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RESEARCH PAPER

Traditional Courtyard Planning for Sustainable Architecture Solutions

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ABSTRACT

Throughout history, courtyards have played a crucial role in architectural design, offering a blend of environmental, social, and therapeutic benefits. Originating from arid and warm regions, courtyard forms have adapted globally to diverse climates and cultural contexts. This study delves into the evolution of courtyard design in Lahore, Pakistan—a city steeped in cultural heritage influenced by various civilizations. By analyzing literature, conducting observational surveys, and examining case studies, the research explores courtyard typologies, functions, design variations, and orientation patterns. Notably, rectangular courtyards prevail in Lahore, strategically oriented to maximize sunlight and ventilation. These multifaceted spaces serve as gardens, light sources, ventilation systems, playgrounds, and social hubs. The findings underscore the significance of considering climatic factors, socio-cultural influences, and user requirements in contemporary courtyard design. Architects are encouraged to create sustainable, contextually responsive designs that blend traditional wisdom with modern innovations.

Keywords: Building Morphologies, Courtyard, Neighborhood, Sustainable Development

Introduction

Courtyards**,** integral to architectural design, serve environmental, social, and healing purposes.The courtyard is an important building element, actually originated from the dry and hot regions (Edwards, Sibley,Hakmi, & Land, 2006) The inappropriate use of some courtyard forms in some regions, is not wisely useable in some another region of different climate which is the centralized courtyard in any home in any region. The concept of courtyard form adaptation and applying it as a basic form in Asian countries from traditional concepts to modern courtyard has come from the western countries. The courtyards in Arab countries or in ancient context have improved an indication that the social, environmental and cultural factors were considered as a design variant (Reynolds, 2002). Successful courtyard design hinges on factors like area, orientation, floors, exposure, and materials, impacting the overall environment. (Almhafdy, Ibrahim, Ahmad, & Yahya, 2013)

Neolithic era settlements determine the courtyard house planning in house design, serving as a protection from the outward's forces like wild animal and enemy's invasions. The maximize built up area mature the form of a courtyard house which not only capture the sun light heat and air circulation in the house interior. The typical house form prevails its cultural relevancy and importance from China to Morocco and from Egypt to Islamic world, especially in the hot and hot arid climate, irrespective of the functional and climatic efficiencies over time.

Lahore, Pakistan's second-largest city, has been a cultural crossroads for centuries, influenced by Hindus, Buddhists, Greeks, Muslims, Sikhs, and British rulers. Today, it stands

as the cultural and provincial capital of Punjab. The city's history, chronicled in the 982 book "Hadud-e-Alam," emphasizes that the street layout reflects its core culture, serving as the epicentre for economic and socio-cultural activities. The socio economic and geographic factors determine the relationship between the compact nature of house form and urban form which help in shaping the cities with reference to urban planning patterns and design strategies (Turner, 2015). The modern housing contains the street block and a house in urban neighborhood of Lahore city, which is a main focus of study.

Literature Review

Courtyard is considered to be an architectural design component which is usually applied in buildings for environmental, social and healing capacities. The courtyard is an important building element, actually originated from the dry and hot regions (Edwards, Sibley, Hakmi & Land, 2006). The inappropriate use of some courtyard forms in some regions, is not wisely useable in some another region of different climate which is the centralized courtyard in any home in any region. The concept of courtyard form adaptation and applying it as a basic form in Asian countries from traditional concepts to modern courtyard has come from the western countries. The courtyards in Arab countries or in ancient context have improved an indication that the social, environmental and cultural factors were considered as a design variant (Reynolds, 2002). The responses of human needs determine the successful oriented courtyard with the variations in courtyard's area, orientation, floors, exposure, wall type and materials used in the infrastructure. These design variants impact the overall environment. (Almhafdy, Ibrahim, Ahmad, & Yahya, 2013).

Functions of the courtyard: A courtyard is commonly used architectural element being used from thousands of years in houses all around the world. It is a common meeting place and day today activities like cooking, gardening, playing, working, sleeping, or somewhere used as a herd place (Edwards, 2006). A Courtyard serve as a functional space for microclimate, leisure and social activities. This importance of courtyard is only due to its centralized space in the building or any urban fabric. Elements like landscape features, ornamental water bodies, and interplay of light and shade enrich our daily lives within these serene spaces (Meir, 2000), (Meir, Pearlmutter, & Etzion, 1995).

Moreover, a courtyard can be served as climatic and visual protector and its geometry, position and material in the design and construction phase define the thermal comfort level (Meir I. A., 2000). Courtyard can be served as a natural healing space and serve as climate responsive design element. An architect while designing the structure should facilitate the five human senses although incorporating nature, shade, waterbodies, wind, colours and pavements. A micro climatic environment can be created through design form. The square or rectangular shaped courtyards have been studied by different researchers to study its impacts in hot and temperate climate and generate micro-climatic effects through forms. A case study in Hong Kong by depicted that experience of user are enriched by introducing courtyard with security, privacy, transparency, visual connection from both indoor and outdoor along with the landscape elements ensures a good sense of privacy and control (Lau, & Yang, 2009).

Courtyard Configuration: There is no any fixed shape of courtyard since decades and centuries. The earliest square and rectangular forms of the courtyard have been modified into new shapes such as T,L, U, or Y in order to meet the basic environmental aspects like topography, site restriction, function and building orientation (Das, 2006), (Reynolds.J, 2002).

There may be different types of courtyard enclosures. They may be Fully or semi enclosed, means enclosed from four sides or from three and two types. Multi storied housing can also be incorporated by courtyards (Meir, Pearlmutter, & Etzion, 1995). There is a deep

relationship between the courtyard form, exposure to sky, Sun location, day light effects and shading performance (Muhaisen & Gadi, 2006). There is a reasonable effect of optimum courtyard height, in hot and cold weather conditions; up to three storeys in hot and humid climate, double story in hot temperate and dry climate and single storey in cold climate. There is a strong relationship of rectangular courtyard's proportion between height and area ratios. Smaller walls around the courtyard work better in cold climates, while taller walls suit hotter regions. It was also explored that the shallow courtyard form, function more during winter and deep courtyards facilitate with internal shadows during summer with the recommendation of annual calculation ratio(Muhaisen & Gadi, 2006). Although this is not ideal for daylight. Narrow courtyards with minimal sky exposure aid passive cooling and correlate with airflow patterns in warm, humid climates (Rajapaksha, Nagai, & Okumiya, 2003).

However, on the other hand explored that the non-typical form of polygonal courtyard proportion & geometry have significant impacts on internal shading conditions and lighting in any building along with sun direction (Muhaisen & Gadi, 2006).

Orientation: The layout of a building significantly influences the orientation of its courtyard. The microclimatic settings of any courtyard in a building depends upon the following (Bagneid, 2006):

- Sun location
- Solar gain
- Wind direction
- Shading performance

Wind speed, ventilation, thermal comfort and day lighting has direct impact with the courtyard orientation (Meir, Pearlmutter, & Etzion, 1995). The authors also concluded that thermal comfort in a building can be attained by correct orientation of the courtyard, otherwise it may create discomfort if not truly considering the solar angles, wind direction and orientation.

Wall enclosure: The size of the enclosing walls around the courtyards, size and shape are variable of different regions and functions as design variant. Socio-cultural environment, socio economic and local environmental conditions determine the differences in design variants of courtyards and are influenced by location and functions (Meir, 2000) . There is a need to consider wall enclosure components like windows, doors and walls during the design stage as these enclosures play an important part to create a microclimatic condition in a building. Window to wall ratio can be change and manipulated by closing and opening the window apertures in order to get an appropriate natural ventilated enclosure size (Al- Hemiddi & Al-Saud, 2001). There was a significant natural ventilation effects in thermal performance of the court by natural aeration procedures. Factors like thermal behaviour, surrounding spaces, microclimatic conditions, and light capture can be optimized through thoughtful design choices, including glazing type, window-to-wall ratio, construction materials, shading devices, and color selection (Aldawoud, 2008), (Lili, Zheng, & Lipei, 2011).

Natural elements within courtyard: It is of environmental benefit to incorporate natural elements within a courtyard (Sadafi, Salleh, Haw, & Jaafar, 2011). The study reveals the effects that the natural elements like shrubs, flower plants and trees generate shades and thermal comfort significantly along the courtyard walls. A pool in the internal courtyard, tent, a fountain or a water spray, provide thermal comfort during the sunny timings and a cooling effects for the inner spaces adjacent the courtyard (Al- Hemiddi & Al-Saud, 2001).

Past research information on the design of the courtyard variants and their environmental performance impacts used as a base to formulate a checklist of inventoried descriptor of the courtyard.

Material and Methods

The qualitative approach is adopted to conduct this research with sequential process starting from the literature mapping. The literature survey conducted starting from the earliest examples of the courtyard houses to understand the need and functionality of the courtyards. This is further complemented with the climatic regional modifications studies in the concept of courtyard planning. After careful analysis of the literature a series of observational surveys were conducted to formulate the variables checklist (Table-01).

Table 1
Courtyard Design Variant Checklist

Form		Rectangular Triangular Square Other
Shape	Fully- enclosed Semi-enclosed	U shape L shape Rectangular shape Square shape
Number of floors		
Area		
Orientation		South North East West
Shading Device	Roof Overhead	
Water ground ratio Vegetation ground ratio Healing properties Courtyard plan aspect ratio Function		

Case Studies Selection Criteria: The case studies were selected to understand the evolution of courtyard houses from the historic time to modern interpretations. The areas selected are as follows:

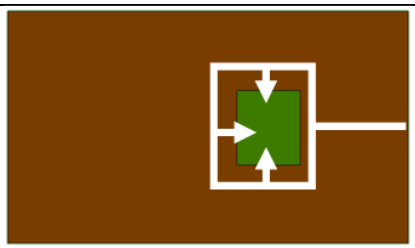
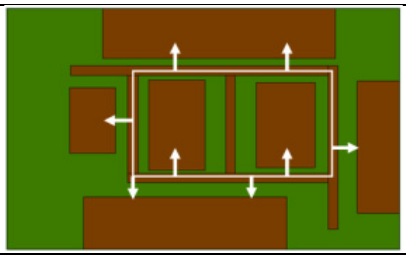
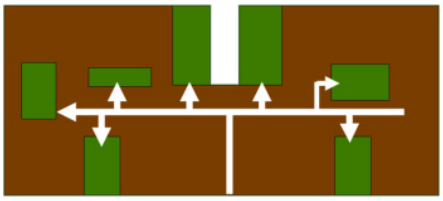
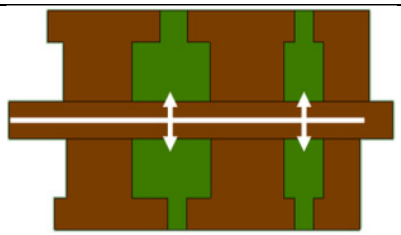
- Walled city Lahore
- Model Town Lahore (houses pre-partition)
- Samanabad,
- Allama Iqbal Town
- Johar Town (after partition)
- Modern Houses Bahria Town

The primary data collection was done though site visits and questionnaire survey to study the courtyard houses plans, shape, function and usage. The data was compiled from the residents who are the actual users of the places generated the real time perception in addition to the identification of the evolving factors of courtyard planning from historic to modern developments.

Results and Discussion

The analysis of data resulted into various design typologies of the courtyards used from historic to modern times. The evolution process was influenced with the number of factors in addition to the cultural shift in our part of the world. The spatial configuration of the courtyards were also affected from this shift and also changed the meaning of this central space from historic perspective to the segregated smaller space transformations as observed in the modern times (Table-02). The spatial configuration variations over the time also changed the shape of this space along with the usage as observed during the visual and questionnaire surveys.

Table 2
Configuration of Courtyard in Lahore House (Authors, 2023)

Courtyard Configuration	Description	Example	Graphical Illustration
Closed Courtyard	Fully Enclosed Courtyard	Low-income house in Walled city	
Open Courtyard	Cluster of houses blocks surround open places into courtyards	Middle income 10 marla houses in planned areas	
Interlinked Courtyard	Patios and courtyard located in different floor of a house	Modern houses in new developments	
Cluster Courtyard	Spinal	More than one courtyard attached to the crucial circulation of the house.	 10 marla house plan
Cluster Courtyard	Multiple	The design of the housing form generates entirely surrounded courtyards	 1 kanal House Plan

The characteristics of the courtyard in houses of selected neighbourhoods in Lahore City: There is limited empirical research on the courtyard characteristics. The least understood research area is the built courtyard. The built courtyard house now has been

moved into the new era of green architecture and sustainability through evolution of different courtyard types.

Functions of the Courtyard: Courtyards have been used through centuries for different purposes. There are five main utilization functions of the courtyard being operated as a daylight component, a garden, and ventilation arrangement, as a therapeutic component and play ground and social gathering place. It is evident from the studies that courtyard has always been used as a source of light.

- Garden
- Lighting
- Ventilation
- Play ground
- Healing

Table 3
User's Perception for Courtyard Usage in Different Towns in Lahore

Number of Courtyards	Perception	Gardening						Lighting						Ventilation					
		Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town
100	Yes	21	100	10	57	31	80	90	93	94	94	94	96	94	97	89	89	89	98
	No	79	0	90	43	69	20	10	7	6	6	6	4	6	3	11	11	11	2

Number of Courtyards	Perception	Play Ground						Healing						Landscaping					
		Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town
100	Yes	54	99	17	23	17	17	67	86	21	2	1	0	77	87	76	67	78	21
	No	46	1	83		83	83	33	14	78	98	99	100	23	13	24	33	22	79

Courtyard Design Variants: Design variants of the courtyard like size, shape, walls as an enclosing structure have been used in some variable ratios in different regions and areas among different housing types.

Aspect Ratio and Forms: The most common geometric form of courtyard prevail in different housing forms in Lahore are fully closed and semi closed and they are of the square and rectangular form.

Table 4
Aspect Ratio and Form of Courtyard in Different Towns in Lahore

Number of Courtyards	Form of Courtyard																		
	Irregular						L-Shape						Rectangular						
	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town
100	7	12	14	3	17	3	13	0	9	9	10	0	38	0	31	13	7	21

Number of Courtyards	U-Shape						Detached						Square Shape					
	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town

100	0	24	23	69	42	40	12	64	5	6	3	19	30	0	18	0	21	17		

Table 5
Area of Courtyard in Houses of Six Neighborhood of Lahore

	`Area of Courtyard in Square Feet																							
	>100 sqft						**100-400sqft**						**400-700sqft**						**700-1000sqft**					
Number of Courtyards	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town
100	17	0	15	11	2	0	21	0	17	17	23	0	17	0	13	13	17	34	19	0	12	12	35	26

	1000-1400sqft						**1400-1700sqft**						**1700-2000sqft**						**2000sqft and above**					
Number of Courtyards	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town
100	10	0	23	27	11	29	4	17	17	13	3	11	7	23	3	7	6	0	5	60	0	0	3	0

The analysis from the collected samples depicted that the maximum no of courtyards contain highest wall's height towards the west and south so as to protect the house from the sun and the lowest walls in the east direction and results in decreasing the comfort while increasing the sun light capturing during extreme sunny hours.

Orientation: Orientation is another design aspect of the courtyard as a microclimatic convertor that can influence the external and internal surrounding places. The elongated North- south facing courtyard is considered to be well oriented and functional.

Table 6
Courtyard Orientation in Houses of Six Different Neighborhoods in Lahore

	Orientation																							
	North						**North-East**						**East**						**South**					
Number of Courtyards	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town

100	3	11	4	18	10	3	4	6	6	6	3	7	6	4	2	2	6	4	45	40	40	36	30	37

	South-West						**South-East**						**West**						**North-West**					
Number of Courtyards	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town	Walled City	Model Town	Samanabad	Allama Iqbal Town	Johar Town	Bahria Town
100	13	9	22	12	17	17	12	14	14	14	14	6	12	10	8	8	13	13	5	6	4	4	7	13

Conclusions

This is a research effort to contribute to comprehend the character of courtyard design in Lahore, which reveals that the courtyards are usual design elements used as an architectural foot print in historic city of Lahore. The courtyard footprints are in the form of enclosed, semi enclosed, open and multiple types being used in residential housing forms in Lahore. The most commonly used housing courtyard form is the rectangular form. Open space as a courtyard is the most common form of the usability in the houses in Lahore mostly oriented in the South and South-West direction, which is almost 90 to 60 percent of the total sample collected to evade through solar exposure and solar rays. Usability of Courtyard oriented in the North-South direction can be enhanced while increasing number of stories in this direction. The collected sample results depict that almost 80 percent of the courtyard are located in the south ward., 60 % in the South- West and minimum number of courtyard's location are in North, North-East and North-West. Size of the courtyard vary between 400 Square feet to 1000 square feet and above which shows that the relationship between the total area of the house. It shows that the small houses contain small courtyard area and even big houses contain also small square feet area of the courtyard or side space and open spaces. The basic purpose of the left open spaces is to get natural light and air or people also use it for landscaping and plants décor but the healing characteristics of the courtyard are minimum utilized. Shape of the courtyard is square and U-shaped, L shaped afterwards determining the maximization of light capturing ability in the layout of the house normally.

Recommendations

- The use of courtyard planning in the climate like Lahore modifies the micro climate and reduces the active means for cooling and heating.

- The North-South direction is recommended to achieve maximum utilization of courtyard.

- The layout and size of the courtyard should be corrodinated to maximize the benefits of the courtyard planning.

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