Ecological Aspects of the Courtyard House As a Passive Cooling System

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Abstract

The objective of the present research paper is to determine the benefits of the courtyard house as a passive cooling system from ecological design point of view. The paper started with defining and discussing the courtyard house as a building form, how can the courtyard house acts as a passive cooling system, and the ecological design and its applicable principles in the courtyard house. At the end the paper concludes that the courtyard house is environmental friendly building form, and can be considered as a passive cooling system which may help to minimize the non-renewable energy consumptions to conserve the global natural environment healthy, clean, and livable environment for future generations.

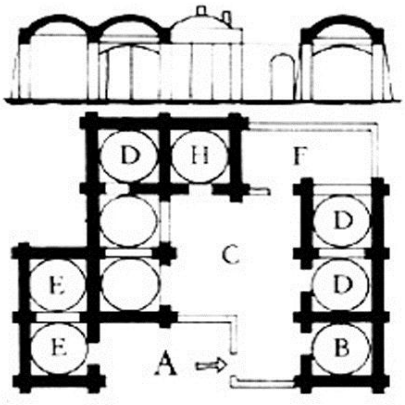
Keywords: Ecological Design, Courtyard House, Passive Cooling systems, Environment, Energy, Sustainable, Ventilation, Future Generations, Thermal Comfort, Outdoor Space.

1. Introduction

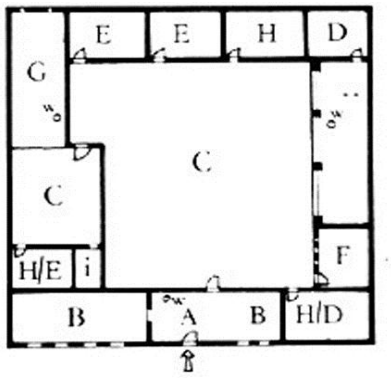
The present day politics of housing, poor professional practice in architecture and planning, a non ecological approach to the design problem, building codes, land speculation and zoning have contributed to the assassination of the courtyard house typology. The courtyard house form also had a utilitarian function: to adequate the house to the tropical climate by providing the rooms with ventilation and light and, in some cases, to collect the rain water for household uses. Thus, the courtyard was both a sustainable ecological response to the weather and also a social device to keep the inhabitants in touch. Ecological design is a way of integrating human purposes natures own flows, cycles, and patterns. The present research paper aims to rediscover the aspects of the courtyard house building form considered as low-energy design technique and as a passive cooling system that can help to reduce the non-renewable energy consumptions to preserve the environment healthy for future generations.

2. Courtyard House

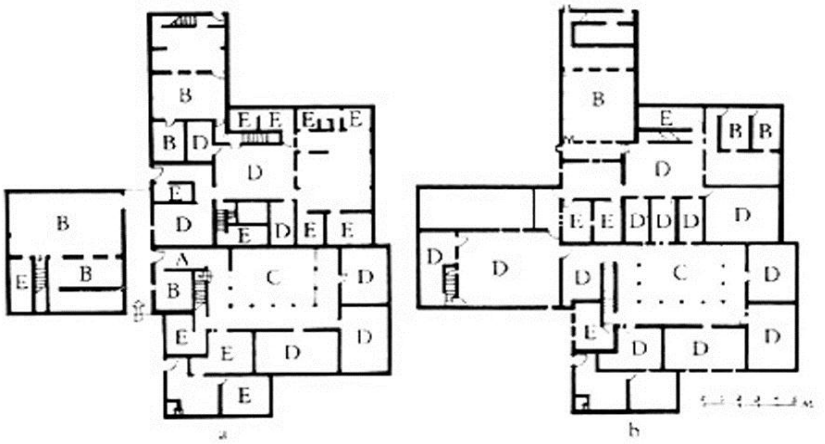
The courtyard houses are found in most of the climates and world regions, though it is most commonly associated with the Mediterranean and Middle Eastern regions. It is the dominant vernacular prototype of many of the world's hot arid climates. Many different societies in very different locations have used this traditional housing form. The vernacular courtyard house form has been viewed as an architectural response to a set of physical and cultural factors intrinsic to a particular physical and socio-economic environment. The courtyard house creates a complex regulating system that creates a microclimate, which historically worked, and still works, in a "passive way": heat transfer processes are all natural, without mechanical devices powered by non-renewable energy [1]. The courtyard house in the Arab or Islamic world may be considered as prototype diffused in many variations through all Arab countries and Islamic areas (Figures 1&2).



Courtyard house in the Souf, Algeria.



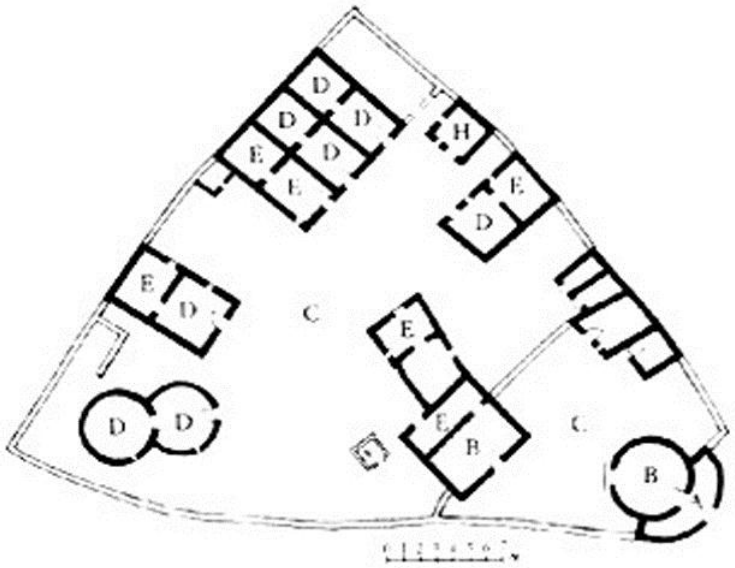
Courtyard house at Qustul, Nubia.



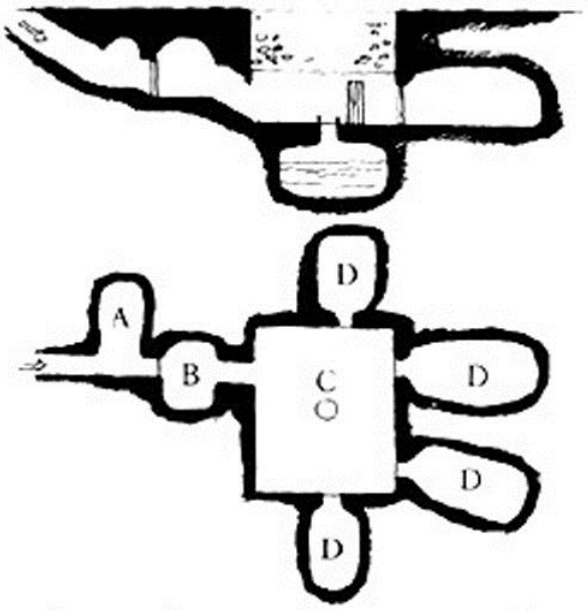
Courtyard house at Al-Majma'ah, Saudi Arabia, showing the ground floor (a) *and upper storey* (b).

Figure 1[2]

Plans of interior and exterior courtyard houses from Algeria, Egypt, and Saudi Arabia



Compound of a West African family house in Zaria, Nigeria.



Plan and section of an underground house in southern Tunisia. The sloping tunnel entrance is on the left. A, *visitors' room;* B, *stable or storehouse;* C, *courtyard open to the sky, with cistern in the centre;* D, *living rooms.*

Figure 2[2]
Plans of interior and exterior courtyard houses from Nigeria and Tunisia.

The courtyard house has a fundamentally different view of the relationship of indoor space to outdoor space. In the courtyard house form, the house itself is an interlocking combination of indoor and outdoor spaces that together make up the house. The character and scale of the outdoor space is not significantly

different than that of the indoor space. In a sense, the house is made up of a variety of rooms, some with roofs and others without. The courtyards are simply rooms without roofs (Figure 3&4).

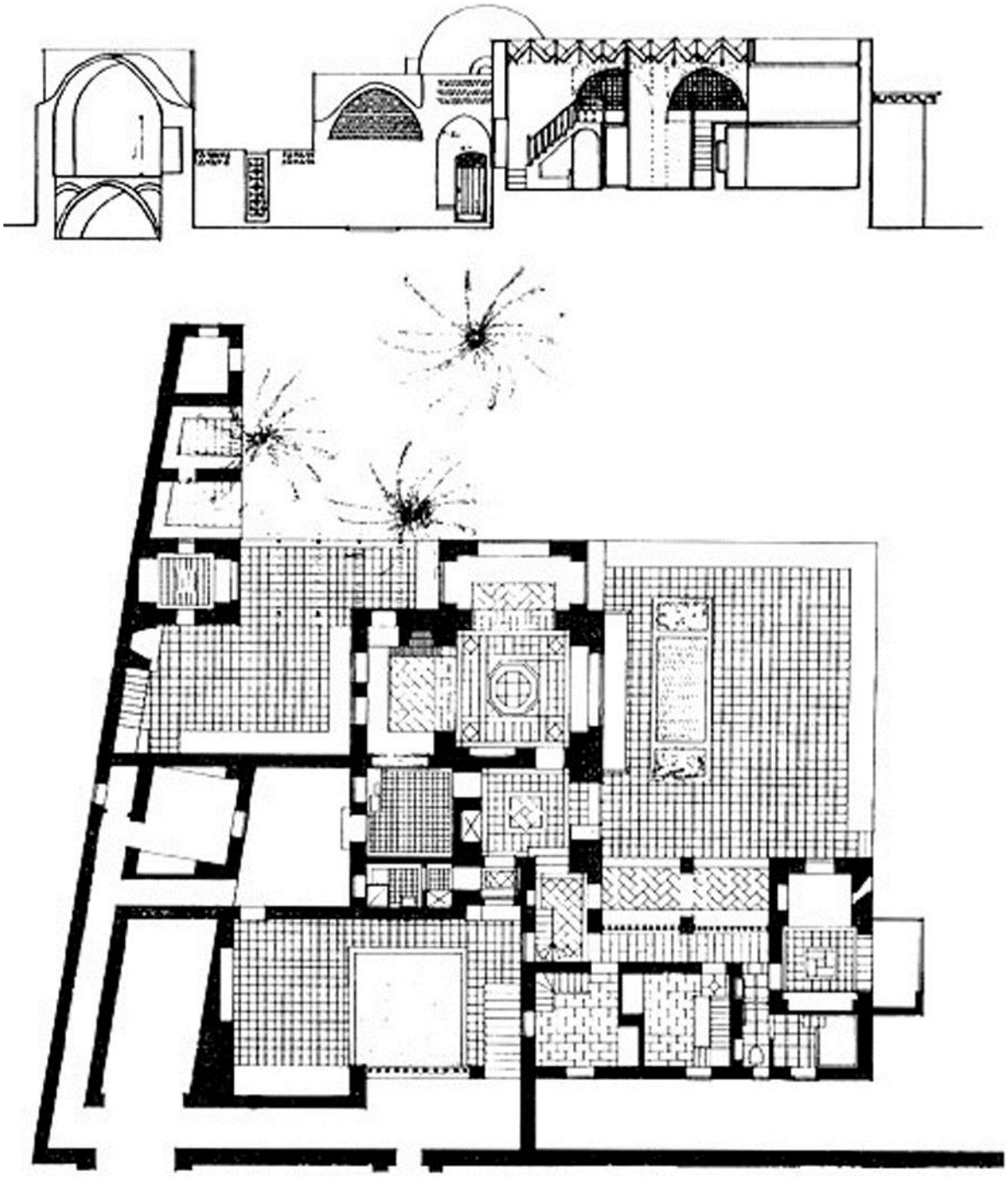


Figure 3[3]
Plan and section of Riad House by Hassan Fathy, Egypt

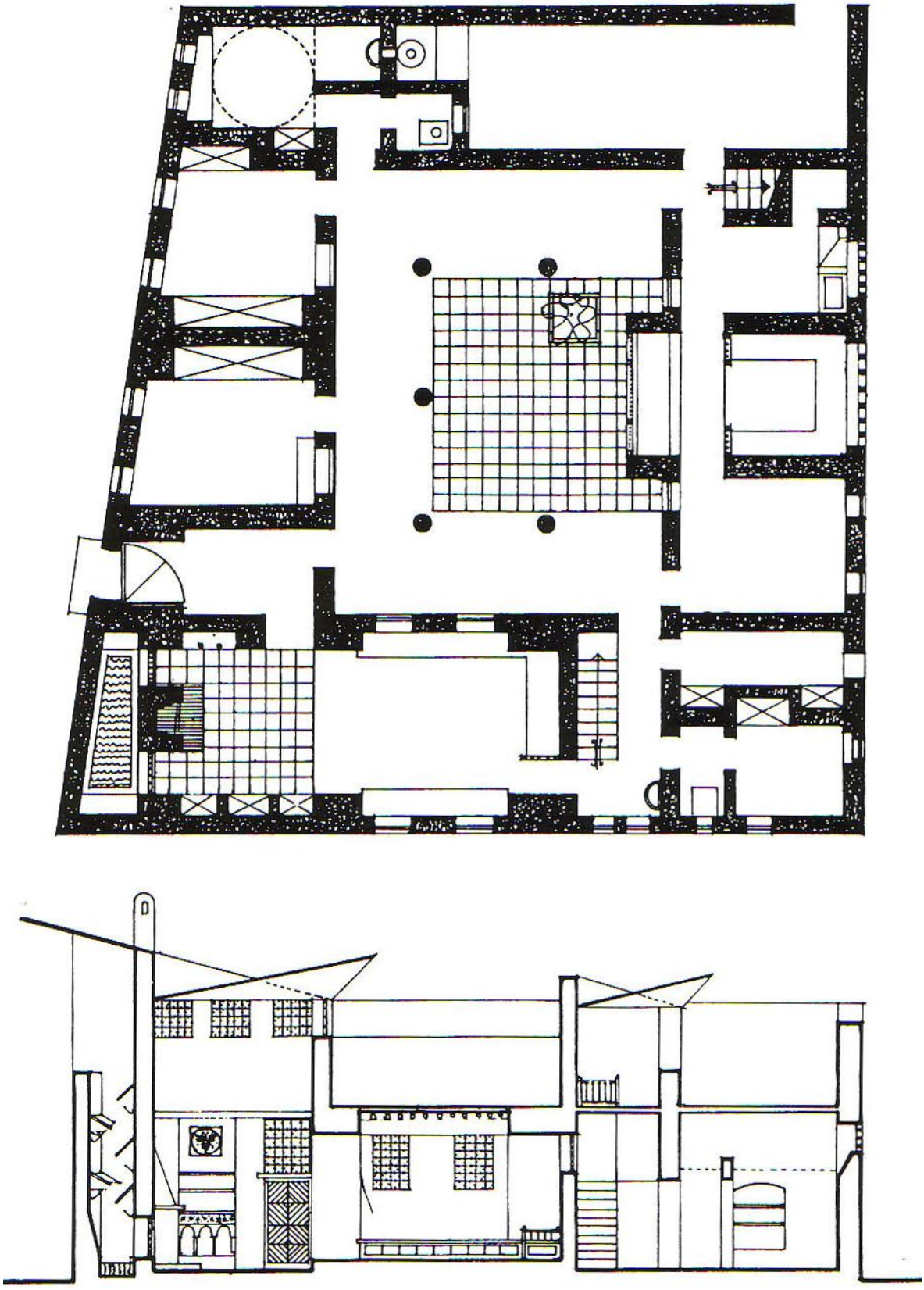


Figure 4[3]
Plan and section of housing prototype for Dariya, Saudi Arabia.

3. Passive Cooling Systems

Passive cooling means to provide acceptable thermal comfort in summer without using mechanical systems. The courtyard environment is a cooler private area suitable for many uses. It moderates the climatic extremes, as cool air of the summer night is kept for many hours undisturbed by hot and dusty winds provided that the surrounded walls are as tall as the yard is wide. The surrounded rooms draw daylight and cool air from the courtyard. During the pleasant morning and evening hours, the household gathers in the courtyard protected from inquisitive eyes. Arcades at the perimeter are significant to shade the overheated midday sun. Running water, in dry dusty climates, is imperative to cool by evaporation (Figure 5).

View into the courtyard of a traditional house in Cairo

Courtyard with central pool in Aleppo.

Figure 5[4]
View of some traditional Arabic courtyard houses showing the surrounded arcade and running water using in the courtyard.

The unique properties of the courtyard house are not generally or fully appreciated particularly with respect to climate. As a Climatic Moderator or a passive cooling system the courtyard house can moderate its own microclimate. A well-designed courtyard house is cool during the day when ambient temperature is high and warm at night when it is low. This is because the in courtyards the cool night air is stored until mid-hours of the next day while plants shield the court walls from the direct solar heat gain.

The Courtyard in a house acts as an air shaft, bringing both air-movement and natural light to the house rooms around the courtyard. In hot-dry regions the courtyard functions in three regular cycles [5]:-

- During the first cycle, the cool night air descends into the courtyard and fills its surrounding rooms. Walls floors, columns, roofs, ceiling, and furniture are cooled at night and remains so until the late afternoon. The courtyard loses heat by irradiation to the sky and may be used for sleeping during the summer.
- During the second cycle, around noon the sun radiation directly strikes the courtyard floor. Some of the cool air begins to rise and also leaks out of the surrounding rooms. This action sets up convection currents in the rooms which may afford further comfort. The courtyard now begins to act as a chimney. At this hour the ambient temperature is very high outside. Thick walls do not permit the external heat to penetrate to the in side of the house. The adobe walls are excellent insulators, and the time-lag for an external wall of average thickness may be as much as twelve hours. Three out of four external walls on an average are party walls; thus the house remains enclosed on all sides and is insulated from heat gain during the day.
- During the third cycle, the courtyard floor and the inside of the house get warmer and further convection currents are set up by the late afternoon. Most of the cool air trapped within the rooms spills out by sunset. During the late afternoon the street, the courtyard, and the building are further protected by shadows in the closely-knit 'mud-lump' structure. As the sun set in the desert, the air temperature falls rapidly, the courtyard begins to irradiate to the clear sky, and cooler air begins to flow and descends into the courtyard. Thus a new cycle begins (Figure 6).

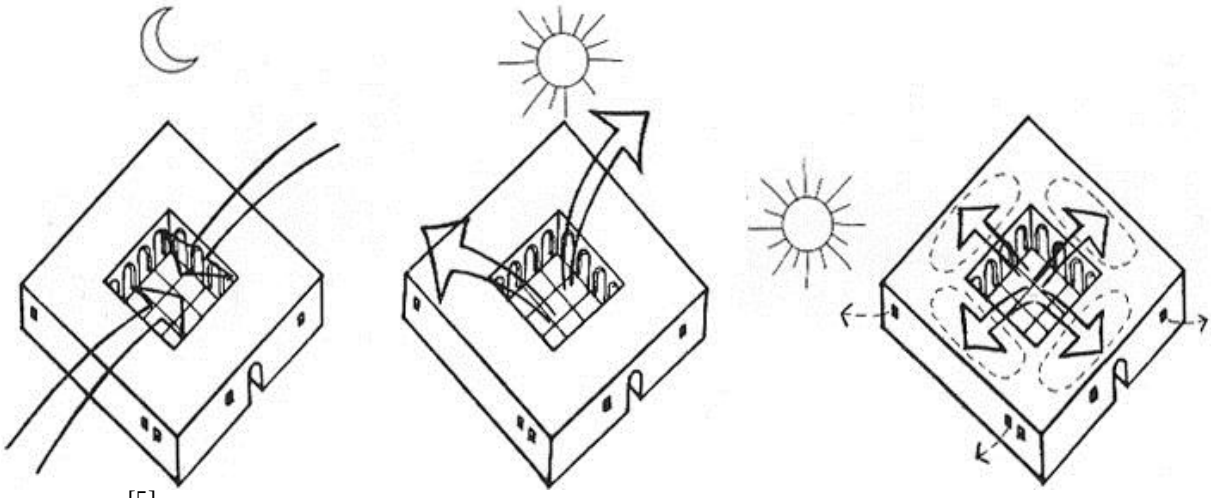


Figure 6[5]

Diagrammatic explanation of three climatic cycles each at night, noon, and afternoon.

4. Ecological design

Ecological design explicitly addresses the design dimension of the environment crisis. It is not a style. It is a form of engagement and partnership

with nature that is not bound to a particular design profession [6]. Ecology, as defined by Eugene P. Odum , emerged from the study of biology and now discipline that integrates the study of organisms, the physical environment, and human socieecology derives from the Greek root oikos, meaning "the study of the household," which represent the entire environment in which we live [7].

Ecological Design or sustainable design is, at its most basic level, an approach that seeks to ensure that future generations enjoy continued access to natural resources [8]. Ecological design seeks to reverse unsustainable economic and social trends by demonstrating the importance of the natural world in our lives and by showing how a green ethos can actually save people money and simplify their Lives. Of particular interest is the environmental as well as social impact of what we build and how and where we built it.

Ken Yeang defines the key criteria for ecological design as; Assess need for building, Assess where it is to be built, Assess what is to be built, Assess impacts of building operations, and Assess recovery of all materials and equipment after useful life of building[9].

5. Ecological Design Principles

Ecological Building is a movement in contemporary architecture. This movement aims to create environmentally friendly, energy-efficient buildings and developments by effectively managing natural resources. This entails passively and actively harnessing solar energy and using materials which, in their manufacture, application, and disposal, do the least possible damage to the so-called 'free resources' water, ground, and air.

Ecological design involves the holistic consideration by design, of the careful use of energy and materials in a designed-system, and the Endeavour endeavor by design to reduce the impacts of this use on (and its integration with) the natural environment, over the life-cycle of the designed-system from source-to-sink[10]. The main ecological design principles that can be applicable in the courtyard house performance includes:-

Ecological Design Principles	Courtyard House Performance
• Design with sensitivity to place. Allow site to inform design.	• The courtyard house may be built in response to climate; with respect to local wildlife and cultural traditions; and with recognition of appropriate scale, our designs become integrated into the pattern of the landscape. Courtyard housing has the additional attributes of providing easy and natural privacy, allowing for increased densities without negatively affecting the quality of life, and forming a limited

	oasis microclimate that can moderate climate and provide a manageable green space (Figure 7).
• Use only materials that are non-toxic, renewable, and resource efficient. Don't create burdens for future generations.	• Courtyard housing has economic implications in that it can produce better desert housing with significant cost savings. In the underdeveloped desert regions, the lack of availability of wood or steel products makes it difficult to develop spaces with a structural span of more than 3m. By making the courtyard the large "room" of the house, one can provide a larger space without the material cost associated with that structural span. Thus a low-cost house could have a central courtyard "room" of 6m without the associated cost (Figure 8).
• Select landscape materials and plantings which need no mowing, and never require fertilizers, herbicides, or pesticides.	• The interior open space of the courtyard itself organizes the houses rooms around it. It is usually planted and has a water source to provide both shade and humidity. The carefully designed courtyard landscape specially the ground cover of various types of tiles and shrubs will have a cooling effect on the micro-climate. Groups of trees may create shaded areas which are advantageous for sitting out of doors (Figure 9).
• Make use of the passive energy flows of sun, wind, and water. The sun provides a perpetual income of solar energy that if used efficiently can provide all of our energy needs.	• The courtyard, in the hot season of the year, can serve the same purposes in the morning and evening and, while often hot in the sunny areas during the day, the walls provide a portion of shade on at least some part of the courtyard throughout the day. Courtyard houses provide an ideal prototype for desert communities. In the colder periods of the year the courtyard, if properly oriented, provides a source of sun at the heart of the house, not at its perimeter. By maximizing the number of habitable rooms that face the courtyard, the major portion of the house is afforded an adjacent sunny outdoor space. Even in the desert communities where nighttime winter temperatures reach freezing, the daytime temperatures are sufficiently moderate that this courtyard can become an active and usable living space. It provides a safe outdoor play area for young

	children and a safe outdoor sitting area for adults and the elderly. (Figure 10)
• Design for activating cross-ventilation in all occupied spaces, rather than air conditioning.	In multi-story buildings, the courtyard acts as a ventilation shaft. The dimensions of the courtyard must be carefully considered in relation to its width and depth. If the courtyard is narrow and deep, then it may act only as a ventilation shaft and not bring any cool air to the surrounding rooms. The loggia that are covered patios open to the courtyard, usually face north to achieve maximum cooling. This semi-room provides a completely shaded area with excellent ventilation. (Figure 11)
• Use only urban patterns which are appropriate to culture and the local environment.	• Urban space, principally streets and plazas, maintains the same relationship to urban buildings and blocks that courtyards have to the rooms of the house, that is, approximately the same size and proportion. Thus outdoor space in a courtyard city is not conceived as an open rambling park but instead is viewed as a contained space with a specific length, width, and height. In the same way that a house is viewed as an interlocking composite of indoor and outdoor-space, the city itself is conceived of as an interlocking composite of indoor and outdoor space on the next larger scale (blocks of buildings and streets and plazas). By the clarity of its edge definition and its scale and proportion, streets and plazas become clearly defined urban spaces that maintain a human scale. The courtyard city becomes a honeycomb of carefully designed indoor and outdoor spaces, with a range in scale from the smallest private patio to the largest public space to accommodate the size and variety of human groupings and activities (Figure 12).

Figure 7[11]
A courtyard house Integrated into the pattern of the landscape, Tsukuba City, Japan.

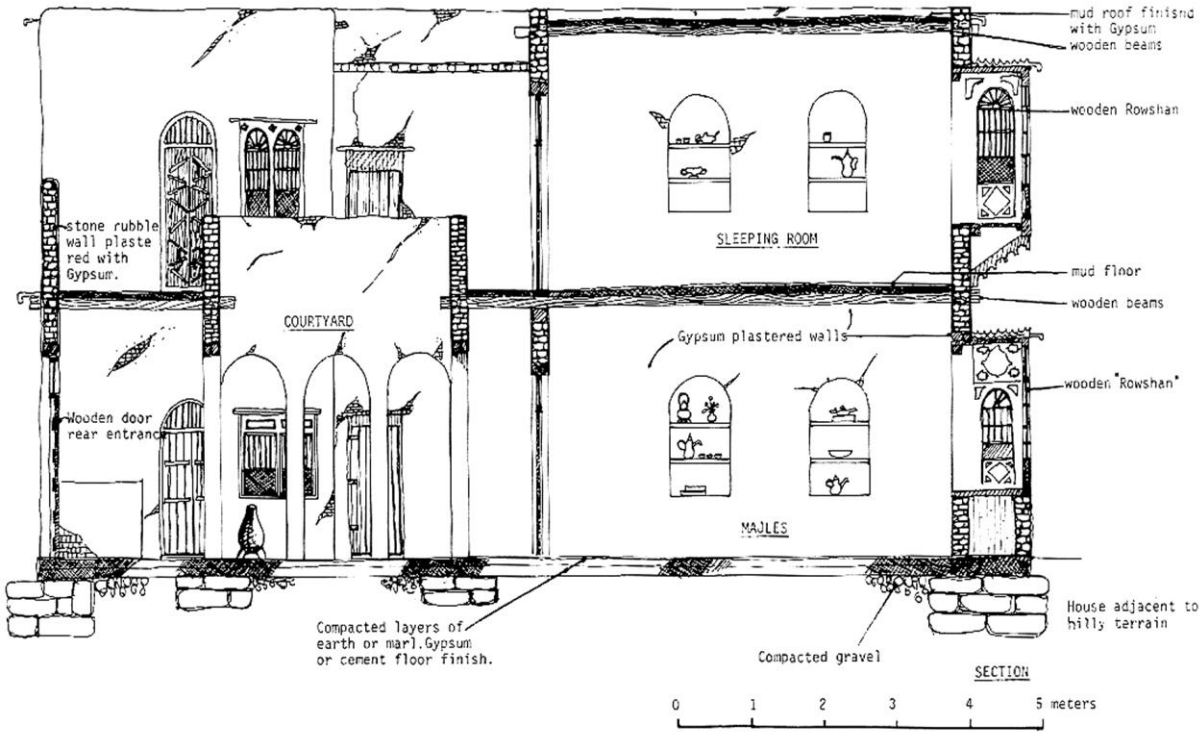


Figure 8[5]
Section of a courtyard house in Mecca showing the use of the local building materials.

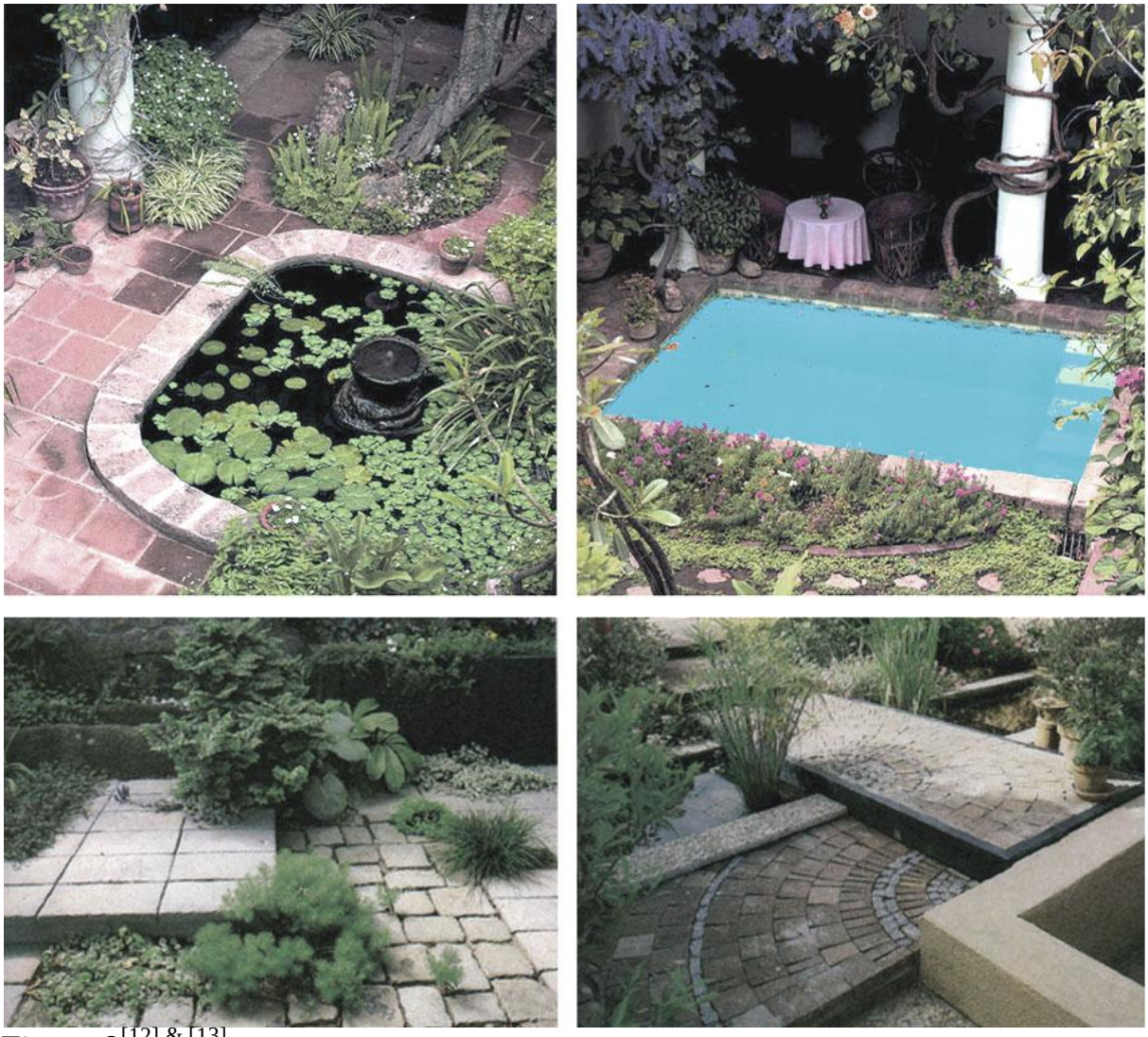


Figure 9[12] & [13]
Samples of using landscape materials and plantings in a courtyard.

Figure 10[14]
Country villa by Hassan Fathy, Giza, Egypt.

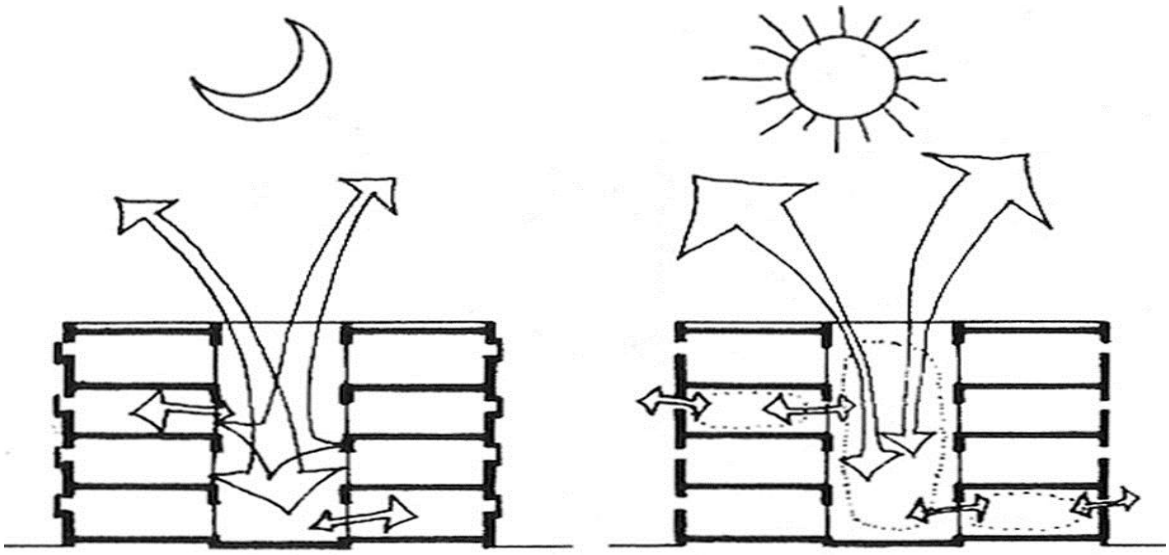


Figure 11[5]

Section in a courtyard acts more like a ventilation shaft.

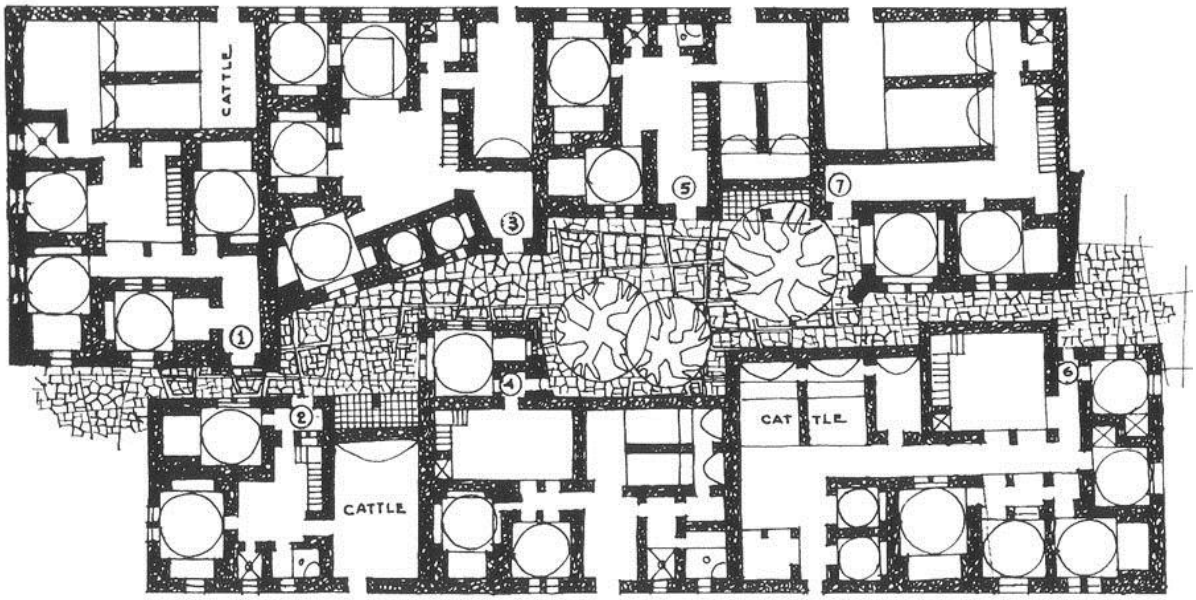


Figure 12 [15]

Urban patterns appropriate to culture and the local environment at New Gourna by Hassan Fathy.

6. Conclusion

Ecological design seeks to reverse unsustainable economic and social trends by demonstrating the importance of the natural world in our lives and by showing how a green ethos can actually save people money and simplify their lives. One of the main factors of ecological design is to regulate the interior temperature by using as little non-renewable energy as possible. Ecological designed building meets the needs of the present without compromising the ability of future generation to meet their own needs.

The courtyard house emerged as both an urban and rural prototype. In the courtyard house, outdoor space is captured and included in the residential volume and ultimately becomes the heart of its morphology. As a passive cooling system the courtyard house may regulate the interior temperature of the house with the minimum use of energy. Based on the present day politics of conserving the natural environment save, clean and healthy for the future generations, the courtyard house may helps to provide the human thermal comfort inside the house by natural ways to reduce the energy consumptions and conserve the global nature clean and healthy for the future generations.

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السمات البيئية للمسكن ذو الفناء كنظام تبريد سلبي

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الملخص

إن هدف ورقة البحث الحالية التعرف على إيجابيات المسكن ذو الفناء كنظام تبريد سلبي من وجهة نظر التصميم البيئي. الورقة بدأت بتعريف ومناقشة بناء المسكن ذو الفناء، وأداء بناء المسكن ذو الفناء كنظام تبريد سلبي، والتصميم البيئي ومبادئه القابلة للتطبيق في المسكن ذو الفناء. في النهاية، تستنتج الورقة بأن المسكن ذو الفناء هو نموذج بناء صديق للبيئة، ويمكن أن يعتبر كنظام تبريد سلبي قادر على المساعدة في تقليل إستهلاك الطاقة غير المتجددة والمحافظة على بيئة الأرض الطبيعية بيئة صحية، نظيفة، صالحة للحياة للأجيال المستقبلية.

الكلمات المفتاحية: التصميم البيئي، المسكن ذو الفناء، التبريد السلبي، البيئة، الطاقة، المستدامة، التهوية، الأجيال القادمة، الراحة الحرارية، الفراغ الخارجي.