Courtyard: A Look at the Relevance of Courtyard Space in Contemporary Houses

Richa Gupta^{1,*}, Mahendra Joshi²

¹Institute of Arch & Planning, SRMU, Lucknow, India

²Lovely School of Architecture and Design, Lovely Professional University, Jalandhar, India

Received August 2, 2021; Revised September 9, 2021; Accepted October 17, 2021

Cite This Paper in the following Citation Styles

(a): [1] Richa Gupta, Mahendra Joshi, "Courtyard: A Look at the Relevance of Courtyard Space in Contemporary Houses," *Civil Engineering and Architecture*, Vol. 9, No. 7, pp. 2261-2272, 2021. DOI: 10.13189/cea.2021.090713.

(b): Richa Gupta, Mahendra Joshi (2021). *Courtyard: A Look at the Relevance of Courtyard Space in Contemporary Houses*. *Civil Engineering and Architecture*, 9(7), 2261-2272. DOI: 10.13189/cea.2021.090713.

Copyright©2021 by authors, all rights reserved. Authors agree that this article remains permanently open access under the terms of the Creative Commons Attribution License 4.0 International License

Abstract The paper attempts to uncover the key issues concerning the sustainable built form of towns in the aftermath of rapid urbanization and growing population. The objective of this study is to understand the suitability and practicability of the courtyard forms in the urban settlement. Traditional courtyard houses in India are the native types of houses. These typologies of houses have been developed through the time-tested method and reached widespread acceptance. It became apparent that contemporary along with the traditional courtyard design should be studied on various parameters to determine the most suitable courtyard design for an urban context and quantify possible design solutions in various regional contexts. The paper presents a literature review at two levels. The environmental and socio-cultural impact of courtyard typology has been addressed at the first level. And the second level explores the typological implication of courtyard houses at an urban scale with special emphasis on parameters like building bye-laws, Floor area ratio, and density. The study revealed that the courtyard serves as a holistic space within the house, however depending on the regional and climatic context, the attributes may differ. The paper concludes that courtyard typology has the potential to justify the cultural, anthropological, and climatic needs of the occupant therefore could be adopted in urban settings. The study also provides future direction for the research work as a very limited background study is available to establish a direct relationship between courtyard typology and building bye-laws.

Keywords Bye-Laws, Courtyard Typology, High-Density, Microclimate, Sustainability

1. Introduction

Globalization leads to the opening of the boundaries politically, economically, as well as culturally. There is no doubt that globalization has contributed to economic growth, improved standard of living, and imported trends of architecture style throughout the world. As a consequence, the architectural characteristics of different regions and climatic zones have started losing their regional identity and uniqueness. Traditional dwellings and typologies are the true expressions of their occupants and possess high longevity and durability [1].

It is quite challenging to include all traditional elements of housing in the contemporary context. However, the architect used the term critical regionalism to describe how we adopt traditional elements after assessing their suitability in a contemporary context. Likewise, the courtyard is also one of the architectural element that loses its identity with time in the housing typology. Consequently, this element needs further exploration.

The courtyard system has gone through a major transformation in contemporary architecture due to advancement in technology, modern building materials, social as well cultural transformation, change in the belief system, change in lifestyle, change in building regulation, etc.

Therefore, it is quite crucial to identify the benefits and impact of this traditional courtyard typology, as well as its relationship with new housing parameters so that this

ageless typology might reclaim its place in contemporary architecture.

Oxford's Dictionary defines courtyard as:

"An unroofed area that is completely or partially enclosed by walls or buildings, typically one forming part of a castle or large house."

Moreover, The National Building code (2005) defines the courtyard as:

"Space permanently open to the sky, enclosed fully or partially by building and may be at ground level or any other level within or adjacent to a building."

The basic courthouse comprises of the following components:

- The court
- Semi-enclosed arcade or verandah
- The rooms

The following characteristics of a "Typical courthouse" are examined to comprehend the various elements of the courtyard typology (Figure 1). Although these components have been modified and changed to meet the needs of many countries and cultures, they are often found in all courthouses around the world.

Source: Das, N. 2006. [2]

Figure 1. Typical Layout of Courtyard

2. Evolution of Courtyard Form

In his book "Dwellings: The House Across the World," Paul Oliver (2003,) wrote: courtyard houses have an extended history and examples of the same have been discovered in Kahun, Egypt, that are thought to be 5000 years old, and further back to 2000 B.C. The Chaldean City of Ur on the Euphrates River in Mesopotamia also had houses of courtyard typology (Figure 2).

Source: After Tabesh et.al [3]

Figure 2. Traditional Courtyards building in Ur, Mesopotamia

The ruins of courtyard dwellings found in different ancient civilizations such as Mesopotamia, the Indus Valley, Egypt, and China, along with Classical Roman and Greek periods, Figure 3 shows that the "courtyard form" is rather perpetual in the history of Architecture.

Courtyard houses, as we've seen, may be found throughout the world and are still in use today. This universal building form has been present for over 5000 years, and there are several reasons for its continuity.

Source: Taleghani, M. et al, [1]

Figure 3. Traditional Courtyards typologies in the World

Ancient Civilization

Schoenauer and Seeman, in their book “The Court-Garden house,” stated that a troglodyte hamlet in the Matmatas region of southern Tunisia is the most primitive and homogeneous community to create courtyard dwellings. Douars in North Africa, nomadic tribes ‘encampment in West Africa, the Kraals of Bechunaland in South Africa, and the first rectangular dwellings in Morocco lay the foundation stone for the conventional courthouse [2].

The earliest courtyard dwelling in China of the middle Neolithic period represented by the Yang Shao civilization (5000-3000BC) was unearthed during Archaeological Excavation. The layout of a fully built Chinese house includes a courtyard and a light well. In philosophical terms, a courtyard serves as a link between heaven and earth. The principle of early Chinese courtyard houses (Figure 4) is also reflected in later Japanese Courtyard Dwellings.

Source: Adapted from Beijing: Zhongguo gongyue chubanshe, 1984.

Figure 4. Plan and View of Traditional Chinese Courthouse

Around 2000–1500 B.C., the philosophy of designing houses in Indus valley is apparently the same having a square Mandal in the center as a representation of cosmos. The houses were built as a series of rooms that opened towards the central courtyard (Figure 5).

Source:

(<https://www.boloji.com/articles/892/the-indus-valley-civilization>).

Figure 5. Typical Plan of Indus valley Courthouse

There is a strong motive behind the constant use of courtyard dwellings in the Indian subcontinent to date, even after the collapse of the Indus Valley Civilization around 900 B.C. The elementary style of the courtyard dwelling in India may differ considering the vast regional context and climatic variation. The style and construction of Indian courtyard dwellings vary by location, giving rise to names like Haveli (Gujarat, Rajasthan, or Punjab.), Wada (Maharashtra.), Nalukettu (Kerala), Rajbari (Bengal), Chettinad (Tamil Nadu), and Deori.

Classic Civilization

The classic age of architecture, which is marked by the unique ability of Greek and Roman design, underlines the acceptance of universal courtyard design. The first Greek courtyard house originated in the 4th or 5th centuries BC. The Greek hall-style house was gradually superseded in urban areas by the peri-style home (Figure 6a). The Roman atrium home was influenced by the Greek peristyle houses and atrium houses of the Etruscans. During the Late Roman period, the typical Roman urban residence included two quadrilateral inner court gardens, the smaller one known as the atrium and the bigger one known as the peristyle (Figure 6b).

Source: Adapted from Zhang D.[4]

Figure 6. Typical Plan of Greek house (a) and Roman house (b)

The Middle Ages and Renaissance Civilizations

The courtyard dwellings experienced a setback after the fall of the Roman Empire in A.D. 476. The only remains of courtyard dwellings were found in Italian cortile houses and monastic cloisters during the Middle Ages. The traces of a rich Roman civilization were still existent at the time of the Moorish conquest, and the Moors brought their culture into Mediterranean cities. Even though the religions were very different, Islam's philosophy has absorbed the Greek and Roman styles. Further, The Ur houses also influenced the design of classic Islamic courtyard buildings [5]. Traditional Arab dwellings (Figure 7) adhere to the principle of "privacy and seclusion with a minimal display of the occupant's social status to the outside world" [6].

Source: Adapted from El Mansuri S. [7]

Figure 7. Typical Plan of an Arab house

Modern Civilization

Between 1890 and 1930, the Spanish introduced the patio home to Northern America, and due to Spanish colonial influences, it was quickly adopted in Southern California. Even now, certain features of Spanish Colonial design, such as the patio, are being used by some architects to create modern architecture. A historical precedent can be found in the new atrium home in Northern Europe. The majority of modern courtyard houses, on the other hand, were built after World War I and are distinguishable from any of the old Mediterranean types. However, in order to achieve higher population densities and more distinctive forms, L-shaped and U-shaped Courtyard typology has been reinfused.

3. Courtyard Element and Forms

Courtyards fit into a specific type of architectural space, known as 'Transitional space.' Transitional spaces can be defined as the 'in-between' architectural spaces where the micro climatic condition of indoor and outdoor climate is moderated without using active strategies [1]. These transitional spaces could be broadly classified into three categories. Courtyards, atriums, and patios come under category one. The second type comprises attached semi-open spaces such as a balcony, a corridor, an arcade, a veranda, or a porch. And under the third category, the building is surrounded by open spaces all around such as gardens or pavilions (Figure 8).

Although there is no particular shape for a courtyard, the most common designs are rectangular, square, and circle. However, more complex shapes such as the U, L, single line, or double line shape (Figure 9) could be adopted to overcome constraints such as site restriction, topography, building orientation, or specific function [2]. A good courtyard, according to Meir (2000), is a semi-enclosed space with a well-thought orientation that could optimize its microclimatic efficiency.

- A. Open Space within the building
- B. Open Space attached to the building
- C. Open Space encircling the building

Source: Author

Figure 8. Different categories of Transitional Spaces

- A: Single type
- B: Double line type
- C: L type
- D: U type
- E: Enclosed court type

Source: Lee M. et al, 2015 [8]

Figure 9. Different designs of courtyard houses

Several studies have been carried out to evaluate the performance and behavior of courtyard shapes and features at both architectural and urban scales. This study helps to define the limitation, difficulties, and potential for optimizing the shape and size of the courtyard. The rectangular shape of the courtyard was found to shield the building from solar radiation and dusty wind [9].

Furthermore, Courtyard typology can be characterized by the following attributes as shown in Figure 10.

Source: Author

Figure 10. Different attributes of a courtyard

4. Courtyard Benefits

The courtyard plays a crucial role in influencing the climatic, physical, and psychological environment of the courtyard house. Countless rewards of courtyard typology have been cited by scholars over time, to explore the potential of the courtyard in a social and ecological context. This open yet enclosed space within walls, clusters, or urban fabric, courtyards perform a wide range of social, cultural, and spatial functions. It became quite thought-provoking to quantify the benefits of the courtyard based on parameters such as psycho-social, cultural, religious, climate, and architectural.

4.1. Psycho-Social Benefit

The inner courtyard provides a sense of confidentiality and enclosure [10]. Traditional courtyard dwellings provide the utmost level of mental comfort by considering privacy and security [11]. Shade, trees, plants, water, pavement, color, and other elements that satiate the five senses of the human body could be used in courtyards to provide a healing touch in the house. During the study of a Hong Kong university, the healing properties of the courtyard were explored and substantiated. The user experiences can be improved multifold by introducing a courtyard that provides visual connection, privacy, and

security. It is evident that the courtyard acts as a public and social gathering space in a public building while in a residence it provides a sense of confidentiality and enclosure [12].

4.2. Cultural Benefit

Courtyard houses have their own benefit in different cultures. The courtyard acts as an Oasis as well as a screen in Islamic architecture where privacy is of utmost importance. The ancient science of architecture (Vaastu shastra) could be of help as it also promotes courtyard as Brahmathan (central courtyard) in houses and Vaastu has a constructive impression on Indian households. The courtyard as a space is significant both ways, be it symbolic or religious. This open-to-sky space has been considered as a central focal point around which other habitable spaces are planned. The courtyard may indicate many things: the central emphasis, a light well, a windcatcher, or pool of water which serve the purpose of a secluded, safe, and life-inducing space.

4.3. Climatic Benefit

The courtyard acts as a requisite buffer zone between the building's outdoor and indoor environments. Due to their ability to moderate-high temperatures, provide cross-ventilation, and adjust humidity, courtyards are usually referred to as microclimate modifiers [10]. Building geometry, shading pattern, orientation, built mass, natural elements (water and plant), material, and airflow pattern produce considerable environmental implications in modifying the microclimate of the courtyard's houses [13]. The courtyard also acts as a light well for the narrow land parcels. Finally, the courtyard acts as one of the most appropriate passive strategies in climate-responsive buildings.

4.4. Architectural Benefit

Courtyards function as a crucial point in houses, which connects the different areas and functions. It acts as an extension of the living area. Further, the courtyard plays important role in providing access hierarchy that is from public space to semi-public/private, and private spaces in concern of privacy [11]. An architect could use this space very tacitly for providing better visual connection and acoustic buffer for spaces situated around. Moreover, the courtyard is a multifunctional space used for various activities like sleeping, eating, cooking for ages. Courtyards consisting of elements like water, plants, furniture, etc. enhance the ambiance of the house and support the concept of an interior landscape.

5. Methodology

The study thoroughly reviews the available literature on

the climatic, behavioral, and typological aspects of courtyards. It categorizes current publications into two main groups to identify the key parameters of courtyard typology: 1- Those examining the environmental and socio-cultural implication of courtyards, (Table 1) and 2- Those incorporating an integrative approach towards the

typological impact of the courtyard cluster. (Table 2) The goal of the literature review is to gain a different perspective on courtyard dwellings on a global scale, however, in a broad perspective, the study tries to identify the challenges of using courtyard typology in Indian cities.

Table 1. Parameters of Environmental and Social Attributes

Author	Attributes	Key parameters	Research method
(Taleghani & Tenpierik, 1986)	Environmental Aspect	Natural elements, courtyard configuration, openings (For various climates)	Literature study
(Nibedita Das, 2006)	Environmental and Functional	Temperature, Humidity, Light Intensity, Courtyard comfort, Form and function.	Field Survey Simulation Method
(Lee & Park, 2015)	Functional Psychological	Privacy and Protection, Natural Light	Field Survey
(Tablada et al., 2005)	Environmental	Indoor AirSpeed, Thermal Comfort	Simulation Method
(Sthapak & Bandyopadhyay, 2014)	Environmental & Socio-Cultural	Thermal Comfort	Literature study
(Soflaei et al., 2017)	Environmental	Dimension and proportion of opening, Natural and physical bodies courtyard Configuration Physical	Literature study Field Survey
(Zamani et al., 2018)	Environmental	Solar Gain, Humidity and Natural Ventilation	Literature study
(Markus, 2016b)	Environmental	Form, Wind Movement, Lighting	Literature study
(Gulati & Pandya, 2014)	Environmental	Ventilation, Air Movement, Mutual Shading	Field Survey Simulation Method
(Gupta, 1987)	Environmental	Air Temperature, Solar Exposure	Numerical Analysis
(Patherya M. et al, 2012)	Environmental	Height to Width Ratio	Comparative study.
Author	Attributes	Key parameters	Research method
(Taleghani & Tenpierik, 1986)	Environmental Aspect	Natural elements, courtyard configuration, openings (For various climates)	Literature study
(Nibedita Das, 2006)	Environmental and Functional	Temperature, Humidity, Light Intensity, Courtyard comfort, Form and function.	Field Survey Simulation Method

Table 2. Parameters of Typological Attributes

Author	Attributes	Key parameters	Research method
(Mohammed Al-Hussayen, 2015)	Typological	Courtyard Configuration, Built-up Area	Field Survey
(Ratti et al., 2003)	Typological	Daylight, Sky View Factor, Shadow Density, Surface to volume Ratio	Simulation Method
(Lall et al., 1991)	Typological	Urban Structure, Social Pattern Symbolic Language, Construction	Case Study
(Dutta & Bardhan, 2017)	Typological	Environment Quality Index	Literature study Numerical Analysis
(Al-Hafith et al., 2017b)	Typological	Urban Shading, Urban Compactness	Simulation Method
(Azad et al., 2018)	Typological	Spatial openness index, Wall perimeter Index	Numerical Analysis
(Qureshi et al., 2019)	Archetypal, Functional, Typological	Sense of Enclosure, Layout, Geometry, Orientation	Case Study
(Cremers et al., 2015)	Typological	Urban Compactness, Density	Numerical Analysis
(Lin et al, 2017)	Typological	Urban Form	Simulation Method
(Madangopal et al, 2015)	Typological	Building Byelaws	Case Study

6. Literature Review

The review of literature aims to understand the effectiveness of the courtyard in the build environments along with its function as a microclimatic modifier at the first level. Further, the study has been done to investigate another level which includes a typological impression of courtyard form and its relation with prevailing urban planning and buildings norms.

The detailed study of courtyard typology for the hot humid climate of Kolkata, reveal the social, cultural, climate, symbolic and religious benefits of the courtyard. The comparative case study approach adopted for this research clarifies that there are several benefits of incorporating courtyard design in residences especially nourishing the climatic and socio-cultural outlooks of the inhabitants [2]. In terms of religious, economic, climatic, and psychological relevance, the courtyard typology has been proven to be one of the best-suited plan forms in residential architecture for ages [10].

While discussing the environmental benefit, Zamani et al. concluded that shading is the most efficient cause of heat mitigation in courtyards. Hence, the courtyard's length-to-height ratio should be optimized to achieve heat mitigation [14]. The proportions and dimensions of the courtyard will significantly increase its capacity for improved environmental efficiency [15]. While considering major characteristics of the courtyard, which includes optimal size and shape and shading pattern. Courtyard proportion 1:1.3, 1:1.5, 1:1.7 has been well-thought-out as best suited proportion for hot and arid zones and most acceptable shape of a courtyard as a square or a rectangle with the maximum built-up area which is suitable for a courtyard house that is 500 sq.m [16]. It is rather obvious that the courtyard proportion plays pivoted role in designing the courtyard. Furthermore, Gulati et al. verify that effective shading of walls & fenestration has shown a reduction in heating & cooling loads by 30% and the presence of small courtyards has also indicated usefulness in all seasons. Verandas could act as facade shading devices & prevent thermal shock in extreme outdoor conditions [17].

Second, a courtyard with natural components like water and plants shows microclimatic properties, which ultimately reduces heat stress, within as well as outside the building. As a result, the courtyard, which incorporates optimized design components and natural elements, acts as a microclimatic modifier [14]. While examining the behavior of courtyard form in different climatic zones, it was observed that all climatic zones have nearly the same design criteria, but variables such as the suitable form, sizes, and proportions are highly dependent on the climatic context of each zone [15].

Al-Masri et al. discussed the environmental impacts of courtyard integration in midrise housing in the hot-arid climate of Dubai and observed that changing a six-floor

building from the conventional form to a courtyard form, considering the same parameters, resulted in a 6.9% reduction in the year-round total energy consumption [18].

Patherya M. et al. in their study proposes guideline about the optimum courtyard size concerning height to width ratio for the warm climate of India [19].

Several professionals are arguing that courtyard houses in low-rise low density or low-rise medium density are not appropriate in the present context to cater to the need of increasing population and limited land availability. In the past few decades, high-rise- high-density housing gain immense popularity due to the huge pressure of urbanization but simultaneously it caused many psychological issues, therefore some would like to prefer to live in low rise low density or low-rise medium density houses. The courtyard houses maybe still relevant in the present context also provide options to fulfill the diversified demands of people.

Being a traditional form, courtyard plan form is generally associated with social, cultural, or environmental benefits, however opting for a different approach of considering the typological behavior of courtyard, parameters such as urban compactness, Floor area ratio, ground coverage, residential density, land availability, building bye-laws, and urban planning norms are quite essential.

An interview approach with practitioners of architectural regionalism in India highlights how taking a regional approach to urban planning and building bye-laws result in a cohesive architectural fabric that promotes contextual harmony in our built environment. [20]. Cremers et al., in their study, claimed that the new interpretation of very compact courtyard buildings allows for significantly higher densities and more privacy compared to traditional typologies along with many more benefits such as a high level of design quality, low energy demand, very high interior comfort, and flexibility and also very high resource efficiency. Further, it is evident that density has an impact on environmental quality so identifying desirable density ranges for neighborhoods with different residential patterns will help to derive guidelines and suggest methods to achieve environmentally conducive patterns of residential development [21].

Lall, et al., proposed architectural solutions in their study, that are the density of 120 dwellings/Hectare and optimum size of the plot as 80 m sq. which aim at improving environmental potentials along with climatic comfort and energy efficiency for a housing project with the traditional courtyard plan form [22]. The courtyard pattern is always been encouraged for its efficiency to provide thermal comfort in hot and arid climate regions and function as a microclimate modifier in a diverse climate. Accordingly, whether courtyard buildings or contemporary building typology are to be used, dense urban form has always been appreciated to increase

mutual shading and achieve a thermally comfortable environment [23].

Ratti et al. demonstrated in their study that the courtyard configuration showed better response as compared to the pavilion types building in the specific context of hot-arid climates. The computer-aided simulation method was adopted considering the environmental variables like surface to volume ratio, sky view factor, daylight distribution, shadow density [26].

The floor area ratio / Floor space Index is also one of the significant tools for monitoring the typological pattern of any development. However, Floor area ratio (FAR) and Building coverage ratio (BCR) have serious limitations in determining the quality of open space and do not allow us to distinguish between different housing layouts [27]. In the view of the Indian context, it has been observed FSI (Floor Space Index) in cities are not based on densities or available land but either on-road widths, setbacks, or nature of the building activity. Based on the comparative study model, it is found that the FSI is independent of the land availability and density in India and there is no standard model for assigning FSI [28].

Azad et al., in their study, suggested an alternative approach of using new variables in urban design. Application of new indices such as SOI (Spatial Openness Index) and WPI (Wall perimeter index) can be an effective way to design housing environments with high environmental value [27].

Qureshi et al in their study employ the methodology of the "Deep Beauty Framework" on three levels: functional, typological, and archetypal. The comparative analysis between typical traditional courtyard house and a typical modern detached single-family house of Lahore offers innovative designs that are an amalgamation of the unique physical characteristics of the traditional house with the predisposition of the modern house, that is more responsive to the current need, and further, re-establish the coherence between the past and the present. With specific modifications in the bye-laws, the proposed design can be implemented in any typical housing development in Lahore. Author validate that traditional courtyard house offers effective strategies for contemporary designs and planning process [29].

Generally, in the case of courtyard buildings, wide-ranging investigations have been done to explore the social and cultural angle of this building form. While considering environmental effects, most researchers have addressed the energy performance of courtyard form in sufficient depth to achieve sustainable typology which lowers down the energy demand required for heating, cooling, ventilating, and lighting. The thermal performance of traditional building forms is well known but these buildings respond differently when laid in a cluster. therefore, efforts to transform the urban climatic knowledge into specific design guidelines become complicated [25]. Most of the cities in India have their specific guidelines and regulations starting from

large-scale measures such as zoning, infrastructure, urban landscape to small scale such as building form, setbacks materials, etc.

However, urban planning and design regulations rarely consider the parameters of urban microclimate. Lin et al. in their study identified vegetation and urban geometry as the most significant urban design aspects that affect outdoor microclimate [30].

Madan Gopal et al. found in their study that no specific typology is capable of providing a sustainable built form; therefore, a combination of typologies must be used to get the intended outcome, and building regulations must be flexible in this approach [31].

However, further research into the typological impact of courtyard plan type is required to better understand the relationship between density pattern and courtyard typology. Although there are various key parameters for courtyard houses, as available in existing literature, however, there is a significant variation in behavior between individual courtyard houses and cluster courtyard housing. As a result, a rubric may be created to comprehend the relationship between the attributes of courtyard dwellings as a single house or when arranged in a cluster.

Table 3. Parameters of Courtyard Typology

Attributes	Individual Courtyard House	Courtyard House in a cluster
Environmental	Day Light, Thermal Comfort	Surface To volume Ratio, Sky View Factor, Shadow Pattern
Social	Daily Activities, Privacy, and security Cultural Implication	Walkability, Urban Compactness, Community Green Spaces
Typological	Location, Size, Proportion, Inter-connection of spaces.	F.A.R (Floor Area ratio), density, Built to open ratio. Environmental Quality Index

7. Challenges in Adopting Courtyard Typology in India

Traditional courtyard houses in India are the native types of houses. These typologies of houses have been developed through the time-tested method and reached widespread acceptance. Courtyard houses fulfill the needs of their inhabitants in a variety of ways whether it is functional, socio-cultural, religious, environmental, or economic. The changing needs, requirements, and urban lifestyle lead to a residential typology that is mostly irrelevant to our context and climate. In the global scenario, rapid urbanization results in the merging of rural areas into nearby towns and urban centers. The major impact of this process is the change in the housing typologies of the area which ultimately affected the

physiological health of the user. Unfortunately, traditional courtyard houses have lost their importance and existence in the past few decades in India and there could be many reasons for it. The changing structure of families, give the utmost importance to privacy, without giving thought to the integration of space. Elements like blind facades, introvert planning, and unconditioned spaces are rejected by people. The family lounge becomes new normal in place of the courtyard due to changes in the behavioral and lifestyle pattern. Due to the trend to achieve high density, maximum ground coverage, and F.A.R., apartment housing emerges as a viable alternative for low-rise development. Furthermore, the compulsion of providing front and rear setbacks as per building bye-laws for small and medium-sized plots has narrowed down the courtyard choices. The improved luxurious experience such as air-conditioning further questions the existence of open spaces like a courtyard in houses. It became apparent that traditional along with the contemporary courtyard design should be studied on various parameters to determine the most suitable courtyard design for urban settlements and quantify possible design solutions in various regional contexts.

Traditional dwellings and typologies are the true expressions of their occupants and possess high longevity and durability. Home is the first unit through which a human being communicates with the built form in his routine life. Hence, the planning of a dwelling in such a way that it straightaway satisfies all the requirements of the user in terms of its spatial arrangements. Traditional dwellings suggest a path for a cohesive built environment, as every space has been meticulously planned. These buildings have become a bridge between the user and the society since they were closely knitted with the culture. The courtyard is one of the prominent features of the traditional house that had contributed to sustainability.

India claims rich architectural traditions which have evolved over centuries in response to its climate, culture, and resources. As India experiences a predominantly hot climate in the majority of its geographical area, therefore major concern is to create spaces with mutual shading and thermal comfort, as a result, habitable rooms in India have customarily been organized around courtyards and verandas which act as microclimate modifiers [20]. The central courtyard, which is at the core of most built forms, serves as an outdoor living area while also providing light and ventilation to the surrounding rooms. Thus, lessons learned from Indian traditional architecture could be used to provide better answers to present-day concerns.

Research on courtyard houses in traditional societies has proved to be contextual because these houses responded to the cultural and climatic needs of people very well. Growing population and rapid Urbanization have put forth a lot of pressure on land resources in urban areas, further complicating the issue some other factors like stringent Byelaws, Floor area Ratio calculation, and huge

investment, unresponsive behavior leads to the disappearance of the open spaces or courtyards.

The actual essence of courtyards is somehow losing its identity due to the current designing and construction practices. Therefore, this study tries to understand the implication of courtyard form in the contemporary era. Contemporary architecture has to necessarily “be regional and contextual” to avoid becoming a “global architecture.” [34].

Modern architects and designers who advocate traditional architecture are often in a misperception to choose from two competing types of housing - courtyard housing and detached housing. The limited understanding of 'function' offered by modernist architecture seemed insufficient to certain architects who make serious efforts to fulfill the social and cultural aspirations of their Indian clientele [20].

Courtyards are perhaps the best introvert spaces in traditional housing that meet the inhabitant's needs of privacy, serenity, and security. Architects and designers should examine traditional elements of housing and use these ideas to form new designs that are relevant to the present and future. Along with architects' users also need to understand the substantial resource and potential that courtyard housing will offer for improving the appearance of the environment and enhancing the desirability of home living.

The suggestive measures could be taken by professional organizations, municipalities, and town planning offices to create awareness among developers and residents about the incorporation of holistic and transitional space in their housing schemes. New design possibilities within the framework of building regulations could be explained to them employing illustrative prototype courtyard house designs [22].

Finally, it may be asserted that concerted effort is needed on the part of architects, designers, and others concerned in recognizing and appreciating the significance of courtyard housing to create interest in this type of housing.

8. Conclusions

This paper analyses the various research effort that has been made to contribute to establishing the fact that courtyard is multidimensional space for residences. Further, the study highlights that the thermal behavior of the courtyard depends on various parameters such as thermal massing, material, shading, water elements, etc. but still courtyard typology provides an integrated solution to the climatic concerns of chaotic built form in the contemporary context. It is also noteworthy that the size of the courtyard has a significant impact on the performance and applicability of courtyard design which ultimately depends on the land parcels available in new

development. Courtyard typology has the potential to justify the cultural and anthropological needs of the occupant. The study also emphasized the need to shift the paradigm from architectural climatology to urban climatology. The study also provides future direction for the research work as a very limited background study is available to establish a direct relationship between courtyard typology and building bye-laws.

REFERENCES

- [1] M. Taleghani and M. Tenpierik, "Environmental Impact of Courtyards — a Review and Comparison of Residential," *J. Green Build.*, vol. 7, no. 2, pp. 113–136, 1986.
- [2] Nibedita Das, "Courtyards Houses of Kolkata : Bioclimatic, Typological and Socio-Cultural Study by Nibedita Das Submitted in partial fulfillment of the requirements for the degree Department of Architecture," 2006.
- [3] T. Tabesh and B. Sertyesilisik, "An Investigation on Energy Efficient Courtyard Design Criteria," 2015, doi: 10.15242/iicbe.c0615072.
- [4] D. Zhang, "Courtyard Houses around the World: A Cross-Cultural Analysis and Contemporary Relevance," *New Approaches Contemp. Archit. Urban.*, no. May, pp. 23–44, 2020, doi: 10.38027/n3iccaua316235.
- [5] N. YU, "the Human the Human," p. 2002, 2002.
- [6] Norbert Schoenauer & Stanley Seeman, *The court-garden house*. McGill University Press, Montreal, 1962.
- [7] S. Elmansuri, "Courtyard Housing in Tripoli: Tradition, Modernity and Users' Perceptions," 2018.
- [8] M.-S. Lee and Y. Park, "The Courtyard as a Microcosm of Everyday Life and Social Interaction," *Archit. Res.*, vol. 17, no. 2, pp. 65–74, 2015, doi: 10.5659/aikar.2015.17.2.65.
- [9] A. Tablada, B. Blocken, J. Carmeliet, F. De Troyer, and H. Verschure, "The influence of courtyard geometry on natural ventilation and thermal comfort: CFD and thermal comfort simulations," *22nd Int. Conf. PLEA 2005 Passiv. Low Energy Archit. - Environ. Sustain. Chall. Aware. Dev. Soc. Proc.*, vol. 1, no. January, pp. 75–80, 2005.
- [10] S. Sthapak and A. Bandyopadhyay, "Courtyard houses: An overview," *Recent Res. Sci. Technol.*, vol. 6, no. 1, pp. 70–73, 2014.
- [11] F. Soflaei, M. Shokouhian, and A. Soflaei, "Traditional courtyard houses as a model for sustainable design: A case study on BWHS mesoclimate of Iran," *Front. Archit. Res.*, vol. 6, no. 3, pp. 329–345, Sep. 2017, doi: 10.1016/j.foar.2017.04.004.
- [12] S. S. Y. Lau and F. Yang, "Introducing healing gardens into a Compact University Campus: Design natural space to create healthy and sustainable campuses," *Landsc. Res.*, vol. 34, no. 1, pp. 55–81, 2009, doi: 10.1080/01426390801981720.
- [13] J. J. F. Forés, "Courtyard housing: Environmental Approach in Architectural Education," *Conf. Technol. Sustain. Built Environ.*, pp. 839–856, 2006.
- [14] Z. Zamani, S. Heidari, and P. Hanachi, "Reviewing the thermal and microclimatic function of courtyards," *Renew. Sustain. Energy Rev.*, vol. 93, no. March 2017, pp. 580–595, 2018, doi: 10.1016/j.rser.2018.05.055.
- [15] B. Markus, "A review on courtyard design criteria in different climatic zones," *African Res. Rev.*, vol. 10, no. 5, p. 181, 2016, doi: 10.4314/afrrrev.v10i5.13.
- [16] Mohammed Al-Hussayen, "Significant characteristics and design considerations of the courtyard house," *J. Archit. Plan. Res.*, vol. 12, no. 3, pp. 240–258, 2015.
- [17] R. Gulati and Y. Pandya, "Comparative Thermal Performance of Vernacular Houses at Lucknow: A Quantitative Assessment and Dominant Multiple Strategies," *30th Int. PLEA Conf.*, no. December, pp. 1–8, 2014.
- [18] N. Al-Masri and B. Abu-Hijleh, "Courtyard housing in midrise buildings: An environmental assessment in hot-arid climate," *Renew. Sustain. Energy Rev.*, vol. 16, no. 4, pp. 1892–1898, 2012, doi: 10.1016/j.rser.2012.01.008.
- [19] M. Patherya and B. Lau, "Assessment of the behavior of 'courtyards' as a design element in India and its implication as an environmental solution," *Proc. - 28th Int. PLEA Conf. Sustain. Archit. + Urban Des. Oppor. Limits Needs - Toward an Environ. Responsible Archit. PLEA 2012*, no. November 2012.
- [20] S. Bahga and G. Raheja, "An account of critical regionalism in diverse building types in postcolonial Indian architecture," *Front. Archit. Res.*, vol. 7, no. 4, pp. 473–496, 2018, doi: 10.1016/j.foar.2018.09.001.
- [21] S. Dutta and S. Bardhan, "Density and Neighbourhood Environmental Quality – A Comparative Study in the context of Indian Cities," *Int. J. Emerg. Technol.*, vol. 8, no. 1, pp. 315–323, 2017.
- [22] A. B. Lall, M. Pandit, and P. Appasamy, "Climate and Housing Form : a Case Study of New Delhi," *Energy Build.*, vol. 16, pp. 837–849, 1990.
- [23] O. Al-Hafith, B. K. Satish, S. Bradbury, and P. De Wilde, "The impact of courtyard compact urban fabric on its shading: Case study of Mosul city, Iraq," *Energy Procedia*, vol. 122, pp. 889–894, 2017, doi: 10.1016/j.egypro.2017.07.382.
- [24] B. Markus, "Review of Courtyard House in Nigeria: definitions, history, evolution, typology, and functions," *AFRREV STECH An Int. J. Sci. Technol.*, vol. 5, no. 2, p. 103, 2016, doi: 10.4314/stech.v5i2.8.
- [25] V. Gupta, "Thermal Efficiency of Building Clusters: an Index for Non Air-Conditioned Buildings in Hot Climates," *Energy Urban Built Form*, no. 1974, pp. 133–145, 1987, doi: 10.1016/b978-0-408-00891-4.50012-9.
- [26] C. Ratti, D. Raydan, and K. Steemers, "Building form and environmental performance: Archetypes, analysis, and an arid climate," *Energy Build.*, vol. 35, no. 1, pp. 49–59, 2003, doi: 10.1016/S0378-7788(02)00079-8.
- [27] S. P. Azad, R. Morinaga, and H. Kobayashi, "Effect of housing layout and open space morphology on residential environments –applying new density indices for evaluation of residential areas case study: Tehran, Iran," *J. Asian*

- Archit. Build. Eng.*, vol. 17, no. 1, pp. 79–86, 2018, doi: 10.3130/jaabe.17.79.
- [28] G. Karteek, “Is FSI Dependent on Land Availability and Densities? A Comparative Review of FSI in Indian Cities,” *Eur. J. Sustain. Dev.*, vol. 4, no. 2, pp. 27–34, 2015, doi: 10.14207/ejsd.2015.v4n2p27.
- [29] R. A. Qureshi, M. Akhtar, and S. J. Shah, “Deep Beauty in Architecture: Comparative Analysis of the Traditional-Courtyard and the Contemporary Residences of Lahore,” vol. 25, pp. 64–79, 2019.
- [30] P. Lin, Z. Gou, S. S. Y. Lau, and H. Qin, “The impact of urban design descriptors on outdoor thermal environment: A literature review,” *Energies*, vol. 10, no. 12, pp. 1–19, +2017, doi: 10.3390/en10122151.
- [31] A. S. Madangopal, “The Role of Building Byelaws in Shaping the Sustainable Built Environment - Comparative Analysis Between Portland Building Byelaws with Bangalore Building Byelaws,” 2015.
- [32] A. B. Lall, M. Pandit, N. Kulshreshta, and P. Appasamy, “Climate and housing form - a case study of New Delhi,” *Energy Build.*, vol. 16, no. 3–4, pp. 837–849, 1991, doi: 10.1016/0378-7788(91)90079-i.
- [33] O. Al-Hafith, B. K. Satish, S. Bradbury, and P. De Wilde, “The impact of courtyard compact urban fabric on its shading: Case study of Mosul city, Iraq,” *Energy Procedia*, vol. 122, pp. 889–894, 2017, doi: 10.1016/j.egypro.2017.07.382.
- [34] S. Bahga and G. Raheja, “Complexities of practicing architectural regionalism in India: An interview study,” *Front. Archit. Res.*, vol. 9, no. 3, pp. 568–578, 2020, doi: 10.1016/j.foar.2020.03.003.