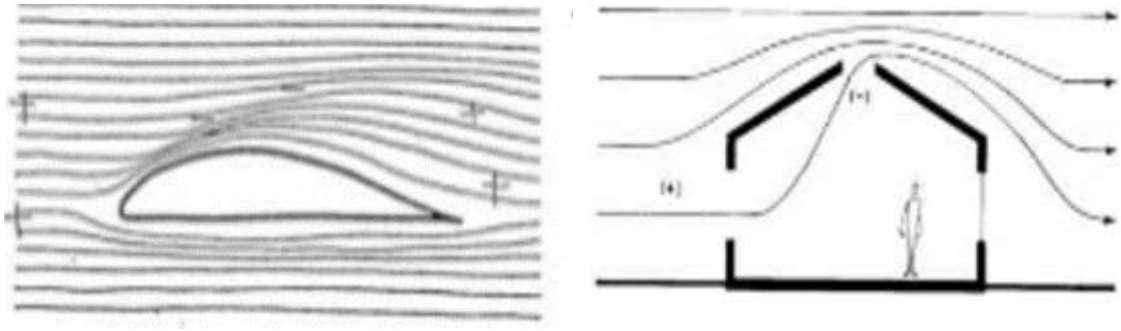

**Figure 3** Bernoulli Principle. Note that the presence of an opening on the roof like in the case of the vernacular beehive dwellings of Harran village helps increase air flow across the space. [19].

When it comes to shading, as where the sun provides overheating and excess lighting indoors, we can see some features in vernacular architecture that help in reducing that effect especially in the hot areas. One feature are the loggias which are found as elements attached to the elevation facing the most direct sun light, loggias provide shading from the sun as well as enhancing the air flow due to the differences in air pressure in the shaded areas verses the non-shaded ones which generates natural air flow [8].

The courtyard itself is a really common feature which responds to the sun factor and helps provide natural ventilation (Figure 3), and cooling to the spaces around it as the floor of the courtyard itself gets heated by the sunlight which makes the air above it warmer and less dense, this low density air flows up by convection while the denser cooler air moves down [20]. As the air in this case in rather hot and dry, many vernacular courtyard houses add a water feature (Figure 4) to help add humidity to the air cycling through the spaces, this provides cooler ventilation as the air flowing carries the evaporated water particles near the surface of the water feature in a process called evaporative cooling [19]. This is one way some of the well-known vernacular forms are generated in response to the water – humidity – factor [8].

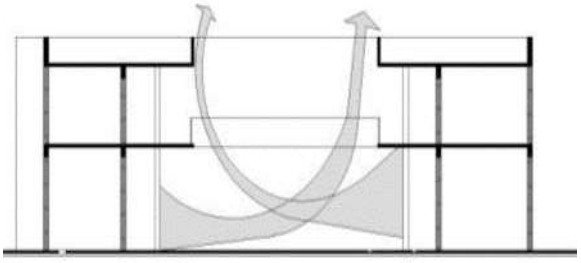

**Figure 4** Natural air flow through a courtyard – Sectional view. [20]

**Figure 5** Water feature as an element inside the courtyard. [20]

## 6. CASE STUDIES

This part of the research will adopt an analytical descriptive approach, where the researcher will present several cases from common vernacular dwelling typologies found in the Levant region and describe how each case's forms and features are responsive to the natural energy forces in their context in a way of providing environmental sustainability measures and human comfort to the users.

The first case study is a beehive dwelling (Figure 6), a type of vernacular housing found commonly in the arid areas of Syria, Jordan and southern turkey. The climate conditions are commonly hot and dry. This type of dwelling respond to this climate conditions by providing minimum openings to decrease solar gain, and are usually built with thick adobe and mud walls, this both helps carrying the massive dome structure for the roofing while also preventing the travel of heat from the outside during the hot hours of the day. The dome structure provides extra height which –with the addition to the top opening (Figure 7) - helps convection forces provide natural air flow for cooling and ventilation. The conical dome roof here helps protect the mud covering of the building from cracking or sliding off during seasonal rain periods [21].

**Figure 6** Beehive dwellings on the edge of Syrian arid area near the city of Hallab. [21]

**Figure 7** Top opening, source of natural lighting and helps the hot air flow to escape. [21]

The Second case is a common peasant dwelling from AL Hommud village from Jordan (Figure 8), most villages in Jordan are on the northern highlands which explains the common features in them, they are mostly all built with stone and have vaulted roofing. The walls are thick to carry the heavy stone vaulted roof, this adds to the insulation of the unit as it provides cool atmosphere indoors due to the high thermal capacity of the stone which is naturally found in the Jordanian mountains. The walls are thick and the openings are minimal [16].

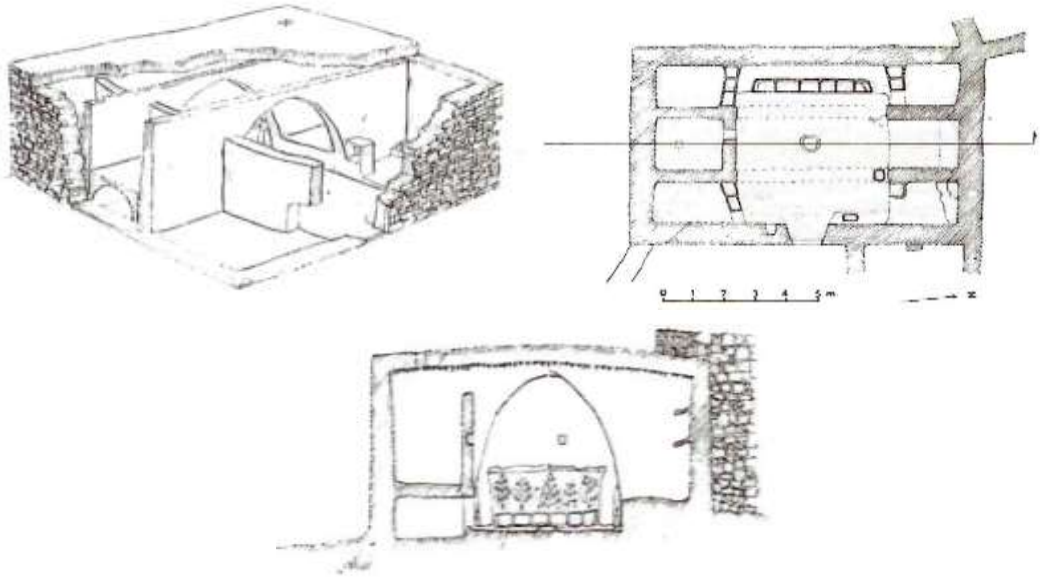

**Figure 8** The house of Khalaf Al Halasneh, Hommud Village, Jordan. [16]

The villages south of Jordan are on low lands and are mostly near the desert, which means a new type of the simple peasant house appears, the differences only match the different climate conditions and the local materials available so it is only normal to see the villages to the south built from mud and brick with big openings and flat wooden roofs [16].

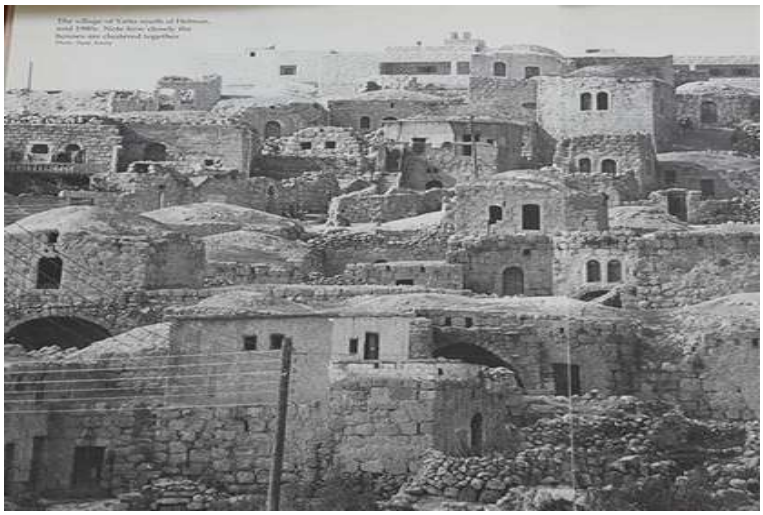

**Figure 9** Palestinian village south al Khalil city – Mid 1980 – Note the cluster formations, domed roofs and stone exterior. [22]

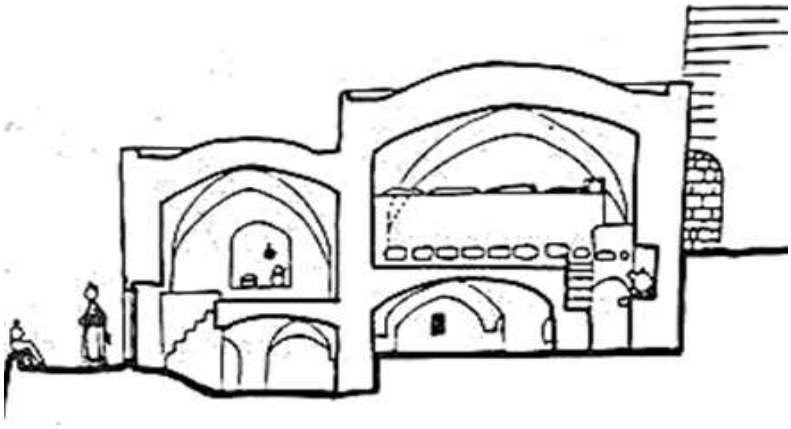

**Figure 10** Sectional view to a traditional house from a Palestinian village near Ramallah city. Note the thick walls and domed roofs. [22]

The dome roofing again provides extra height to help circulate air through convection, while the wind speeds up above the roof creating low pressure areas on the inside which helps with more air flow naturally. Moreover, the house is typically split into two levels (Figure 10) with no interior partitions which enhances the air flow [22]. The domed roof here helps during the winter season where rainfall is high, so that the exterior coating to the dome which is mostly mud or plaster doesn't slide off or leak coldness into the building if left to build up on a flat roof.

The next case is a prototype of the traditional Loggia houses (Figure 11) that originated in the early nineteenth century, and is found in several places within the Levant region, mainly in the rural parts of Syria and Lebanon where the climate is mostly moderate. This type consists of a linear plan house where all spaces open up to a loggia that is placed on the elevation facing direct sun radiation, this form especially responds to the sun factor by shading it – preventing over heating in summer where the sun in high and obtain solar heating in winter where the sun is low- and obtaining means getting a natural air flow in all spaces because of the air circulation through the shaded loggia due to different pressure zones as discussed earlier.

The roof here is mostly flat, made of wooden beams that are covered with sticks and mud for insulation. As for building materials they are local brick or stone depending on what is available in the location, if brick they are usually covered in plaster for protection and insulation, the structure of the building depends on stone columns, this is why no massive walls are needed to carry the roof which is slightly light comparing to the previous examples [20]

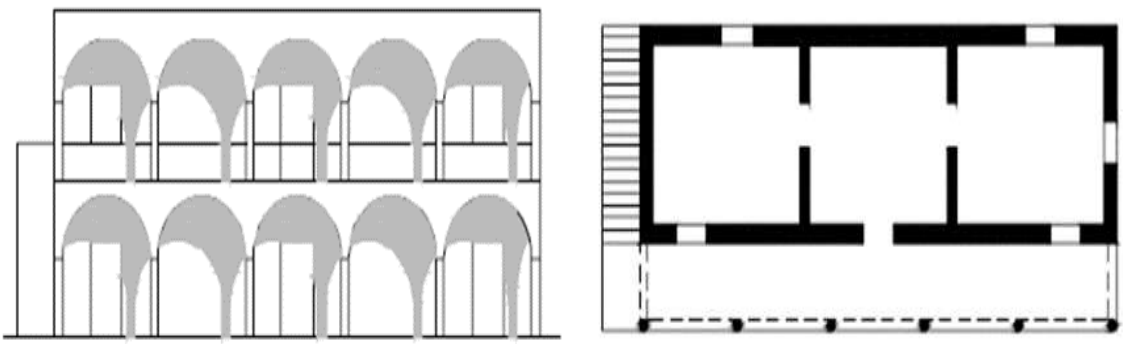

**Figure 11** Elevation and plan of a traditional loggia house from Syria. [20]

**Figure 12** Loggia house from Syria. [20]

The Last case study in this research will look into are the courtyard houses, this type of house is found in many places within the Levant region, especially in Syria. It is well characterized by its centralized organization of spaces around an open court. Courtyard houses are found in several types depending on their location, mainly rural or urban.

The rural court yard houses come in two different types; the first one is the courtyard house with flat roof (Figure 12), these houses are a simple grouping of spaces built around an open court which is considered the private space for the gathering of family members, and where some house chores are done like cooking, or children playing – which is perfect for social interaction, the houses are usually built with local stone or brick with simple column and beam structure where the wooden beams carry the flat roof which is then covered with sticks and mud for insulation [20].

The second one is the beehive courtyard house (Figure 13), it's the grouping of several beehive houses around a central court, same building materials and techniques of the traditional beehive cells mentioned before apply here. Usually, the court in the rural courtyard houses opens up into a garden for the houses, where the family members grow their own vegetables and fruits. The courtyard however provides means for social and environmental sustainability for reasons discussed earlier [20].

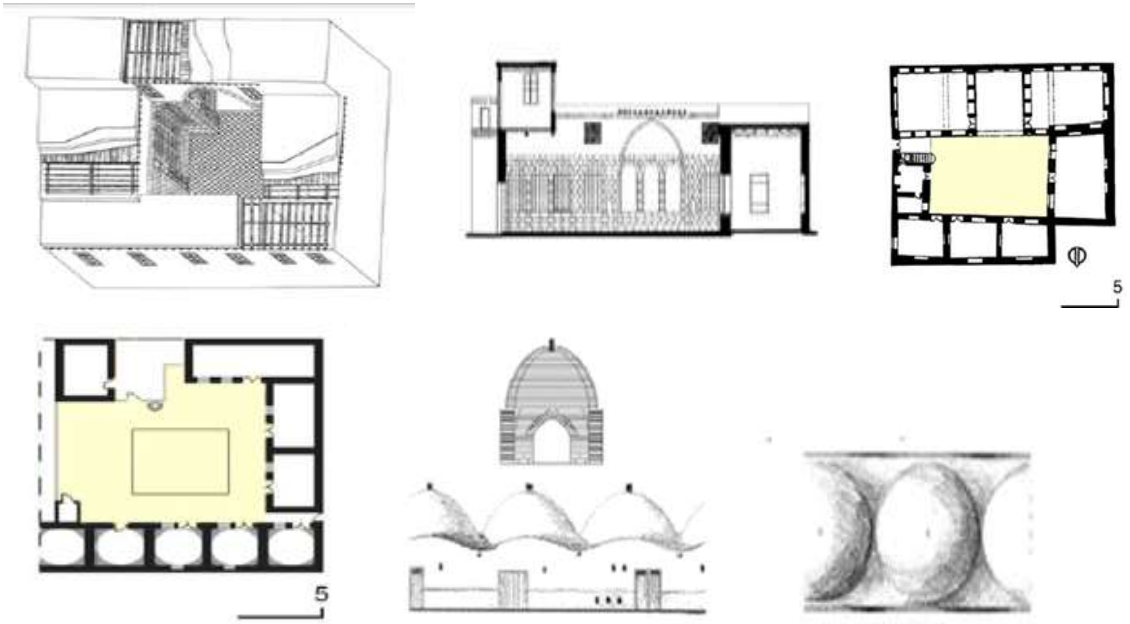

**Figure 13** Flat roof courtyard rural house VS a beehive cells courtyard rural house from Syria. [20]

In Palestine, most courtyard houses in the villages belong to an extended family, where spaces keep adding up whenever a family member gets married and moves out into an adjacent space. Spaces keep forming around the court, at some point several courts for the

same extended family gets created, the primary court gets connected to the secondary courts by private uneven walkways [22].

The Urban courtyard houses were created basically to provide privacy and equality, since most courtyard houses in the Levant region were built after the Islamic religion laws were the outside of the houses show equal exterior finishes where the rich and the poor live in equity, moreover, the provide privacy as the openings are mainly to the inside of the house and onto the private family court. The exterior openings here have mashrabiyyas added to them to insure privacy from the alleys and to provide natural lightings and ventilation for the inside. Social and environmental sustainability are accomplished here, environmental sustainability however is most noticeable upon the urban fabric of the city as a whole where the courts from all the houses form pools of cool air and help with maintaining a comfortable microclimate within the city as each court works on its own in providing natural ventilation through natural convection forces which were explained earlier in the paper [23].

Urban courtyard houses are usually more sophisticated than those from the rural parts, decorative elements are added to the interiors which shows the wealth of the family, also the number of courts of each house does the same, where some courtyard houses come with two or three courts (Figure 14) with different functions socially but same benefits environmentally [20]. Most courtyard houses have a water feature added to the court, which enhances environmental sustainability as it helps achieve evaporative cooling in the hot dry climates [20]. Some courtyard houses have loggias and wind catchers added too to help achieve natural cooling by cross ventilation, sometimes the water features are added directly under the wind catcher in a way that allows the air coming into the court to be cooled by the water vapor from the water feature, this feature is called the salsabeel [8].

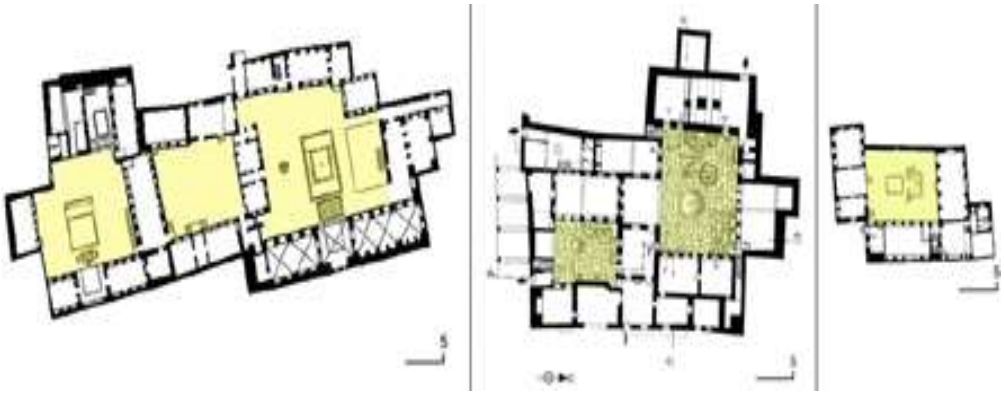

**Figure 14** Urban courtyard houses with single, double and triple courtyards. [20]

## 7. CONCLUSIONS

The points that follows explains the findings of this paper, the research problem was based on how the form of the vernacular architecture was generated in a way that shows how it responded to the natural sources found in site, the discussion throughout the paper explained how the natural forces work and how many vernacular features respond to those forces, the points below are the conclusion of the discussion – the answer to the research question, added to that, are how those features reflect sustainability. Findings are formed into a matrix (Table 1).

- Almost all the features of vernacular architecture respond directly to the local building materials found naturally on site, which means that the resulting form of the architecture at any specific site reflects the building materials found in it. Moreover, Economic sustainability is achieved because no materials are brought from outside the

site, Environmental sustainability is achieved because the natural materials are always most fit for building within a specific location as they are naturally environmentally responsive to the climate conditions on site.

- The Sun factor is responsible in forming most of the features of vernacular architecture in the Levant region, the Vaulted and domed structures help with providing shading and less thermal penetration into the dwellings, the Massive walls provide big thermal capacity for less solar heating, the small openings allows minimum solar gain to the inside, when the windows are big the mashrabiyya element provide less solar penetration through shading and diffused lighting, the courtyard responds to the sun to provide natural convection forces, and finally the loggia provides shading.
- Many features respond to the wind feature, as explained in the discussion the domed and vaulted roofs work perfectly in enhancing natural air flow which provides cooling, it also helps the water from the rain to slide through easily, the big openings insures natural ventilation when solar gain is not to a big concern, the mashrabiyya enhances wind flow as it speeds up the air passing through its small openings, the courtyard responds directly to the sun but the resulting feature in natural cooling, water features depends on the wind to insure evaporative cooling especially in dry climates, and of Corse the wind catcher is basically used to catch the wind and create natural cooling.
- The Humidity is most responsible for having flat roofs and big openings where minimum heights insure that cross ventilation works so no heavy humid air gets trapped around the users, the flat roofs are usually extended to provide shading to those big openings especially that the walls are usually light so humidity won't be trapped inside. The water features insure providing moisture to the air flowing especially in the hot dry weather. The wind catchers are usually found in hot humid regions where the air flows high away from the ground and where humid heavy air usually minimizes natural ventilation through normal openings.
- The sustainability pillars are obtained in so many features, some features insure social sustainability like the courtyard, the wind catcher and the mashrabiyya where privacy is achieved. Economic sustainability is always obtained because only local materials and local building technologies are being used. While Environmental sustainability is the most important resulting factor, as the main goal is providing thermal comfort.

The table below shoes a matrix of how features found in the vernacular houses in the Levant region respond to one or more natural energy source, and how they achieve sustainability pillars accordingly.

**Table 1** Natural energy sources VS vernacular features matrix. (Author, 2018)

| Feature / Natural Energy source | Vaulted / Domed roofing | Flat roofing | Massive Walls | Light Walls | Big Openings | Small Openings | Al Mashrabiyya | Courtyards | Water Features | Loggias | Wind Catchers |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SUN | ✓ | | ✓ | | ✓ | ✓ | ✓ | ✓ | | ✓ | |
| WIND | ✓ | | | | ✓ | | ✓ | ✓ | ✓ | ✓ | ✓ |
| WATER | ✓ | ✓ | | | | | | | | | |
| HUMEDITY | | ✓ | | ✓ | ✓ | | | | ✓ | | ✓ |
| BUILDING MATERIALS | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| SUSTAINABILITY PILLAR | Economic Environmental | Economic Environmental | Economic Environmental | Economic Environmental | Economic Environmental | Economic Environmental | Economic Environmental Social | Economic Environmental Social | Economic Environmental | Economic Environmental | Economic Environmental Social |

It is important to note here that the sustainability measure of today is different from what was found in vernacular architecture, the paper focused on how the features and the forms of vernacular architecture provided sustainability at its simple aspect, where minimum technologies were used, those are lessons to be learned. Further research might include a detailed methodology of how to use those vernacular features that brought sustainability naturally into our contemporary design.

## ACKNOWLEDGMENTS

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