International Journal of African Society Cultures and Traditions

Vol.4, No.4, pp.1-12, October 2016

Published by European Centre for Research Training and Development UK (www.eajournals.org)

EVALUATION OF COURTYARD USAGE AND ITS DESIGN REQUIREMENTS IN RESIDENTIAL BUILDINGS IN NIGERIAN HOT-DRY CLIMATE

Markus Bulus

Department of Architecture, Faculty of Built Environment, Universiti Teknologi Malaysia

ABSTRACT: *The courtyard is an element that is mostly used in buildings in all the climatic regions due to its passive tendencies for low energy consumption. But studies on evaluating its usage and design requirements in Nigerian hot-dry climates are very few. It is on this note that this study evaluates courtyards usage in residential buildings in Gusau metropolis. A specification list was developed for the survey of Fifty two (52) courtyards in fifty two residential buildings. Courtyard design requirements such as; configuration, orientation of courtyard, aspect ratio, vegetation, water pond and shading device were documented. The study shows that the courtyards were not innovatively designed to maximise their passive potentials for improved eco-friendly performance. The study concluded by recommending future studies on courtyard functions and its design variants in building typologies in Nigerian hot-dry climate and this study has provided a starting point to support further investigations in this regard.*

KEYWORDS: Courtyard usage, Design requirements, Residential buildings, Climate

INTRODUCTION

Among the architectural design component, the courtyard seems to have drawn the attention of scholars in recent times due to its numerous benefits. According to Edwards *et al.* (2006), courtyard as a building component was initiated originally from the hot and dry climatic regions of the world. Thus, its application is most suitable in the tropics, even though it is applicable to all climatic regions. Abass et al. (2016) defined courtyard as a covered outside space but open to the element at its apex. Mishra & Ramgopal (2013) also defined a courtyard as an open room into the heavens, a square or rectangular in sketch and bordered by a group of buildings or most important rooms. The definitions can go on and on. But the appropriate courtyard form supposed to vary from one climatic region to the other, even its location for instance, having a courtyard at the middle of the architectural design may not do better in all climatic situations (Ghaffarianhoseini et al., 2015). Thus, adopting the courtyard form from the western states into the tropical region; the hot-dry climatic region, rather than the original indigenous concept which is adaptable to the cultural, climatic and religious requirement of the people may be a mere deception. More so, many primordial courtyards in the Arab nations have elucidated a clear picture of a courtyard designed based on the social, cultural and climatic requirements. The categories of the design requirements for instance; area, height, orientation, exposure to the sky, nature of the wall components and many more were evolved to realise effective courtyard that respond to the human requirement for comfort in buildings (Berkovic et al., 2012).

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

In architectural design and practice, the courtyard is mostly used in buildings in all the climatic regions due to its passive tendencies for low energy consumption in buildings. Its benefits cut across; social, cultural, religious, environmental and even therapeutic. But studies on evaluating its usage and design requirements in the hot-dry climates are very few. It is on this regard that this study attempt to evaluate courtyards usage in residential buildings in Gusau metropolis, a hot-dry climatic region in Nigeria. Fifty two (52) courtyards in fifty two residential buildings were surveyed. In addition, courtyard design requirements such as; form, orientation of courtyard, aspect ratio, vegetation, water pond and shading devices in the courtyard were documented.

LITERATURE REVIEW

Courtyard Usage

In architectural design, the courtyard as an element that has been put into practice for many years particularly in housing design. Its application is justified due to its numerous benefits. In recent times, scholars have opined the benefits of courtyard in order to explain its relevance in a building. These benefits include: architectural benefits; social benefits, climatic benefits; cultural benefits; economic benefits; and the religious benefits (Almhafdy et al., 2013a). Courtyards are frequently used as meeting area for specific functions such as: gardening, cooking, working, playing, sleeping, or even as places to keep animals (Edwards et al., 2006). The courtyard suitability for diverse functions may not be far from its location in the house layout (which varies from one group of culture to another). According to Antonio & Carvalho (2015), the importance of such a space was by their being located in central sites within the urban fabric or building surrounded by arcades and colonnades, paved, landscaped with water bodies, various plants, shade and light, they all played an important role in our social and working life. In terms of its contribution to good health, Antonio & Carvalho (2015) continue that the courtyard can be used as a space that stimulates the healing process due to its natural healing environment. Courtyard also contribute in a major way by modifying the climatic setting and thereby inducing mental and physiological sensation of its end users.

Courtyard configuration

The rectangular and square forms are the most commonly adopted for courtyard in buildings even though, there is no any particular form that is considered as the most suitable (Almhafdy et al., 2013b). In residential design, courtyard are in rectangular or square form, but circular, curvilinear and other forms may evolved. The courtyard form can be adapted by using the numerous eco-friendly factors such as: scenery, site limitations, building orientation etc, to generate new shapes, for instance; U, L, T or Y (Das, 2006; Reynolds, 2002). Also, the courtyard form can be fully enclosed, semi-enclosed or in some cases even two sided (Berkovic et al., 2012). Again, the application of these forms is not limited to residential buildings alone but even in non-residential and multi-storey buildings.

Scholars have conducted studies on courtyard design concepts explaining how the form can be manipulated to act as a microclimate modifier to the built environment. For instance, courtyard form was found to be a key design requirement in a study on

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

"the archetypal rectangular courtyard form and its impact on the eco-friendly performance in the tropical region" by (Aldawoud, 2008). Tablada et al. (2005) studied and suggested that the courtyard form and its entire envelope needed to be protected against extreme solar radiant heat and the penetration of dusty air as well as air movement which has a severe impact on thermal stress. Also, Ganem et al. (2014) conducted a study on "the effect of three sided courtyard on the microclimate behaviour in a building". The result revealed that, the courtyard generates improved microclimatic condition; mostly when the design requirements for instance; orientation, depth of courtyard and ventilation strategies are not ignored. Again, Muhaisen (2006) research on 'The Effect of a Rectangular Courtyard Proportions at Four Different Climatic Locations' using the simulation method, the impact of courtyard form and orientation on shading effect was investigated. The appropriate courtyard elevation to obtain a good shading effect in summertime and wintertime was discovered to be at least nine (9) metres in hot-humid region, six (6) meters in hot-dry region and three (3) metres in cold and temperate region. This suggest that higher elevations should be use for courtyards in warmer climatic regions while low elevation should be applicable for courtyards in cooler climatic region. Furthermore, Huang et al. (2014) revealed that the deeper form generates more shadow within the courtyard in summertime whereas narrow courtyard form behave well in wintertime. They suggested an annual calculating ratio. But, for the daylight, this recommendation is not applicable. The courtyard potential to act as a passive cooling element can be compare with a building composition in terms of airflow rate and pattern.

Orientation

Courtyard orientation is also another design variant that seems to record very few literatures. However, scholars that have contributed in this regard include Antonio & Carvalho (2015), he studied the impact of courtyard orientation on its environmental performance by using both experimental and simulation methods. He discovered that increased height of courtyard walls will cause reduction in the degree of air temperature in the courtyard as well as the rooms in nearby location to the courtyard. On orientation, the study reveals less significance on air temperature, but affects ventilation significantly as the enclose walls tend to block air free passage. Berkovic et al., (2012), continued that elongated east-west rectangular courtyard has the smallest portion of shade and consequently, not recommended for effective shading strategy for cooling. Almhafdy et al. (2013a), asserted that there is no evident record on verification of the most suitable courtyard orientation for its optimum environmental performance, although, there is a general believe that courtyard orientation with the elongated side facing the north to south direction is the best option. According to Meir, et al. (1995), accurate orientation of courtyard can increase their thermal condition but, orienting it irrespective of solar angles and wind course may create thermal distress. But the setting of a building is considered in most cases by the orientation. The factors with direct impact on courtyard microclimatic behaviour include; location of the sun, direction of wind, shading effect and radiant heat (Bagneid, 2006). All these factors are key to Courtyard orientation.

Wall Enclosure

Courtyards enclosing walls varied from one region to the other. The variation are cause by the social, cultural, economic and eco-friendly conditions. Even though the

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

design remains analogous, the requirements of the design are determined by usage and location (Meir, 2000). Wall enclosure can be define as the summation of the courtyard components within the building. These components include; walls, doors and windows. They play a significant role in the microclimate performance of the courtyard through natural ventilation strategies. They can also be influenced by opening or closing of the openings and by altering the wall to window ratio. According to Al-hemiddi & Al-saud (2001), insignificant cooling is observed when all windows are closed. But, opened windows and doors improve natural ventilation in courtyard. Other scholars such as; Muhaisen, A. 2006 and Bagnied, A. 2006 has agreed that other factors to be look into when optimizing courtyard are the choice of the component material, colour and specifications.

Natural elements within courtyard

Application of natural elements such as: vegetation and water pond in a courtyard would impact eco-friendly conditions. Muhaisen (2006), reveals that vegetation in a courtyard can meaningfully impact the thermal performance of a courtyard as they provide shade and increase humidity level in hot-dry regions. Al-Hemiddi & Megren (2001) revealed in a study on the impact of applying a water pond in a courtyard that the interior courtyard with a pool during sunny hours delivered substantial cooling impact within the internal courtyard envelope.

The Study Area

According to Ajibola (2001), and Ogunsote (1992), the climatic classification of Nigerian climate include: the hot-dry, hot-humid, temperate dry and temperate humid. The hot-dry climatic zone of Nigeria include the core northern part of the country, ranging from latitude 11ºN to 14^0N of the equator and longitude 3º'E to 15^0E of the GMT as shown in fig.1. This climatic zone include the following cities: Maiduguri, Potiskom, Gombe, Bauchi, Kasitna, Kaduna, Gusau, Sokoto, Birnin Kebbi, Dutse, Kano, and Minna. Guasau being the study area has a climate characterized with average high temperatures in the months of Febuary, March, April and May as 35^oC, 37^oC38^oC and 37^oC respectively; low precipitation with 252mm in the month of August (being the highest), and low humidity in the dry season (Climate Gusau 2016).

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

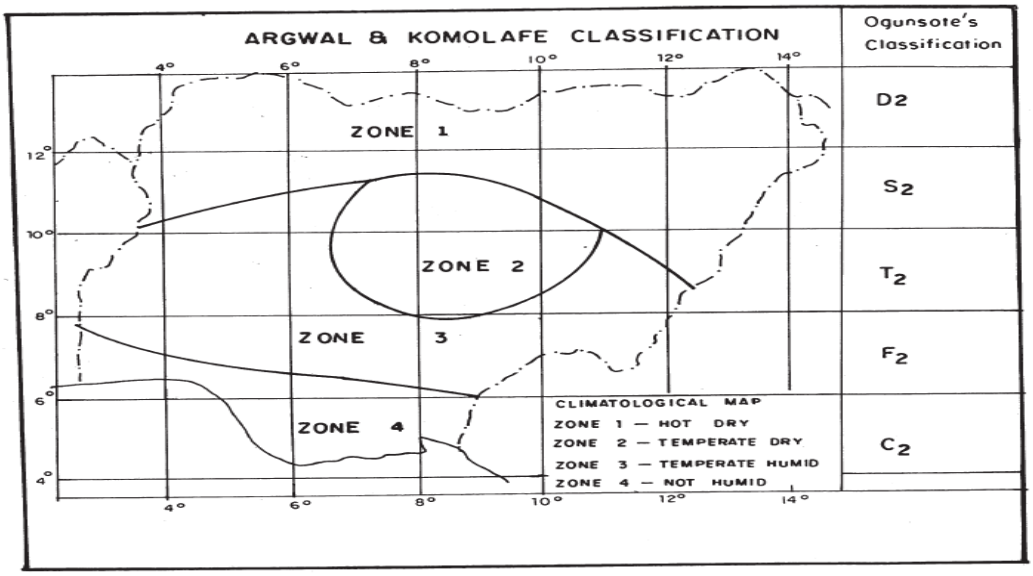

Fig. 1. Classification of the Nigerian climate. **Source:** Proceedings of the International Conference on Low Cost Housing for Developing Countries (1984)

METHODOLOGY

A comprehensive specification list was developed for the survey. The specification list was used to analyse all the fifty (52) residential courtyard buildings surveyed.

The Specification List

Table 1 illustrate the specification list that was applied for the site record survey. The list were derived according to the study background as presented in the literature review of this study. Furthermore, roof shading device was added to the specification list.

				YES	**NO**
FORM	Square				
	Rectangular				
	Triangular				
	Others				
SHAPE	Fully enclose		**O**-Shape		
	Semi enclose	3 Sided enclose	**U**-Shape		
		2 Sided enclose	**L**-Shape		
		Others	**I**-Shape		
AREA	……..m^2				
HEIGHT	……..mm				
ORIENTATION	N/S				
	E/W				
	NE/SW				
	NW/SE				
SHADING	Canti-roof				

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

DEVICES	Overhangs		
VEGETATION			
WATER BODY			
USAGE	Cooking		
	Playing		
	Working		
	Sleeping		
	Keeping animals		
	Privacy		

Table 1. Specification List of Courtyard Design Variants

Sites Visit and Observation

The surveyed courtyard houses were acknowledged due to several consultations with indigenous estate housing agents resident in Gusau-Zamfara State of Nigeria. A total of 52 courtyards in 52 residential buildings were surveyed. The specification list was used for data collection as mentioned. The whole exercise lasted for six weeks due to some religious and security challenges. A comprehensive observation was carried out for each of the courtyard. The observation was based on people activity inside the courtyards and the nature of the courtyard design conditions.

FINDING

The survey documented true-life data such as; the courtyard usage, form and shape, aspect ratio (area and height), orientation, vegetation, water body and roof/shading devices inside the courtyard. It was revealed that Gusau people are familiar with courtyard.

Courtyard Usage

This study revealed that, the courtyard has different usage in residential buildings. In Gusau Metropolis -Nigeria, the courtyard has six (6) key function. As shown in figure 2, its utility include: as a playing ground, cooking area, domestic working, night sleeping, keeping of animals and privacy. Out of the fifty two (52) surveyed courtyard, fourty nine (49) are used for night sleeping, fourty eight (48) for children playing, fourty two (42) for privacy, thirty eight (38) for cooking purposes, sixteen (16) for domestic works, and five (5) for animals housing.

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

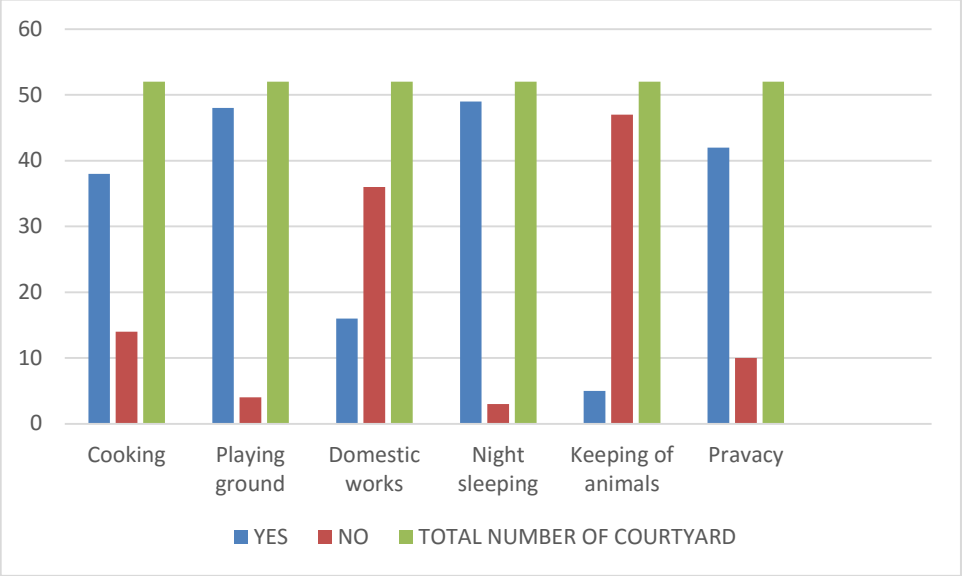

Figure 2. Courtyards Usage in Residential Buildings

Courtyard configuration in Gusau Residential Buildings

As illustrated in fig.3&4, courtyard configurations are categorised as fully enclosed, and semi-enclosed. Among the surveyed courtyards, fourty nine (49) are fully enclosed and belongs to individual residence while only three (3) are semi-enclosed large tenants residential compounds.

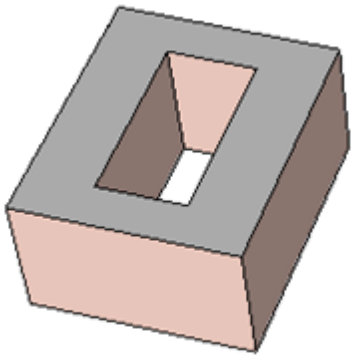

Fig.3: Showing a fully enclosed courtyard

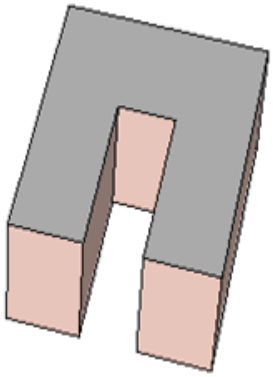

Fig.4: Showing a semi-enclosed courtyard

Form and Aspect ratio

The study shows that they courtyard are in square, rectangle, U-shape and L-shape forms. Figure 5 revealed that out of the 52 surveyed courtyards, 38 are in a rectangular form, 12 are square, 2 are U-shape and 1 is L-shape respectively. The Most popular form is the rectangular, follow by the square, U. and L-shape respectively.

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

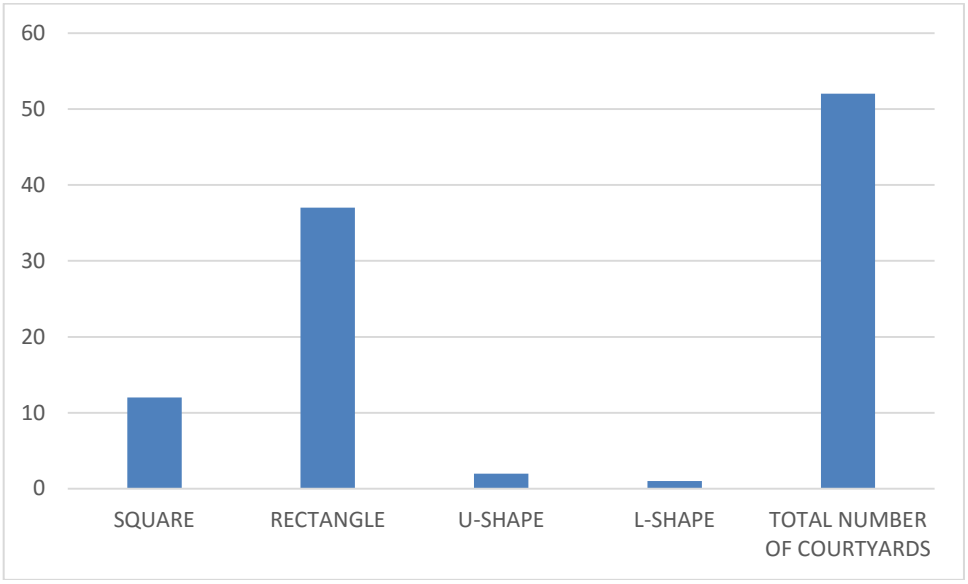

Figure 5: Showing Courtyard Form

Total area of the surveyed courtyards ranges between 18 and 30m^2. Figure 6 illustrates the distribution of the sizes. The width, length and height are used to describe the courtyard aspect ratio.

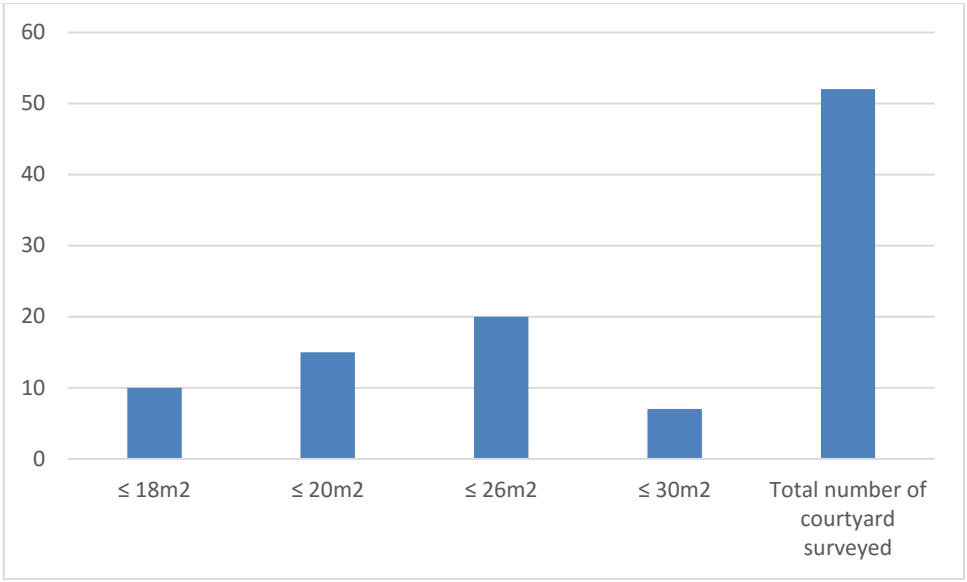

Fig. 6. Courtyard Sizes and Areas

As illustrated in Figure 7, thirty two courtyards has the lowest height of 2,400mm, follow by twelve (12) courtyards with 3,000mm height, then six (6) courtyards with 4,100mm, and four courtyards with the highest height of 6,200mm.

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

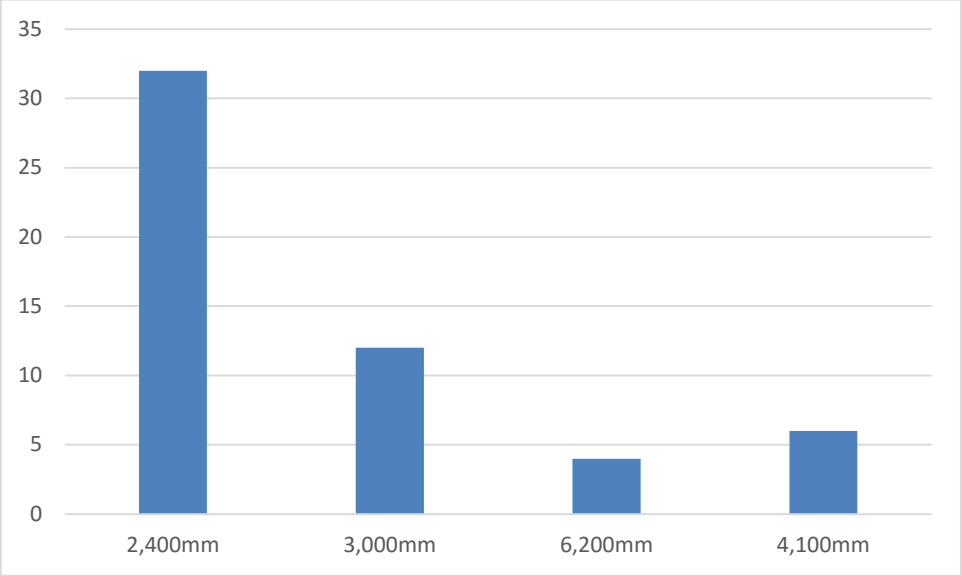

Figure 7: Showing Courtyards Height

Orientation

In figure 8, the study revealed that thirty two (32) courtyards are elongated in the East-West orientation, fourteen (14) in the North-South direction, seven (7) in the South-West and four (4) in the North-East direction respectively.

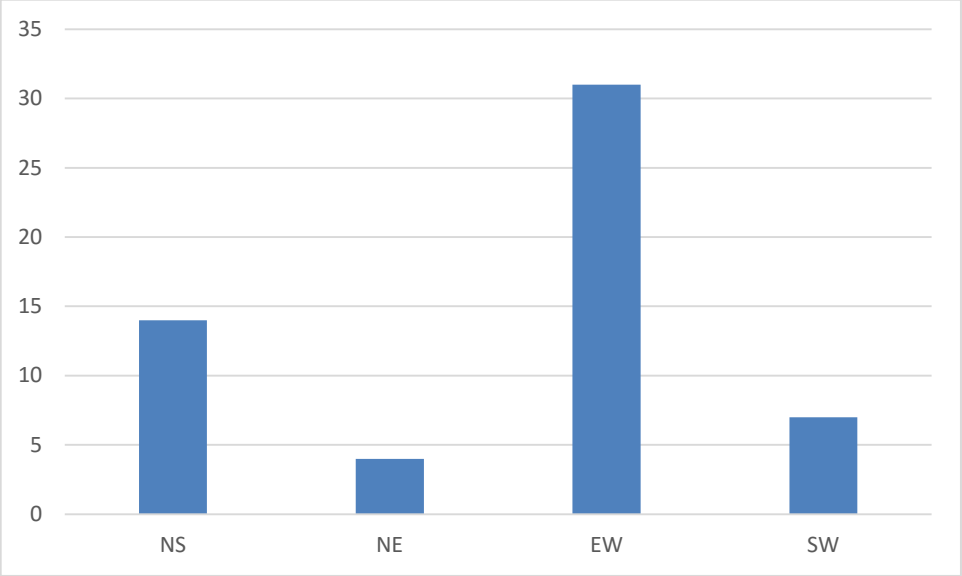

Figure 8: Showing Orientation of Courtyards in Gusau Residential Buildings

Shading Devices, Vegetation and Water Body

Figure 9 reveals only sixteen (16) courtyards had vegetation and only six (6) courtyards had shading devices made of overhangs. Finally, only one courtyard has a water pond. But water pond can improve courtyard humidity level and thereby influencing positively the hot-dry atmospheric conditions.

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

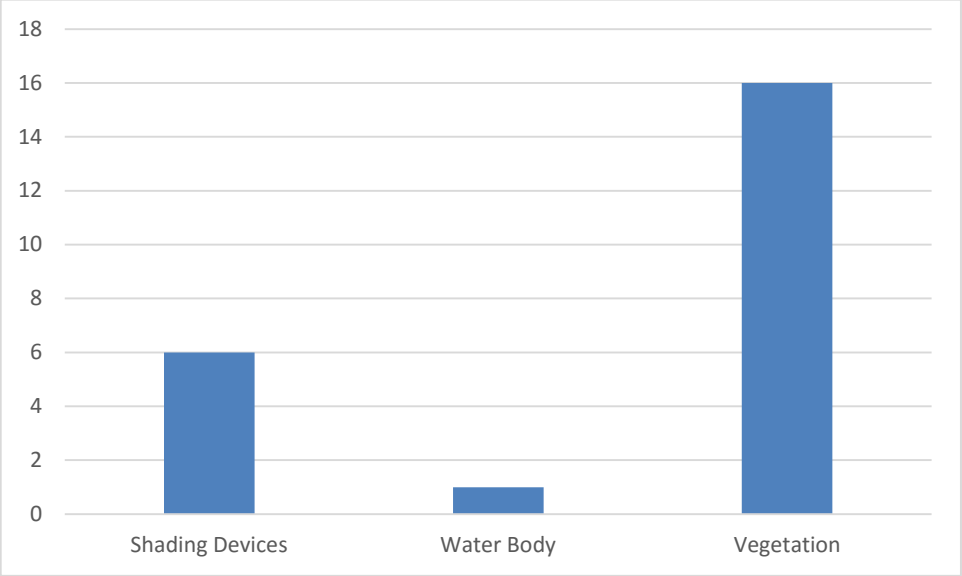

Figure 9: Showing Shading devices, Water Body and Vegetation

DISCUSSION

It is quite obvious from the literatures that experiential based studies on the nature of courtyard used in residential buildings in Nigerian context are very few. This is true as the concept of courtyard in buildings is the least understood area of enquiry (Almhafdy et al. (2013a). According to the revelation of this study, courtyards usage in residential buildings include: playing area for children, area for cooking, working, keeping of animals, and privacy, and these has concord to what the literatures had opined (Almhafdy et al. 2013b; Edward et al., 2006). The implications of the findings on courtyard usage is that the courtyards are truely multi-functional. On its configuration, this study has discovered that the application of courtyard is in its primordial stage as compare to other Asian countries, for instance Iran, where the courtyard has been designed and configured to act as a microclimate modifier (Farzaneh et al. 20016). The Most popular form is the rectangular, follow by the square, U. and L-shape respectively. This revelation has agree with Almhafdy et al. (2013b) assertion that rectangular and square courtyard form are the most used in residentials buildings.

Courtyard orientation is another vital design requirement. Although past studies have not proved the best orientation, the common assumption is that courtyard orientation with its longest axis facing north-south will improve thermal performance (Almhafdy et al. 2013a). It is obvious that about eighty four (84%) percent of the courtyards has small portions under shade, as these courtyard are oriented on the East-West direction and are rectangular in form configuration as illustrated in figure 5.
Figure 9 reveals only sixteen (16) courtyards had vegetation. This connote only 30% of the surveyed courtyard, and application of vegetation in courtyard has been shown as effective in courtyard thermal performance (Edward et al. 2006). The figure also reveals only six (6) courtyards had shading devices made of overhangs. It means that only 12% of the surveyed courtyard had shading devices, and these devices have been recommended as passive design strategies (Akande 2010). Finally, only one courtyard

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

has a water pond, and according to Muhaisen (2006), water pond can improve courtyard humidity level and thereby influencing positively the hot-dry atmospheric conditions.

IMPLICATIONS TO RESEARCH AND PRACTICE

The implication of this study is quiet relevant to both architectural theory or research and practice. It has revealed the architects approach to courtyard design and the need for a greater design awareness by researchers in this endeavour is necessary. The architects in practice and in the academics have to collaborate in terms of implementation of research findings.

CONCLUSION

This study reveals a research effort that adds in the direction of understanding the characteristics of courtyards in Guasu-Nigeria. The findings reveals that courtyards are common architectural elements used in residential buildings in Gusau. They are categorised into fully enclosed, and semi-enclosed configurations. The most ordinary courtyard form is the rectangular courtyard. Courtyard sizes are between $18m^2$ and $30m^2$. About 84% of the courtyards has small portions under shade, as these courtyard are oriented on the East-West direction. It is revealed that only few courtyards has shading devices, water body and vegetation. Night sleeping and playing was the most popular usage of courtyards. In conclusion, more studies on Nigerian courtyard building typologies in terms of its functions and design variants is required so as to have a holistic appraisal, and this study has provided a background to support further investigations in this regard.

FUTURE RESEARCH

future studies on courtyard functions and its design variants in building typologies in Nigerian hot-dry climate is required and this study has provided a starting point to support further investigations in this regard.

REFERENCES

Abass, F., Ismail, L. H., & Solla, M. (2016). A Review Of Courtyard House : History Evolution Forms , And Functions, *11*(4), 2557–2563.

Ajibola, K. (2001). Design for comfort in Nigeria — a bioclimatic approach, *23*, 57–76.

Aldawoud, A. (2008). Thermal performance of courtyard buildings, *40*, 906–910. http://doi.org/10.1016/j.enbuild.2007.07.007

Al-hemiddi, N. A., & Al-saud, K. A. M. (2001). The effect of a ventilated interior courtyard on the thermal performance of a house in a hot – arid region, *24*, 581–595.

Almhafdy, A., Ibrahim, N., Ahmad, S. S., & Yahya, J. (2013a). Analysis of the Courtyard Functions and its Design Variants in the Malaysian Hospitals. *Procedia - Social and Behavioral Sciences*, *105*, 171–182. http://doi.org/10.1016/j.sbspro.2013.11.018

ISSN 2056-5771(Print), ISSN 2056-578X(Online)

Almhafdy, A., Ibrahim, N., Ahmad, S. S., & Yahya, J. (2013b). Courtyard Design Variants and Microclimate Performance. *Procedia - Social and Behavioral Sciences*, *101*, 170–180. http://doi.org/10.1016/j.sbspro.2013.07.190

Antonio, R., & Carvalho, D. De. (2015). *Courtyard Housing As a Subtropical Urban Design Model*. Queensland University of Technology.

Berkovic, S., Yezioro, A., & Bitan, A. (2012). Study of thermal comfort in courtyards in a hot arid climate. *Solar Energy*, *86*(5), 1173–1186. http://doi.org/10.1016/j.solener.2012.01.010

Bagneid, A. M. R. (2006). The Creation Of A Courtyard Microclimate Thermal Model For The Analysis Of Courtyard Houses, (August)

Das, N. (2006). *Courtyards Houses of Kolkata: Bioclimatic, Typological and Socio-Cultural*
study. (Master of Architecture Msc.), Kansas State University.

Edwards, B., Sibley, M., Hakmi, M., & Land, p. (2006). *Courtyard housing: past, present and future*: Spon Press.

Ganem, C., Barea, G., & Llano, J. F. (2014). Courtyards as a passive strategy in semi dry areas. Assessment of summer energy and thermal conditions in a refurbished school building. *Renewable Energy*, *69*, 437–446. http://doi.org/10.1016/j.renene.2014.03.065

Ghaffarianhoseini, A., Berardi, U., & Ghaffarianhoseini, A. (2015). Thermal performance characteristics of unshaded courtyards in hot and humid climates. *Building and Environment*, *87*, 154–168. http://doi.org/10.1016/j.buildenv.2015.02.001

Huang, Y., Niu, J., & Chung, T. (2014). Comprehensive analysis on thermal and daylighting performance of glazing and shading designs on office building envelope in cooling-dominant climates. *Applied Energy*, *134*, 215–228. http://doi.org/10.1016/j.apenergy.2014.07.100

Meir, I. A., Pearlmutter, D., & Etzion, Y. (1995). On the microclimatic behavior of two semi-
enclosed Courtyards in a Hot-dry Region. Building and Energy, 30(4), 563-572

Meir, I. A. (2000). *Courtyard microclimate: A hot arid region case study.* Paper presented at
the proc. 17th PLEA int. conf..Cambridge.

Mishra, A. K., & Ramgopal, M. (2013). Field studies on human thermal comfort d An overview. *Building and Environment*, *64*, 94–106.

Muhaisen, A. (2006). Shading simulation of the courtyard form in different climatic regions, *41*, 1731–1741. http://doi.org/10.1016/j.buildenv.2005.07.016

Ogunsote, O. (1992). Computer Assessment of Architectural Design, *16*, 25–40.

Reynolds, J. (2002). *Courtyards: aesthetic, social, and thermal delight*: Wiley.

Tablada, A., Blocken, B., Carmeliet, J., & Troyer, F. De. (2005). The influence of courtyard geometry on air flow and thermal comfort : CFD and thermal comfort simulations, (November), 13–16.

ISSN 2056-5771(Print), ISSN 2056-578X(Online)