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Traditional Environmental Performance: The Impact of Active Systems upon the Courtyard House Type, Iraq

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Abstract

The traditional courtyard house in Iraq generally and Baghdad in particular has distinct characteristics. However, there are several reasons underlying the decline of the environmental performance of this type of house. Focusing on this decline, the main objective of this study is to explore how active systems can enhance the existing environmental performance of the traditional courtyard house. The framework of this investigation focuses on two points: first, it seeks to clarify the existing system and, second, it investigates the existing need to add new systems. To achieve these objectives, interviews with 25 architects and 24 occupants of traditional courtyard houses, alongside 12 physical surveys in the Al-Kadhimiya historical area as a case study, are discussed, based on a qualitative method. The research revealed the interplay between the passive and active systems, and the efficiency of technology in enhancing the traditional environmental performance through improving the level of comfort and increasing the response to the environment.

Keywords: enhancing, performance, passive systems, active systems, courtyard houses, Iraq

1. Introduction

The courtyard represents a constant feature of domestic architecture. It has, however, developed in different ways according to the influences of existing local traditions, construction, and climatic features (Sibley, 2006). The courtyard is usually the spatial, social and environmental heart of a dwelling, through which it receives and facilitates sunlight, the air flow, and visual as well as physical communication (Shokouhian, et al., 2007).

Many studies have addressed courtyard houses (CH) in relation to their performance, such as Al-Mumin (2001), who highlighted the type of CH, in terms of built potential and day lighting criteria, in which courtyards perform best. In 2002, Al-Zubaidi discussed CH design, and details for the efficiency of thermal performance. Sozen and Gedik (2007) introduced the features of the traditional courtyard house (T.C.H.T) and the impact of appropriate building performance through energy efficiency. Authors such as Muhaisen (2006) investigated how the proportion of interior courtyard of house in different locations can achieve a reasonable annual performance. Muhaisen and Gadi (2006) found that CH performance is influenced by changing the shape of the interior courtyard, while earlier Leylian et al. (2010) noted that there are both different and similar design principles which enhance the T.C.H.T performance in different regions.

Obviously, in the previous literature, attention has been paid to the type, house design and details, proportion, and shape in enhancing building performance. The most important aspects here were how to give greater attention to the different systems in order to link CH performance. So far, there has been no clear description of the existing systems in the T.C.H type or of the impact of active systems of house performance. Therefore, the aim of the current study is to explore how active systems can enhance the existing environmental performance of the T.C.H.T.

2. Literature Review

2.1 Traditional Courtyard Houses in Iraq

The T.C.H.T has an inward looking plan with habitable spaces gathered around the courtyard, which not only provides an appropriate microclimate but also delivers privacy and communication (Ratti et al., 2003).

The courtyard houses typeS in Iraq are classified into: (1) traditional courtyard houses, (2) transformed traditional courtyard houses, (3) and closed courtyard houses. This research will deal with the first category, which is known in Baghdad as the "*oriental house*". The T.C.H.Ts in Iraq were used the criterion of the number of courtyards incorporated in each house which can be classified into four categories: one, two, three and four courtyards (Al-Azzawi, 1984). The T.C.H.Ts have the same concept but differ in terms of the area, size of building, and the number of habitable rooms, spaces, and levels.

The T.C.H.Ts in Iraq include special components such as a reception room which is used mainly in winter. The "Ursi" is a family room which is used at different times. The "Takhta-Boosh" is mainly used in summer. The "Kafish-Kan" is a multi-purpose room which is used intensely in winter. Bedrooms are used here to denote rooms where the inhabitants normally sleep overnight in winter, but may be used as family rooms during the day and in the evening (UN-HABITAT, 2006-2007). The "Iwan" is another habitable, covered and semi-enclosed space on the ground and first floors, and is used as a family room in winter; it is therefore oriented towards the sun. The "Sardab" is a habitable subterranean cellar located immediately underneath, and the "Neem Sardab" is a habitable place which is located between the sardab and ground floor. The service rooms include the kitchen, bathroom and toilet (Fethi, 1976). Figure 1 shows the special components of T.C.H.Ts.

Iwan

Kafish Kan

Sardab Ursi

Figure 1. The special components of traditional courtyard houses in the Al-Kadhimiya historical area

The main characteristics of the T.C.H.T are adapted to the different environmental conditions through:

(1) Physical architectural elements include: a courtyard, which has a central role in these houses that provide daylight and ventilation, allow the house to be heated and cooled; visual communication is possible with the habitable rooms in different levels (Dilia et al., 2010). The bad-geer is a mechanism which introduces outside air and induces cross-ventilation through the courtyard house space, via a number of air-ducts, and it also cool the

air (Al-Temeemi, 1995). Shanasheels are the extension of the built area on the first floor along opposite sides of the alleyway, which provides visual communication, natural lighting and ventilation. Very thick brick walls consisting of two layers and filled with soil in between provide thermal isolation (Warren & Fethi, 1982). Figure 2 illustrates the physical components in the T.C.H.T.

Figure 2. The physical components of the T.C.H.T in the Al-Kadhimiya historical area – Shanasheel

(2) Users: there is seasonal and daily movement in the T.C.H.T; in the winter, the ground floor is used intermittently during the day, mainly for basic family living activities. The first floor is used for other family living activities. Hence, the ground floor is used less frequently than the first floor. In summer, the residents use the ground floor, underground level and the roof terrace because of the more comfortable environment (Al-Azzawi, 1996A). The same author identified two types of daily movements in summer. First, vertical movements are performed in section, and the occupants moved from level to other. Second, horizontal movements are performed in plan, the occupant moved between the spaces in the same level (Al-Azzawi, 1996B).

The important point is to realize the reason for this movement and to provide suitable spaces which will give the required results. Basically, the movement of sun and wind, and the materials through the structure and construction, change the temperature through the presence of physical architectural elements, and were thus important factors for this movement.

2.2 Enhancing the Environmental Performance

This enhancement encompasses different disciplines, and is underpinned by humans to achieve well-being. This needs a clear picture of what is required to be resilient and what it must be resilient to (Biggs, et al., 2012). The enhancement of a building should be conducted with the aim of improving the environmental quality and performance of that building. A natural stage of developing the built environment is the creation of a method for promoting building performance across as wide a range of environmental and energy criteria as possible (Kua and Lee 2002). Building performance means what in the building needs support immediately or change for users, with optimization of the impact on society and the environment (Kamara, 2013).

There is the concept of the control of the internal environment as a phace of enhancing the performance through active systems in offices, educational or commercial buildings. For example, Wang et al. (2008), and Alwaer and Croome (2010), highlighted that active systems can control and adjust the building environment. Holden (2008) confirmed that active systems can achieve full control of the environment, having a positive impact on building performance. However, the current study will investigate enhancing the performance in dwelling houses through active systems.

2.3 Passive and active systems

Passive systems refer in this research to the assembly of natural and architectural components which convert elements of the climate into usable or storable forms and deliver heating, cooling, ventilation, and lighting without mechanical power. In 2004, Capeluto and Shaviv pointed out that these buildings adapt to climatic principles to allow for significant temperature, air movement, and lighting between day and night through passive means.

Active systems are the elements through which a building self-adjusts to changes initiated by their inside or outside environments, thus enhancing comfortable conditions (Wigginton & Harris, 2012).

These passive systems can substantially reduce conventional energy consumption and, therefore, enhance active systems' performance. In 2008, Ochoa and Capeluto referred to active and passive systems which provide maximum occupant comfort using minimum energy through minimising heat loss. In 2011, Al-Akkam and Kareem clarified that the passive systems which are employed as elements for the heating, cooling, lighting and ventilation of the building are integrated with active systems to achieve sustainable building. Here, previous studies have focused on active and passive systems in offices, and public and industrial buildings, according to the required change. However, the relation between the active and passive systems in enhancing the performance in the T.C.H is unclear.

3. Methodology of the Study

The investigation into enhancing the performance via passive and active systems was provided by quantitative methods, such as Al-Akkam and Kareem (2011), Wang et al. (2008) and others. In contrast with previous studies, the most appropriate method for this study was a descriptive analytical method which would facilitate the extraction of the relevant theme and issues. Fieldwork research was conducted for 14 weeks in Iraq in order to collect data and information, using different methods relevant to the research topic. Semi-structured interviews with 25 architects, chosen through the snowball technique as a purposive sampling procedure and data accessing method (Noy, 2008), were conducted through one to one or group interviews. The architects worked in both the government and private sectors, and the interviews were arranged to discuss issues with the performance of traditional courtyard houses in Iraq generally and Al-Kadhimiya especially. There was a particular focus on clarifying the passive systems in these houses. The second type of interview with 24 occupants was held in the houses in five neighbourhoods of the Al Kadhimyia historic area of Baghdad. At the interviews, issues with the environmental performance of these houses were discussed, alongside what the residents did to improve these houses to feel more comfortable living in them. The residents were of different ages and genders, and had varying levels of education. Moreover, a physical survey was used to support the analysis of the collected data from two types of interview. It was conducted on twelve traditional courtyard houses in Al Kadhimiya city, and photographs of these houses were taken. The research setting for the physical survey was selected based on the number and size of courtyards, income, and available data.

4. Case Study

This study proposes that the active systems should be integral to the T.C.H.T through the process of development and can therefore enhance the house performance. Therefore, the case study was conducted in the Al-Kadhimiya historical area, which is the fourth historic section of Baghdad, and is more preserved than other areas. Al-Kadhimiya derives its name from the shrine of Imam AlKadhim, and its existing core is typical of the entire shrine city in Iraq. (Al-Akkam, 2013).

It is hoped that this research can inform practices by proposing qualitative methods. However, to determine why active systems are needed the following questions will be addressed: what are the existing systems in the T.C.H.T? How should the activeness of the systems be determined? On what basis should these systems be chosen? How will these systems enhance the T.C.H.T performance?

4.1 Existing Systems and Existing Need

The aim of this part is to present the field study findings relevant to the T.C.H.T in Iraq. The study explored the use of active systems in improving the environmental performance in this type of house. The case study process involved two phases: analysis of (1) the existing systems and (2) the existing needs of new systems in the T.C.H.T. in Iraq, generally, and Al-Kadhimiya, especially. Because of the need to take forward the variety of framework issues, a brief review will be provided which contributes to the determination of the main theme: "enhancing the environment performance." These are established below.

4.1.1 Existing Systems in Traditional Courtyard Houses

There are several existing systems in the T.C.H.T in Iraq which have the ability to recognize elements of the climate as the natural environment; these complete the built environment to achieve environmental performance without human intervention. Table 1 illustrates these systems. This issue was expressed in the interviews with architects and was in accord with the physical survey.

Table 1. Existing systems of the T.C.H.T in the Al-Kadhimiya historical area

Passive system	Issue	Indicators	How	
Natural heating	Thermal comfort	Slow process to change the temperature	The urban fabric due to compactness	
			Form of the T.C.H.T	Architectural elements Structural and constriction Spaces proportion and relation
Natural cooling	Shading The stack Thermal inertia	Cold air then reduce the temperature	Three dimensional interior courtyard The presence of the shanasheel Architectural elements Using natural materials Buried habitable The thick internal brick walls	
Natural ventilation	Airflow Cross air	Creating air movement	The compatible dimensions for fabric and house The design principles of T.C.H.T.	
Natural lighting	Sunlight and sky light	Allow the house to be lit	Architectural elements	Orientation Proportion Shape and size
Integrated	Combination and constant	Cooling, heating, lighting and ventilation	Compatible between the courtyard and narrow alley Compatible between the courtyards and the bad-geer	

- *Integrated*

These systems bring together either the components of the sub-system or the elements of the environment into one system. The interior courtyard is compatible with its narrow winding alley and other similar houses in the locality, and it provides constant cooling, heating, and natural ventilation. The use of the principle of shade and light moves the air and provides cross ventilation from the alley to the houses, and vice versa, through interior courtyards and the bad-geer. The courtyard, supported by the bad-geer, acts as a tool for cooling and heating, and they used the bad-geer to facilitate both the exit of hot air from the courtyard and the entry of cold air to it. The bad-geer is often used in combination with courtyards as overall ventilation, which enhances the air circulation inside the inner space. The data highlight the type of existing integrated system due to a combination of a sub-system or elements responding to different environmental conditions in Al-Kadimiya, which enhance the environmental performance in the T.C.H.T. without mechanical power.

- *Natural heating*

It uses a balance of heat loss and gain which is the transfer of heat from outside to inside, to achieve thermal comfort (i.e. satisfaction with the cooling and heating environment). There are many aspects which establish a balance in losing and gaining heat in the T.C.H.T in Baghdad. The thermal gain and loss is a slow process due to these house features, compared to the external environment that works to change the temperature. These balance heat achieved through the urban fabric due to the compactness, as the whole form of the T.C.H.T is linked to the plan, section, and elevation, the direction of space, manoeuvre between the spaces and the proportion of the space, the structure and constrictions, the location and design of architectural elements such as the bad geer, the courtyard and others, and the details of the house. Thus, the thermal comfort is a result of maximizing its massive cooling potential in summer and its power to warm in winter, allowing only a slight temperature change and the presence of a natural course for air currents. The thermal loads of these areas are reduced to the minimum, for thermal loss or gain from inside or outside.

Natural heating is a manifest existing system that responds to change in environmental conditions without mechanical power control.

- *Natural cooling*

Natural cooling occurs when the occupants employ non-technical methods, such as shading, the stack effect, and thermal inertia for heat dissipation from indoor spaces to maintain a comfortable indoor temperature.

(1) Shading was achieved through the shape and three dimensional interior courtyard and the presence of a shanasheel, which maximized the amount of shade at ground level and minimized the heat of direct sunlight in summer that created cool air.

(2) The stack effect was achieved through architectural elements as the agents of cooling, such as the shanasheels, bad geer and courtyard, linked with the materials. It works as a cold-store at night, when the temperature drops at night on hot summer days, all of which helped drive the cold air passing through the courtyard into the rooms built around it due to the difference in pressure between the hot and cold air.

(3) Thermal inertia was achieved through completely or partially buried habitable cellars in the sardab, and the thick internal brick walls which keep these spaces cool throughout the day. Thermal inertia promotes natural cooling in the T.C.H.T., through the use of soil energies as natural resources to heat and cool the house with changes in temperature.

Natural cooling keeps this type of house cooler than other houses without mechanical power and these methods respond to changes in the environmental conditions.

- *Natural ventilation*

This is the process of supplying and removing air through an indoor space through the air flow and cross air caused by differences in temperature and pressure.

(1) Airflow was achieved through the contradiction between the compatible dimensions for fabric and the interior courtyard house which generates differences in air pressure and the formation of air currents, in order to create air flow between the flowing spaces.

(2) Cross air is promoted through the design principles of T.C.H.T. There are several air currents inside the traditional courtyard house. Firstly, there is the convection current that is produced from the difference in the temperature of several air currents. Secondly, currents are produced through the exchange between air currents inside the house and those outside it. Natural ventilation reflects existing systems, which is responsive to the environmental condition.

- *The natural lighting*. This type of lighting refers to the light emanating from the sunlight

and skylight. The orientation, proportion, shape and size of the courtyard helps to gain direct sunlight. The design of the shanasheel enables sunlight to enter directly in winter, and to some extent avoid it in summer. The ratio between height and width of space allows natural sunlight to enter the whole house. The details and decorations reflect light and reduce direct sunrays. As mentioned in the data review, the existing natural lighting in T.C.H is created without mechanical power through a response to the environment.

4.1.2 Existing Need for New Systems in Traditional Courtyard Houses

There are three issues that are required to add systems to the T.C.H.T in the Al-Kadimhiya historical area, as seen in Table 2.

Table 2. Existing need for additional systems

Issues	Indicators	Rezone	Need	Where	When
Environmental conflicts	Natural lighting	Changing the weather and climate condition	Lighting systems	The entire house	During dust storms
	Air movement		Ventilation systems	The entire house	During dust storms
	Moisture and level of odors		Ventilation systems	Specific place and level	During the usage time
	Thermal comfort		Cooling and heating systems	Specific place and level	During the harsh weather
Utilization of systems	Effectiveness and inefficiency.	Changing the weather and climate condition	Ventilation systems	The entire house	Specific time
	Un effectiveness and inefficiency.	Modernization	Drainage systems	Services place and sardab	Usage time, in winter
	Un effectiveness and inefficiency.	Modernization	Water systems	Services place	In summer
	Un effectiveness and inefficiency.	Modernization	Electrical systems	The entire house	Around the year
	Effectiveness and inefficiency.	To presents the specific phenomena	Lighting systems	The entire house	During dust storms
	Effectiveness and inefficiency.	Update through modernization	Communicatio n systems	The entire house	Around the year
	Effectiveness and inefficiency.	Changing the weather and climate condition	Cooling systems	First floor	In summer
	Effectiveness and inefficiency.	Changing the weather and climate condition	Heating systems	First floor	In winter
	Effectiveness and efficiency.	Changing the lifestyle	Safety systems	The entire house	Around the year
	Effectiveness and inefficiency.	Changing the political situation	Security systems	The entire house	In night
Treated and maintained	Level of lighting, thermal comfort, and ventilation	Changing the physical environment	Cooling Heating Lighting, and Ventilation syst.	In specific place	In harsh weather
Activities movements	Thermal comfort	Changing the lifestyle	Different systems	The entire house	In specific time

- *Environmental conflicts in the T.C.H.T*

These issues were expressed in the interviews with occupants and were also in accord with the architects.

(1) Lighting. Direct sun did not enter in summer because of the yard proportions, and at the same time the house in Al-Kadhimiya did not need to be lit during the day. The house was dark during the daytime dust storms.

(2) Air movement. The air movement in the T.C.H.T in Al-Kadhimiya was comfortable due to the presence of the bad-geer and the courtyard, except for during continuous dust storms. Dust storms occurred all year, and the occupants had difficulty controlling the dust and so the atmosphere became breathless. The presence of dust at night in summer made the atmosphere suffocating and more uncomfortable than in the past. Increased odour levels occurred because of occasional blocked sewage pipes due to old drainage or tired connections between the new sewage pipes and the public drainage.

(3) Moisture. One the ground floor, the sardab had high humidity because of the rain in winter for all 12 T.C.H.Ts and a raised water table level in some houses, which deteriorated the building materials and in turn led to bad smells. Also, the high humidity, especially in the service spaces and underground, put the residents under pressure. The rainy period was uncomfortable for the occupants in the traditional courtyard house in Al-Kadhimiya because of the increase in humidity.

(4) Temperature. Both spring and autumn were great seasons in the T.C.H.T. in the Al-Kadimiya historical area. The winter is very cold especially in the sardab and on the ground floor but, at the same time, winter days were comfortable while the nights were uncomfortable due to the difficulty in warming the houses. The summer season was relatively the most comfortable and had the most convenient temperature due to the natural movement of air across the yard and bad-geer. The worst times both past and present for the occupants were in the winter, but the very hot summer also meant that the time between noon and sunset was poor because of the heat.

These findings mean that the occupant faced the environmental conflicts of an inert house during specific times, and this required the addition of new systems.

- *Utilization of systems*

The utilization of systems refers to and describes the services in the T.C.H.T to distinguish between effectiveness and efficiency. These systems are explored in the following sections, with points extracted from both the interviews and physical survey.

(1) Ventilation systems. These are probably efficient and effective due to the natural ventilation from both the bad-geer and the courtyard. The burial of some of the sardab had affected the working of the bad-geer and air movement for these houses, as they were no longer part of one united fabric system through transformation.

(2) Drainage systems. The old sewage system had recently started to become blocked from time to time, and so it is not likely that this system was either efficient or effective for sanitation. The new sewage systems in the individual houses could not cope, and the sewage and sanitation systems between the individual house and the neighbourhood were tiring; however, this system is probably effective in individual houses but inefficient with public systems.

(3) Water systems. The water supply was good in winter, but in summer it was weak. Thus, these systems varied with the season.

(4) Electrical systems. New electrical equipment was provided for houses that had been rehabilitated or conserved since 1980, related with modernization due to unit development. The greatest problem, however, was the unavailability due to unscheduled breaks or an unstable electricity supply, and continuous power cuts for unknown periods of time, especially at night. This was a potential fire hazard, especially with the changes in the electricity supply current. This system was therefore neither efficient nor effective.

(5) Lighting systems. The house did not need to be lit during the day because of its natural lighting, but it became dark during the day with dust storms and at night during electricity cuts. This system would probably be efficient and therefore effective except for the dust storms.

(6) Communication systems. All the ground telephones were not working, and the internet was not available all the time due to heavy usage of the network, and so these systems were probably not effective and therefore inefficient.

(7) Heating systems. The natural heating provided by these systems was probably effective, but seemed to be inefficient because the occupants had difficulty warming the first floor in winter.

(8) Cooling systems. Due to natural cooling, these systems were probably effective but seemed to be inefficient because the residents ignored the first floor in summer.

(9) Safety and privacy systems. The inward looking plan and presence of the architectural elements such as the shanasheel on the first floor, with no windows on the ground floor, achieved safety for all family members as they were separated from the outside. The T.C.H.T used wood in the structure and therefore a few houses had burned down for different reasons, such as car bombings or explosions of materials in the alleyways of different neighbourhoods. Therefore, these systems were effective but inefficient.

(10) Security systems

In spite of the compactness and house design which protected from the outside, a few families had been robbed, and so these systems were effective but inefficient.

The statement of analysis in this study indicates that the evaluation of different services is varied because some were effective or efficient, which affected their lifestyle, and required new systems.

- Treatment and maintenance

This issues raised in the occupant interviews were in accord with the physical survey. Occupants treated and maintained the courtyard by covering it with nylon sheeting during winter and setting up a tent in summer to protect themselves from the harsh weather. In some houses, to improve the sardab's performance, the residents had been forced to close and abandon or bury part or all of the sardab to stop sewage flooding and drainage problems. They had added new protective materials to the doors and windows around the interior courtyard to insulate the rooms from the harsh climate. The occupants dealt with moisture by repeatedly painting the walls. Also, to avoid smells from the kitchen, the occupants changed the site around the old space or used the courtyard for cooking and washing dishes.

From this, we found that the occupants tried to change the physical built environment in the T.C.H.T. or add new materials, making preliminary treatments, and performing maintenance with respect to the families' needs. These findings support the need for additional systems.

- Activities movements

This issue was raised in both interviews and was in accord with the physical survey. There was movement of different activities such as sleeping, cooking, washing, and practice hobbies in the whole house around the year. The occupants moved vertically and horizontally for different activities during the day and night, as well as during the seasons, for thermal comfort. It seems that the daily activities used different places on different levels for the same activity; also, they did different activities in the same place. This indicates how not all the spaces, places, and levels are comfortable all of the time. There was the capability of responding to the changing environmental conditions at different times. However, those spaces which they ignored had a hostile environment and the need for systems to achieve user comfort around the year.

4.2 Enhancing the House Performance

An overall picture was sketched of T.C.H.Ts in the Al-Kadhimiya historical area in the previous section. This part presents how active systems can enhance the existing environmental performance of the T.C.H.T. to fill the gaps created by adopting the technology; this is based on an investigation of the existing needs of the new systems. To achieve this, the following items explore the main theme enhancing the T.C.H.T. performance by referring first to the response to the environment linked to passive systems due to natural cooling, heating, ventilation, lighting, and integrated systems. Also, lifestyle is linked to activities movement and treatment and maintenance. Second, the level of environmental comfort is linked to environmental conflicts and utilization of systems. Both are considered in connection with the existing system and existing need for additional systems. Figure 3 illustrates these issues

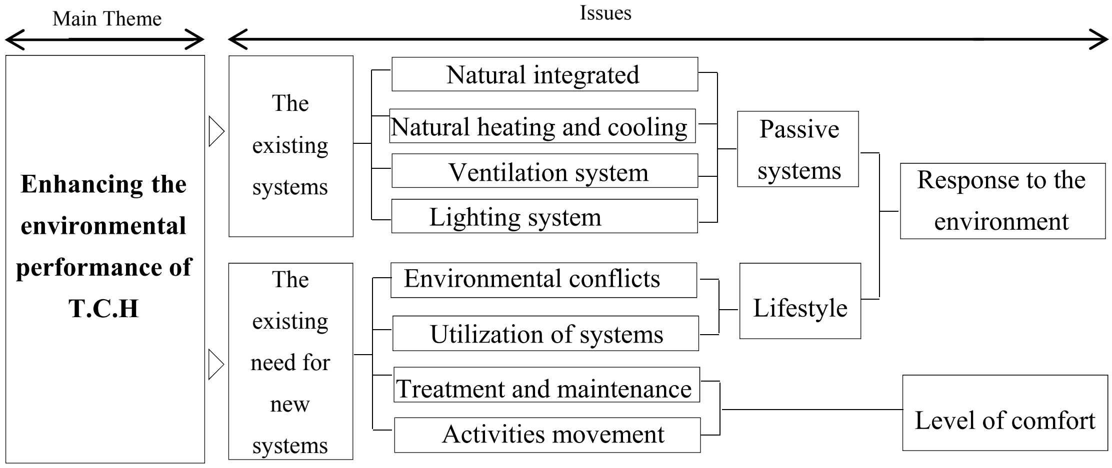

Figure 3. The main themes related with different issues raised from the case study

4.2.1 Response to the Environment

This refers to what the occupants of the T.C.H.T in the Al-Kadhimiya historical area do to enrich the house performance to adapt to changing environmental conditions, and includes:

- Passive systems

The determination of the existing systems in section 4.1.1 was based on the passive systems of T.C.H.Ts in the Al-Kadhimiya historical area. The passive systems have the ability to enhance the environment performance without mechanical power.

A number of aspects demonstrate the strengths of traditional units with an interior courtyard in Al Kadhimiya, at the level of the urban fabric linked to the compactness, and the individual units linked to the design through direction of space, structure and construction, and the shape, proportion, location of architectural elements and details, to promote an environmental performance. These previous findings refer to the fact that the T.C.H.T. has successful air movement around the year, a decreased undesirable effect from change in temperature during the harsh weather, and appropriate lighting during the day, in a way that probably achieves thermal comfort for the occupiers without mechanical power. The evidence in this study indicates that the environment can be enhanced by the use of passive systems as manifestations of existing systems. These systems create a micro climate with integrated systems as a tool for natural ventilation linked to air flow and air cross, natural lighting linked to sunlight and skylight, and natural heating linked to thermal comfort through balance in heat gain and loss. In this way, the studied courtyards acted as fully integrated systems that worked in a natural way without mechanical power. These passive systems not only responded and respected the environment; they also provided inner comfort for the occupiers to encourage energy conservation. All these systems reflect the efficient use of natural resources, and have the ability to adapt to the harsh environment and changes in the climate conditions which improves the environment performance of the current T.C.H.T.

- *Lifestyle*

Part of the everyday lifestyle feature for the activities movement, according to different seasons/ days, was moving from one level to another and from one space to another of T.C.H.T. in Al-Kadhimiya. It seems that one of the more significant elements to emerge from this is the vertical and horizontal movement in both the house section and plan during the day and night, as well as during the seasons for the purpose of accomplishing daily activities as a phase of response to the environment for thermal comfort. Moreover, treatment and maintenance was a part of the lifestyle as the occupants tried to change the environmental performance of specific places, spaces, and levels, reflecting the response to the environment in specific places and levels during specific times, in turn reflecting a response to the environment.

4.2.2 Level of Environmental Comfort

This item means to be comfortable or uncomfortable in a T.C.H.T. in the Al-Kadhimiya historical area in terms of the environmental conflicts due to lighting, air movement, temperature, and moisture. Also, the utilization of systems is linked to ventilation, lighting, cooling, heating, drainage, water, electricity, communication, safety, and security. From this, developing our understanding of the occupants of T.C.H.Ts must consider the different levels of environmental comfort, as not all the house was environmentally efficient all year round. This difference in levels of comfort had caused great discomfort and an unhealthy environmental situation for part of the time. Therefore, the level of comfort in these types of houses was varied. This meant that not all seasons/ days were healthy and comfortable in T.C.H.Ts because the vertical levels, spaces and places all contributed to determining the level of comfort linked to the present passive systems. The variations in environmental performance make additional systems necessary for this type of house. In order to achieve a continuous comfort level for the occupants in the entire house, there is now a need for active systems to improve the existing level of comfort. Table 3 illustrates the comfort level related to different times and levels.

Table 3. Comfortable different times and levels within the T.C.H.T. in the Al-Kadhimiya historical area

	Winter		Spring		Summer		Autumn	
	Day	Night	Day	Night	Day	Night	Day	Night
Sardab			•	•	•	•	•	•
Neem Sardab			•	•	•	•	•	•
Ground floor			•	•	•	•	•	•
Kafish-kan	•	•	•	•			•	•
First floor	•		•	•			•	•
Second floor	•	•	•	•			•	•
Roof	•		•	•		•	•	•

4.2.3 Enhancing Courtyard House Performance

The present response to the environment of the T.C.H.T. in the Al-Kadhimiya historical area was through passive systems linked to natural cooling, heating, lighting, and ventilation, integrated between these and lifestyle due to activity movement, treatment and maintenance. The occupants still had varying levels of environmental comfort linked to environmental conflicts and utilization of systems. There was a lack of environmental comfort and the inner courtyard did not meet the full requirements of comfortable living for most families, who require new technologies adapted to the changeable needs of today through a lack of technological development of different forms. Therefore, the present passive systems as existing systems of the traditional unit in the Al-Kadhimiya historical area are unable to overcome the harsh environment and there is a need to add new systems to improve the level of environmental comfort. The environmental enhancement creates the need for additional new systems that increase the existing level of house performance.

Heating and cooling systems are needed working at uncomfortable times in an efficient way for a specific level and place, to enhance the thermal comfort in both hot and cold weather. This will reinforce thermal comfort in response to seasonal changes in temperature heating systems during the winter for the ground floor, basement and first floor, especially during the night. New cooling systems were also used during the summer for the first floor and the kafish-kan during the day and night, on the ground floor between noon and sunset. T.C.H.Ts require ventilation systems to support air movement during the day and the night, which could be used around the year during dust storms to achieve fresh air across the houses by enhancing the indoor air quality with cleanliness. New lighting systems for the entire house are required, especially during the night and on days when there are dust storms, to enable all the occupants to have good quality light. Continuous, good quality, new communication systems will help residents to access information and connect with others and the world. Moreover, new water and drainage systems are needed for service places and spaces during withdrawal to respond to leakages and store water, especially in the summer season. New systems are needed to avoid flooding or blockages in the sewage pipes caused by leakage problems and moisture problems in the service spaces and lack of control of the water table, especially on the ground floor, which would help to control the odour level. They would also control the flooding which arises from water table level problems in the basement in winter; beside this, systems can be used around the year to control the rainfall. The addition of active systems is required for all the houses all the time to supply stable electricity and achieve general protection against any electrical malfunction, and to enhance and maintain electrical stability and safety, as currently it comes from different sources. Moreover, they need new safety systems for fire detection and alarms, which can include maintenance for electricity and heating systems for the entire house, during different times of the year. New security systems are needed to avoid theft all year round, and fire alarms and protection systems are needed to avoid fires, in the same way.

Therefore, adding active systems will increase the response to the environment in conjunction with the existing passive systems by supporting the natural lighting, cooling, heating, and ventilation. Also, the active systems will enhance the response to the environment linked to the lifestyle by supporting the methods of treatment and maintenance of the houses either by the changing climate or the effects of climate elements and improving the performance of ignored space through the activities movement. Moreover, adding active systems will enhance the level of comfort through improving the utilization of systems by rich efficiency or effectiveness of the services in the houses by increasing the performance, according to occupants' needs. This then reduces the environmental conflict which has a positive effect on the amount of fresh air, odour levels, temperature comfort, and quality of light, among other aspects. These have led to changes in environmental performance in the T.C.H.T. in the Al-Kadhimiya historical area. Figure 4 clarifies the active systems related to T.C.H.T. performance. These systems should be compatible with the existing systems, and can be simple or complex according to occupant needs. Therefore, the combination of both passive and active systems as a phase of enhancing the environmental performance situation is beneficial for reduced energy consumption by active systems, and obtains a stable living environment.

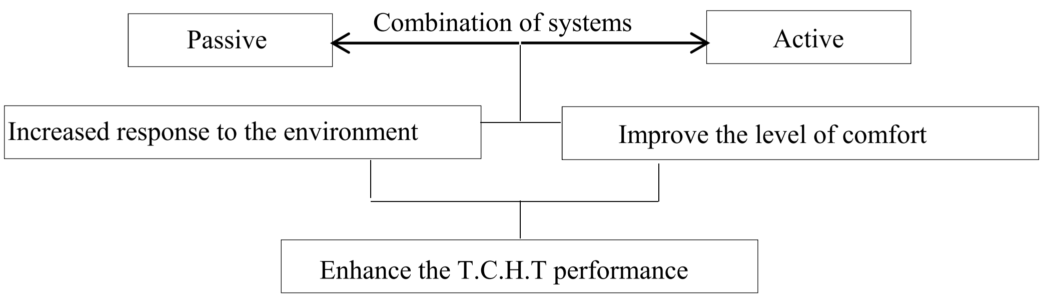

Figure 4. Enhancing the T.C.H.T. performance

5. Conclusion

Courtyard houses change in settlement patterns, and the external appearance of the local houses is influenced by the built environment. Many studies have dealt with passive and active systems for different building types, but have not considered the correlation of these systems for traditional courtyard houses. Thus, the aim of this research was to explore how active systems enhance the existing environmental performance of the traditional courtyard house type.

The previous literature focused on passive systems related to active systems to control the environment using quantitative approaches such as simulation and statistical techniques. The current study used a qualitative method that presented the themes and issues to enhance the T.C.H.T performance.

The conclusions revealed the correlation between the passive and active systems and their association in enhancing the performance of the T.C.H.T. in Al-Kadhimiya historical area. This study shows that using active systems enhanced the response to the environment and improved the level of environmental comfort in these houses, giving more relief and enabling a healthier environment. This is because the environment in Iraq is so harsh, especially at certain times, and the recent frequent phenomena of dust, the rising water table, and increasingly high temperatures, combined, make the atmosphere of the house less suitable for human comfort. Therefore, the new systems should be added to enhance the environmental performance of T.C.H.T. in the Al-Kadhimiya historical area by existing systems that reduce the energy used.

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References

Al-Akkam, A. (2013). Urban heritage in Baghdad: Toward a comprehensive sustainable framework. *Journal of sustainable development, 6*(2). http://dx.doi.org/10.5539/jsd.v6n2p39

Al-Akkam, A., & Kareem, N. (2011). The role of passive and active operational systems on technology of sustainable architecture. *Journal of Architecture and planning- King Saud University, 23*(33-35).

AL-Azawi, S. H. (1984). *A descriptive, analytical and comparative study of traditional courtyard houses and modern non-courtyard houses in Baghdad.* UK, University of College London.

Al-Azzawi, S. (1996A). Seasonal impact of climate on the pattern of urban family life: Indigenous courtyard houses of Baghdad regions of the hot dry climates. *Renewable Energy, 8*(1-4), 283-288. http://dx.doi.org/10.1016/0960-1481(96)88863-X

Al-Azzawi, S. (1996B). Daily impact of climate on the pattern of urban family life: Indigenous courtyard houses of Baghdad regions of the hot-dry climates Part I: Daily shifts or daily movements in summer. *Renewable Energy, 8*(1-4), 289-294. http://dx.doi.org/10.1016/S0960-1481(96)90145-7

Al-Mumin, A. A. (2001). Suitability of sunken courtyards in the desert climate of Kuwait. *Energy and Buildings, 33*(2), 103-111. http://dx.doi.org/10.1016/S0378-7788(00)00072-4

Al-Temeemi, A. S. (1995). Climatic: design techniques for reducing cooling energy consumption in Kuwaiti houses. *Energy and Buildings, 23*, 41-48. http://dx.doi.org/10.1016/0378-7788(95)00915-K

Alwaer, H., & Clements-Croome, D. J. (2010). Key performance indicators (KPIs) and priority setting in using the multi-attribute approach for assessing sustainable intelligent buildings. *Building and Environment, 45*(4), 799-807. http://dx.doi.org/10.1016/j.buildenv.2009.08.019

Al-Zubaidi, M. S. S. (2002). The efficiency of thermal performance of the desert buildings, 30th Annual Conference of Canadian Society of Civil Engineers, 5-8 June.

Biggs, R. et al. (2012). Toward principles for enhancing the resilience of ecosystem services, The annual review of environment and resources: 423-433. http://dx.doi.org/10.1146/annurev-environ-051211-123836

Capeluto, I., & Shaviv, Y. (2004). What are the required conditions for heavy structure buildings to be thermally effective in a hot humid climate? *Journal of Solar Energy Engineering, 126*(3), 886-892. http://dx.doi.org/10.1115/1.1755242

Dili, A. S., Naseer, M. A., & Varghese, T. Z. (2010). Passive environment control system of Kerala vernacular residential architecture for a comfortable indoor environment: A qualitative and quantitative analyses. *Energy and Buildings, 42*(6), 917-927. http://dx.doi.org/10.1016/j.enbuild.2010.01.002

Holden, J. (2008). An introduction to intelligent buildings: benefits and technology. *Information Paper*; BRE global IP 13 part 1.

Kamara, J. M. (2013). Exploring the client-AEC interface in building lifecycle integration. *Buildings, 3*(3), 462-481. http://dx.doi.org/10.3390/buildings3030462

Kua, H. W., & Lee, S. E. (2002). Demonstration intelligent building –a methodology for the promotion of total sustainability in the built environment. *Building and Environment, 37*(3), 231-240. http://dx.doi.org/10.1016/S0360-1323(01)00002-6

Leylian, M. R., Amirkhani, A., Bemanian, M. R., & Abedi, M. (2010). Design principles in the hot and arid climate of Iran, the case of Kashan. *Academic Research, 2*(5).

Muhaisen, A. S. (2006). Shading simulation of the courtyard form in different climatic regions. *Building and Environment, 41*(12), 1731-1741. http://dx.doi.org/10.1016/j.buildenv.2005.07.016

Muhaisen, A. S., & Gadi, M. B. (2006). Shading performance of polygonal courtyard forms. *Building and Environment, 41*(8), 1050-1059. http://dx.doi.org/10.1016/j.buildenv.2005.04.027

Ochoa, C. E., & Capeluto, I. G. (2008). Strategic decision-making for intelligent buildings: comparative impact of passive design strategies and active features in a hot climate. *Building and Environment, 43*(11), 1829-1839. http://dx.doi.org/10.1016/j.buildenv.2007.10.018

Ratti, C. et al. (2003). Building form and environmental performance: archetypes, analysis and an arid climate. *Energy and buildings, 35*(1), 49-59. http://dx.doi.org/10.1016/S0378-7788(02)00079-8

Shokouhian, M., Soflaee, F., & Nikkhah, F. (2007). Environmental effect of the courtyard in the sustainable architecture of Iran (cold regions), 2nd PALENC Conference and 28th AIVC Conference on Building Low Energy Cooling and Advanced Ventilation Technologies in the 21st Century.

Sibley, M. (2006). The courtyard houses of North African medinas, past, present and future. In B. Edwards et al. (Eds.), *Courtyard housing: past, present and future*. USA: Taylor and Francis.

Sozen, M. S., & Gedík, G. Z. (2007). Evaluation of traditional architecture in terms of building physics: Old Diyarbakir houses. *Building and Environment, 42*(4), 1810-1816. http://dx.doi.org/10.1016/j.buildenv.2006.01.019

UN-Habitat. (2006-2007). *The State of Iraq Cities Report, Cities in Transition. In collaboration with the Global Urban Research Unit.* School of Architecture, Planning and Landscape, Newcastle University, United Nations Human Settlements Programme.

Warren, J., & Fethi, I. (1982). *Traditional Houses in Baghdad.* England. Coach Publishing House Limited, Horsham.

Wigginton, M., & Harris, J. (2002). *Intelligent Skins.* Architectural Press, Oxford.

Wong, J. K. W., Li, H., & Lai, J. (2008). Evaluating the system intelligence of the intelligent building systems: Part 2: Construction and validation of analytical models. *Automation in Construction, 17*(3), 303-321. http://dx.doi.org/10.1016/j.autcon.2007.06.003