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User Perception of Courtyard as a Thermal Regulator in Households, Famagusta, Cyprus

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Abstract: **Courtyard Houses have been most popular in residential architecture all over the world and in all climatic regions. Courtyard can be square, rectangular, round or amorphous, generated by placement of rooms or buildings around it. In hot arid climates such houses provide a greater measure of comfort. The courtyards supply light and cool air to the rooms around it. Air circulation within this confined space relies largely on the proportions of the surrounding walls and positioning of window openings in the surrounding rooms. This research is aimed at assessing the user perception of courtyard as a thermal regulator in house-holds, Famagusta, employing a descriptive survey design. 30 questionnaires were distributed between October-November 2017, targeting households both in the ancient and urban cities of Famagusta. The questionnaire in this study was designed to extract information from users on how, when, what and why they use the courtyard. Results were analysed in SPSS v. 2.1 for means (M) and percentages (%), which were used to rank the importance of variables. Findings revealed that majority of the respondents do want a courtyard and prefer using it during evening and noon hours of summer period as it does improve the indoor air quality of the house-holds tremendously, in which quite a number of respondents have admitted to it makes them sleep better and thus, prefer their courtyards to be big-medium sized.**

Keywords: **Courtyard, Households, Climate, Thermal regulator.**

1. INTRODUCTION

Buildings are responsible for an increasing energy use and greenhouse gas emissions. An alternative approach to the way the buildings are designed is needed to improve the environmental performance of buildings and minimize their electricity consumption [10]. Courtyard building is one of the oldest architectural forms, dates back at least 5,000 years and take divers shapes in many regions of the world [7]. The earliest civilizations all had courtyards inside buildings [5]. Courtyards are special spaces that are outside yet almost inside [17]. Few architectural elements are more closely associated with comfort, protection, and security than the courtyard [5]; for all those considerations, we will investigate in courtyard buildings potential as an environmental sustainable morphology and an alternative solution to a new building design; a serene architecture, combined with the environment, taking into account landscape, climate, and local specificities [6].

Thermal and luminous environments influence user's comfort and building energy consumption [20]. However, the natural lighting system might not work independently facing a hot and intense solar radiation [10], which consequently causes overheating that disrupts thermal comfort. The assessment of existing introverted architecture will be useful in finding effective and valuable strategies adequate to thermal and luminous environments. Under a hot and dry climate conditions, most research subjects treat thermal and luminous comfort independently. Unfortunately, in spite of the special place of courtyard in the long history of architecture as an effective microclimate modifier, it has been unfairly ignored in the last couple of centuries. Recently more attention has been given to the courtyard as a concept to solve a number of problems of dense inner city housing. Today, modern courtyard houses are designing in different countries with various climates, and courtyard as a beautiful outdoor garden are available in these houses, but only few designers look beyond the obvious aesthetic concerns of courtyards as an object in the landscape, to skilfully address the

environmental impact of courtyard as a passive strategy to improve thermal comfort, energy efficiency and sustainability in contemporary housing development [19]. This present research evaluates only the effects thermal conditions in courtyard buildings and the role of the courtyard as a regulator of the indoor comfort conditions.

2. REVIEW OF RELATED LITERATURE

The courtyard act as the focal point of the house. Most, if not all, rooms of the house have a direct connection with the courtyard, approached through the veranda around it. The cultural aspects also drove the genealogy of the typology, as the cultures that it thrived in had cultural requirements for privacy and separation from the public realm, as well as grades of the attributes within the family [4]. [17] Refers to courtyards as, "… special places that are outside yet almost inside, open to sky, usually in contact with the earth, and surrounded by rooms" [17].

[16] investigated the potential of a courtyard for passive cooling in a single story high mass building in a warm humid climate. Their results revealed that there is significant correlation between wall surface temperatures and indoor air temperatures [16].

[8] Evaluated the thermal performance of a courtyard house in a hot- arid climate of Los Angeles, and determined whether the courtyard is cooler than the rooms surrounding it during the day and also if that the courtyard is cooler than the street outside during the day [8]. [3] Conducted a comprehensive study on thermal comfort analysis of traditional courtyards in Iran by using Energy Plus software program. Their results proved that courtyard has significant advantages on thermal performance of indoor spaces, especially the areas adjacent to the courtyard in hot- dry climates [3].

Few literatures also highlighted that the thermal condition inside courtyards is highly dependent on the amount of shading. For instance, [14] presented a mathematical model that was developed specifically to calculate the produced shaded and sunlit areas in a circular courtyard geometry. It examined the interaction taking place between the sun at any time throughout the year and a circular courtyard form with any dimensions and proportions in any place on the earth. Their results showed that changing the form's proportions significantly influences the shading or exposure potential of the internal courtyard envelope [14]. [15], also examined the shading performance of polygonal courtyard forms with pentagonal, hexagonal, heptagonal and octagonal plans. A computer program was developed to calculate the shaded and sunlit areas generated in any of the examined geometries with any dimensions. Their results illustrated that the courtyard proportions and geometry have a considerable influence on the shading performance of courtyard forms [15]. [13] Highlighted the effect of the climatic conditions on the suggested courtyard ratios and heights to achieve a reasonable annual performance in four different cities including Kuala Lumpur, Cairo, Rome and Stockholm, with various climates such as hot humid, hot dry, temperate and cold climates, respectively. Their results showed that the shading conditions of the courtyard internal envelope are significantly dependent on the form's proportions, location latitude and available climatic conditions [13]. [1] Conducted a research on the effect of shading as a cooling strategy in traditional courtyard houses in Iraq. According to their study, the shady interior courtyard has the effect that the rooms do not communicate directly with the overheated air outside, but through intermediate buffer spaces. They also mentioned that the northern orientation is perfect for the summer functional rooms, in traditional courtyard houses of Iraq [1].

A comprehensive literature review illustrates that most of the existing literatures emphasize on the thermal performance of courtyards in different countries with various climates. However, only very few research works have been investigated either empirically or theoretically on the potential of courtyard for providing shading, as a passive cooling strategy to improve thermal comfort in hot-dry climate of Famagusta [12].

Therefore, this study goes further to fulfil this gap through questionnaire distribution to house-hold users with courtyard in the ancient as well as the urban city of Famagusta, based on understanding the impact of courtyard design variants on shading performance and thermal comfort in hot-arid climate of Famagusta.

Presentation of the Case Study:

Cyprus enjoys an intense Mediterranean climate, with long dry summers from mid–May to mid–October, and mild winters from December to February, which are separated by short autumn and spring seasons. Maximum temperature is at 33.9˚c in august and minimum temperature is 6.5˚c in January/February. Average annual temperature is 19.5˚ [21].

1. Courtyard Building Samples:

Case study of households have been selected from a variety of typologies covering the entire architecture scenery (panorama) of Famagusta.

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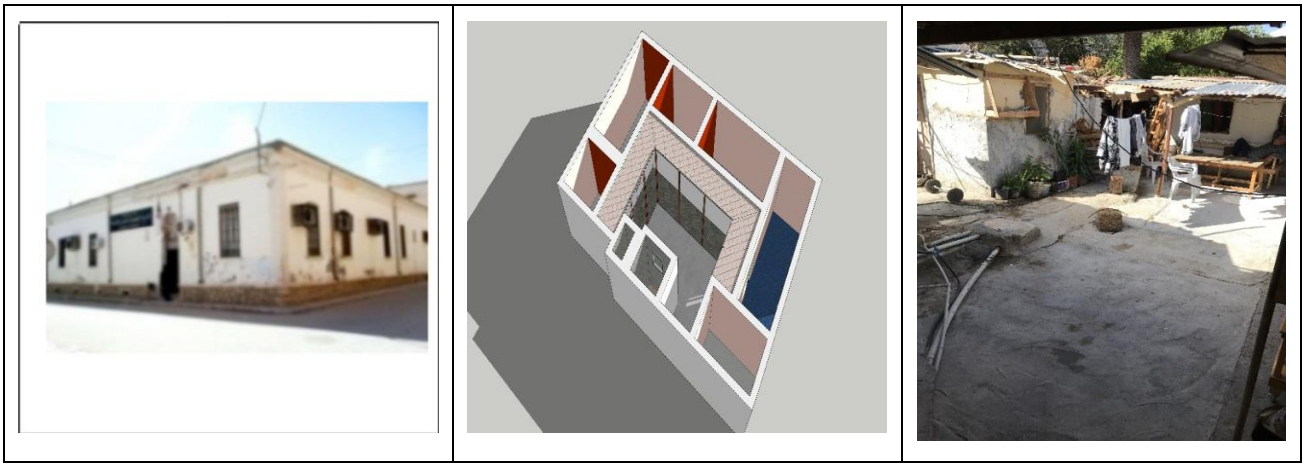

(Source; Author's fieldwork 12th Nov, 2017)

Fig 1.1: Three bedroom bungalow, old city Famagusta

(Source; Author's fieldwork 12th Nov, 2017)

Fig 1.2: Students hostel, Famagusta

(Source; Author's fieldwork 12th Nov, 2017)

Fig 1.3: Lusignans guest house, Famagusta

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(Source; Author's fieldwork 12th Nov, 2017)

Fig 1.4: Lusignans guest house, Famagusta

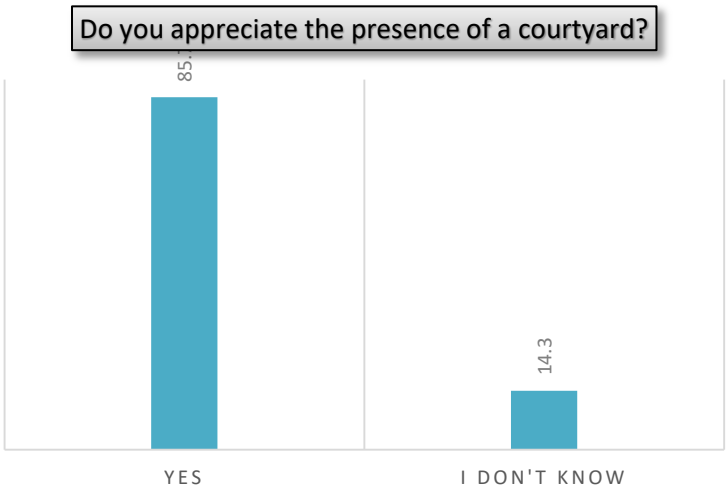
3. METHODOLOGY

Respondents from the study were drawn from both the ancient and urban cities of Famagusta, Northern Cyprus. Data were collected through a self-reported questionnaire, which targeted the users of courtyard. User perception of courtyards was captured by asking respondents how, where, when, why and what they use the courtyard for. Responses were analysed for descriptive statistics namely the mean (M), and percentages (%) using SPSS version 2.1.

4. RESULTS AND DISCUSSION

Results:

This chapter presents the analysis of the data collected from various respondents. The results are presented in pie charts, bar charts, frequencies and percentages. Other interesting findings were made from the data analysis.



(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.1: Do you appreciate the presence of a courtyard ?

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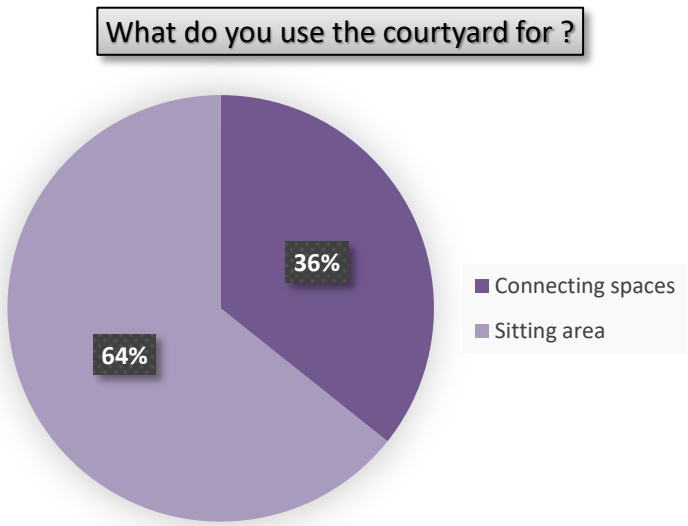
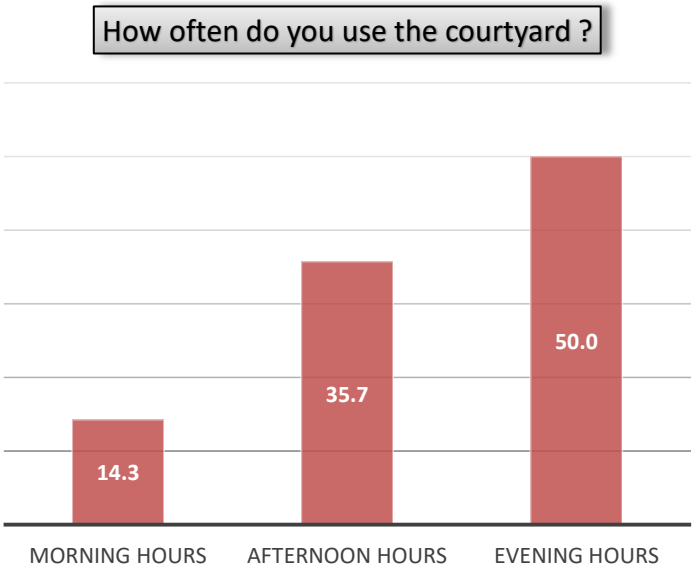
From figure 1 above, findings revealed most of the respondents said yes when asked whether or not the appreciate having a courtyard in their household gaining 85.7% out of a hundred, and about a few of the respondents (14.3%) were indicisive. This is a clear indication that, the courtyard is greatly appreciated and impacts a lot to the house-holds of famagusta.



(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.2: What do you use the courtyard for ?

As revealed from the figure above, when asked what the courtyard is used for, 64% of the respondents said "It's a sitting area", while others (36%) of the respondents said "It serves as a connector of spaces". Judging from above, the courtyard serves a variety of purposes to it's users in Famagusta. It's like a core in the house-holds.



(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.3: How often do you use the courtyard ?

As seen from the above figure, half of the respondents (50%) prefer or use the the courtyard during early or late evening hours the most. Over a quarter of the respondents (35.7%) use the courtyard during noon, and 14.3% make use of the courtyard in the morning. It can be said that, the courtyard is an all day used space in the city of Famagusta depending on when or how the users choose to make use of the space.

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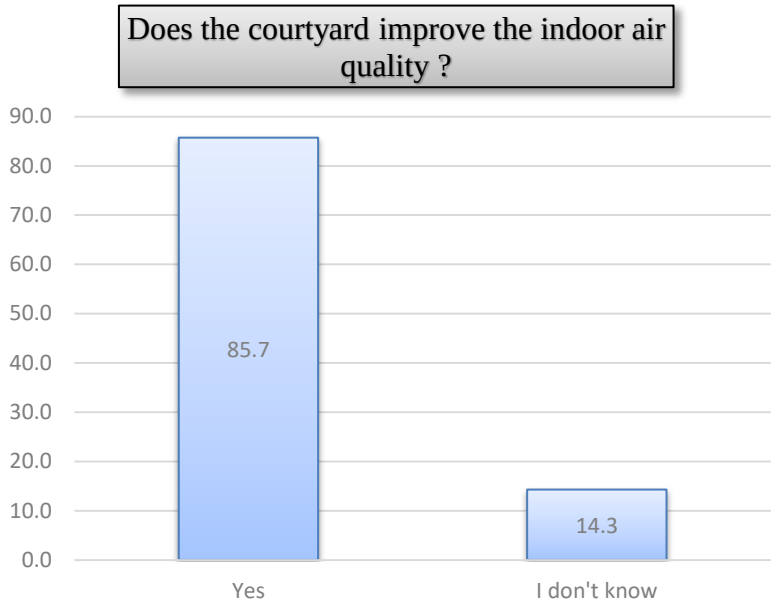
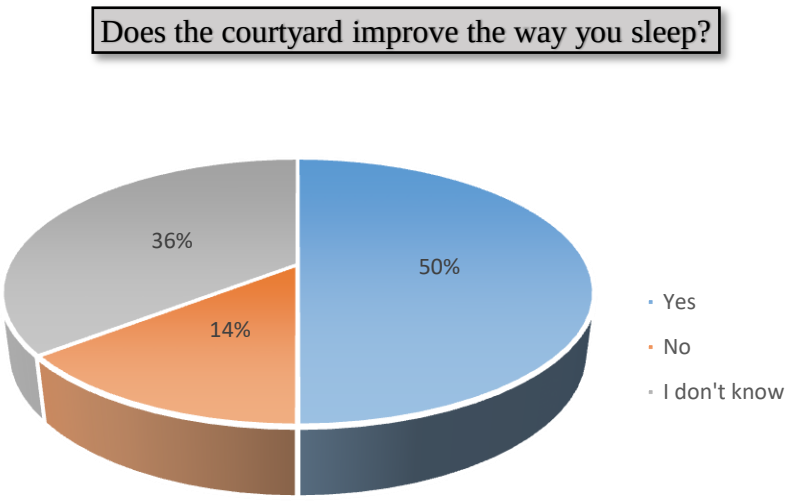


(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.4: Does the courtyard improve the indoor air quality ?

From the above figure, it is evident that the courtyard plays an excellent role as a thermal regulator to it's users. A bulk of the respondents (85.7%) agreed to the courtyard improving their house-hold indoor air quality, while afew (14.3%) of the respondents revealed indiciveness. Going by the above revelation, it can be said, the courtyard truly improves the day-day activities of it's users.



(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.5: Does the courtyard improve the way you sleep ?

As indicated above, half (50%) of the respondents said "Yes, the courtyard does the improve the way they sleep". 14% of the respondents said "No, it doesn't" while, 36% of the respondents answered "they don't know whether or not the courtyard improves the way they sleep".

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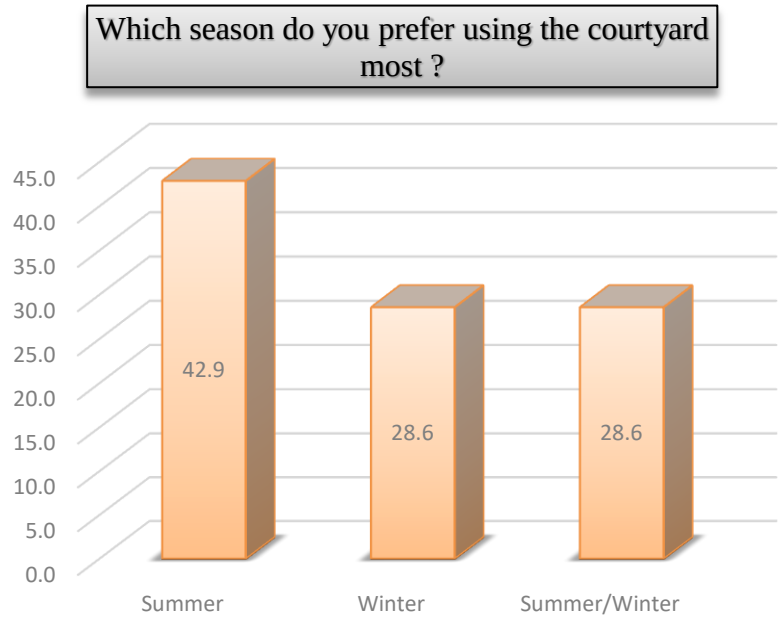
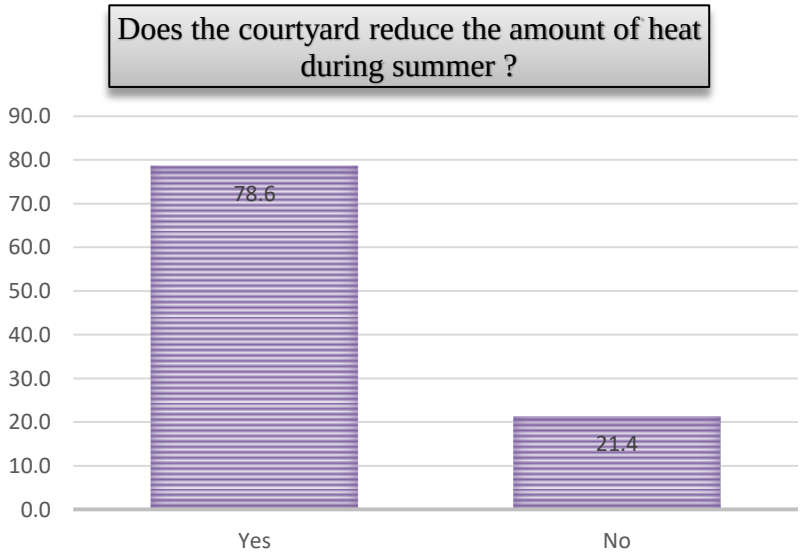


(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.6: Which season do you prefer using the courtyard most ?

From Figure 6 above, about a half of the respondents (42.9%) prefer using the courtyard during the summer period, 28.6% prefer using the courtyard during winter and other 28.6% of the respondets answered both. That is, they don't mind whether suumer or winter, they use the courtyard all year round.



(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.7: Does the courtyard reduce the amount of heat during summer ?

As indicated above, it is evident that the courtyard truly reduces the amount of heat perceived during summer. Majority of the respondents (78.6%) said "Yes" when asked while, a percentage of 21.4 said "No" it doesn't. Going by the data above, it can be said the courtyard servers as a thermal regulator to it's users during intense summer periods in the city of Famagusta.

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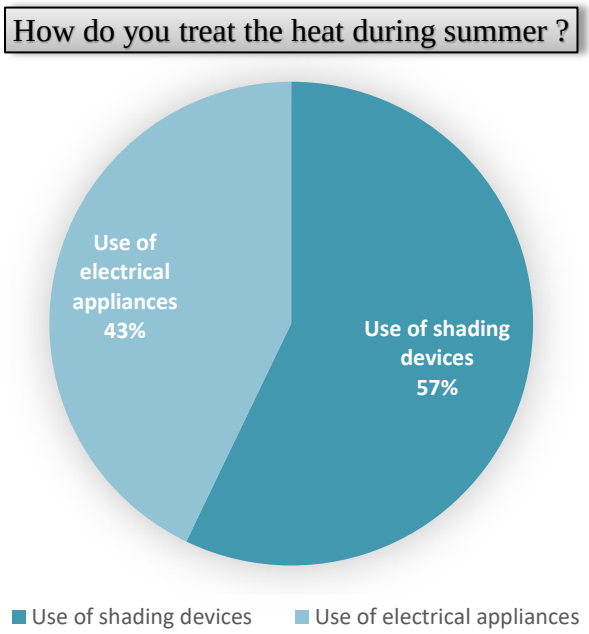
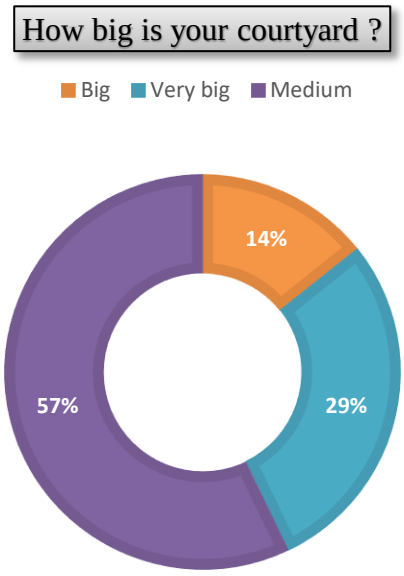


(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.8: How do you treat the heat during summer ?

A number of options were offered to the respondents on how they treat the heat during the summer period. Options like: Use of electrical appliances, Use of swimming pool, and Use of shading devices. Over a half (57%) of the respondents use shading devices, and 43% of the respondents use electrical appliances with 0% on use of swimming pool.



(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.9: How big is your courtyard ?

From the Figure above, when asked on the size of the courtyard, 57% of the respondents answered big, 29% said very big and 14% of the respondents answered medium.

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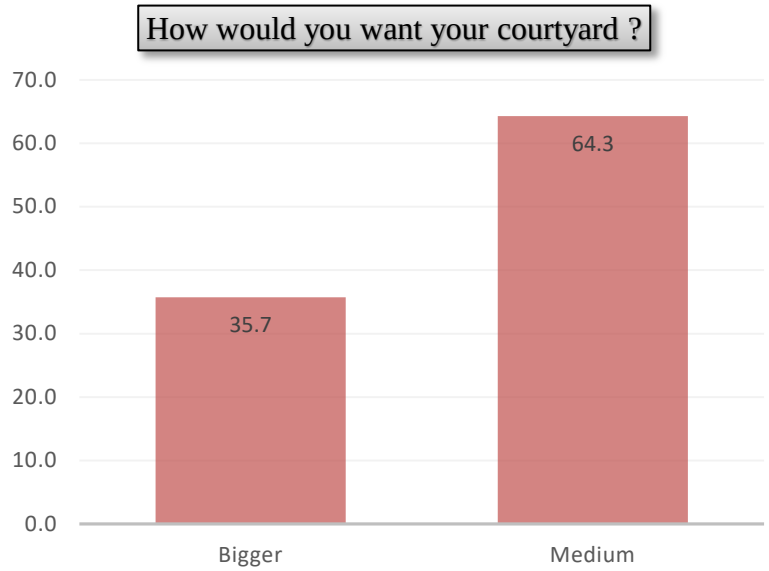
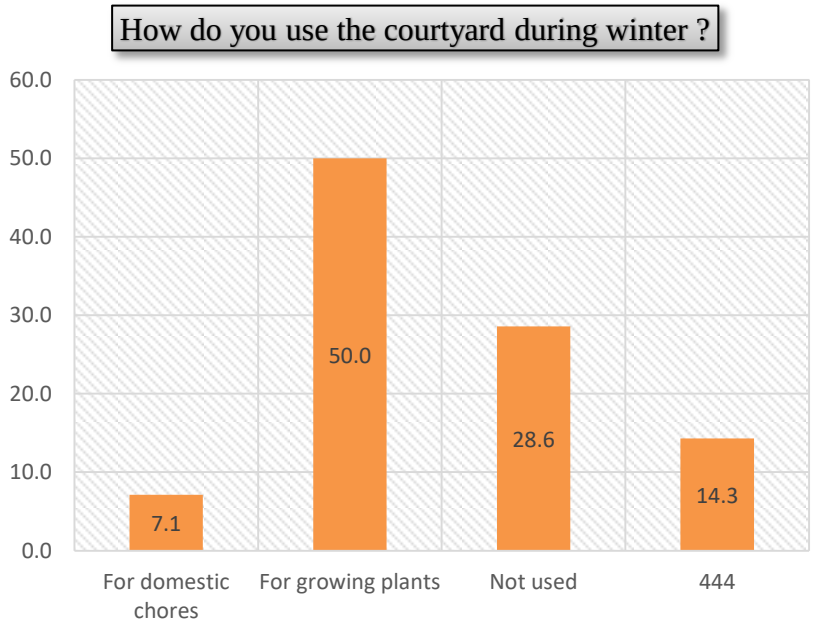


(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.10: How would you want your courtyard ?

When asked the size of the courtyard the respondents would prefer to have, 64.3% answered medium while, 35.7% said bigger. In essence, the size of the courtyard is an adent indicator on how good it will improve the indoor air quality as well as user activities. Judging by the above, Users of courtyard in the city of Famagusta prefer a medium-bigger sized courtyards in their house-holds.



(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.11: How do you use the courtyard during winter ?

From the Figure above, responents were asked how they make use of the courtyard during winter periods as it is usually too cold. Half (50%) of the respondents said "they grow plants", 28.6% said "they don't use the courtyard at all" and 7.1% answered for domestic chores (E.g Hanging clothes, Washing etc) while 14.3% are missing values.

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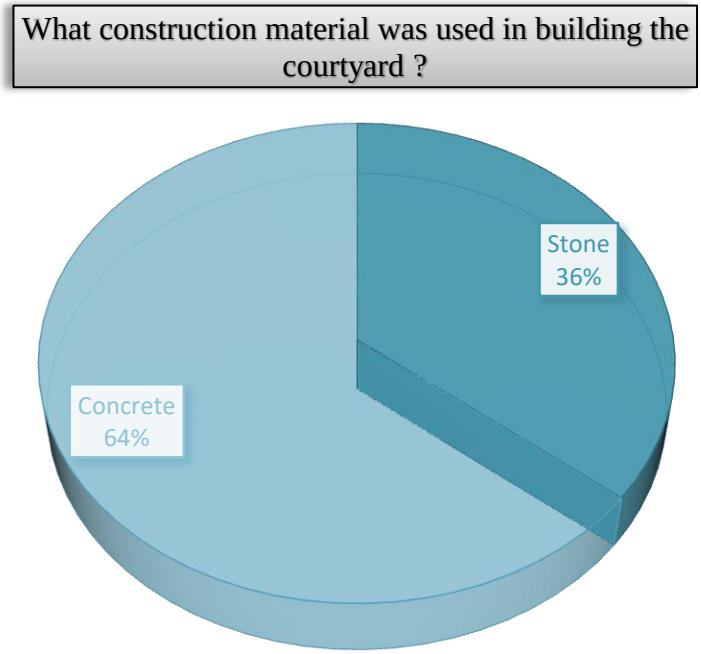
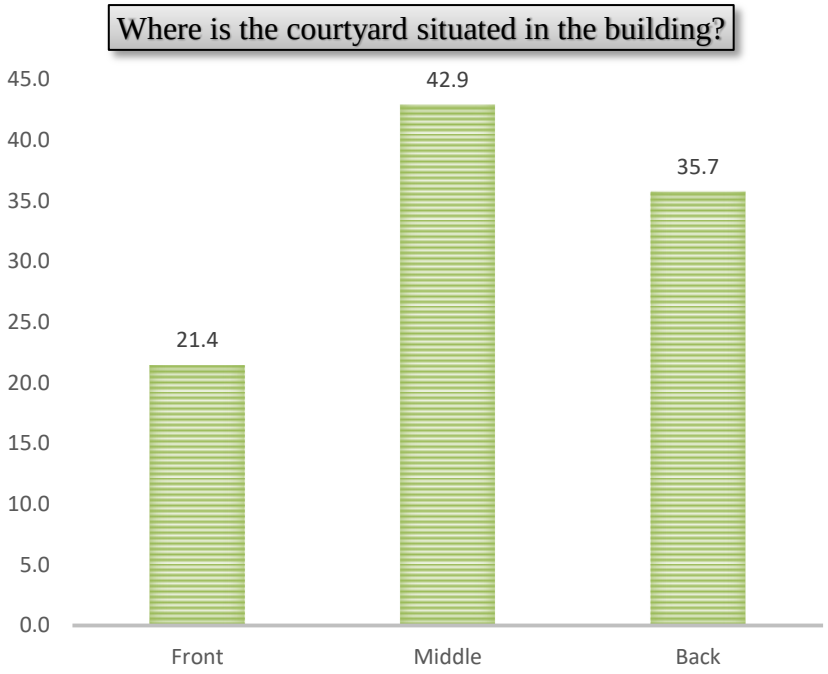


(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.12: What construction material was used in building the courtyard ?

Construction material used in erecting the courtyard walls is mainly concrete with 64% across the city of Famagusta and stone 36% around the ancient city of Famagusta.



(Source; Author's fieldwork 12th Nov, 2017)

Fig 2.13: Where is the courtyard situated in the building ?

Location of the courtyard is very important for adequate ventilation and air flow. About half (42.9) of the respondents said it is located at the middle of the house, 35.7% said at the back and 21.4% at the front the house. Going by the results, most house-holds have the courtyard situated at the centre which gives room for adequate air flow into connected spaces.

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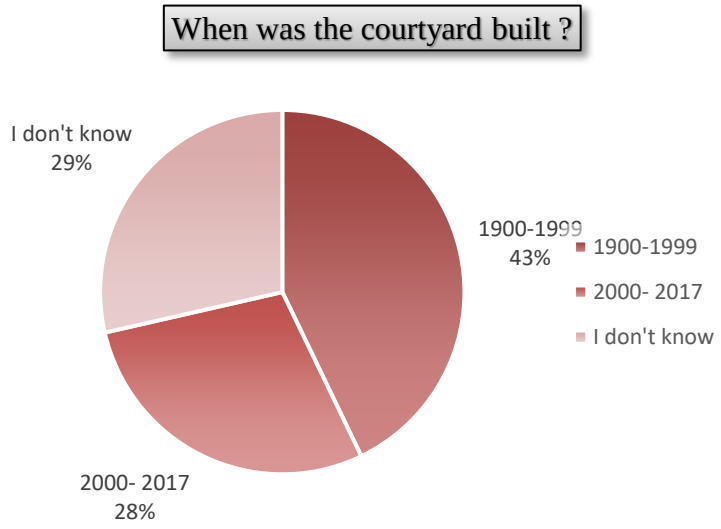

(Source; Author's fieldwork 12th Nov, 2017)

Fig. 2.14; When was the courtyard built ?

From the figure above, 43% of the respondents said the courtyards were built in the range of 1900-1999. This are mostly residences in the ancient city of Famagusta and 28% said 2000-2017 which are located in the urban city of Famagusta while 29% of the respondents said they have no idea when the courtyard(s) was/were built.

5. DISCUSSION

[2] Said the traditional structures of courtyard houses developed As a result of environmental and privacy factors, the climate in the Middle East region is generally hot and dry, courtyard is a simple strategy to protect from the heat, the created space used to escape from the extreme heat outside reminds one of an oasis in a desert [2]. Most of the spaces views into the courtyard, for the spaces get air and light from this central part of the house. When examined within the compact structure of the city, the design of the courtyard house can be evaluated more realistically. The adjacent placement of the houses can prevent the direct exposure of the sun to the side walls. Narrow streets allow transportation in relatively cool areas. In hot climates like the Middle East, especially in cities, the traditional living spaces consist of houses that are designed in this way [11].

Going by the results, it's revealed that majority of the respondents want a courtyard. It is also discovered that most of the respondents prefer using the courtyard during evening hours and a few of them during afternoon hours. Results indicated that majority of the respondents treat the heat during summer by use of shading devices and electrical appliances. Courtyard has shown to be used as a sitting area as well as serve the purpose of connecting spaces; It's more of a core of the house-holds.

It has been revealed that the courtyard does improve the indoor air quality of the house-holds and encourages the daily activities of it's users treamendously in which quite a number of respondents have admitted to it makes them sleep better and thus, prefer their courtyards to be big-medium sized.

Respondents prefer using the courtyard during summer due to presence of intense heat. Results have also indicated that, the courtyard is been used as garden to grow plants during winter period and some little domestic chores like spreading/hanging of clothes.

6. CONCLUSION

In conclusion, use of courtyard as a thermal regulator can be dependent on the courtyard size, courtyard location within building, as well as construction material. This is confirmed in the results as majority of the respondents preferred big-medium sized courtyards for better air flow within the house-hold. Majority of respondents prefer the courtyard to be situated at the middle of the house, rather than the front or back, this will serve as a space connector and for proper indoor air flow which can help reduce the usage of electrical aplliances in treating heat and cut cost as well. Construction

materials vary, use of appropriate material in erecting courtyard walls can improve the indoor air quality. It can be said that, the courtyard is an all day used space in the city of Famgusta, depending on when or how the user's choose to make use of it. A relevant conclusion admits the use of courtyards in buildings as a bioclimatic strategy to solve the dilemma of protecting passively buildings from sunlight. Also noted that, courtyard offers more opportunities for both thermal and daylight environments through the interior and the exterior of the building's vertical surfaces. Courtyard as a singular space can't behave without the other part of the building area; it was found that the three important areas (Outdoor, indoor and courtyard areas) are interacting in a systemic ways.

[1] Conducted a research on the effect of shading as a cooling strategy in traditional courtyard houses in Iraq. According to their study, the shady interior courtyard has the effect that the rooms do not communicate directly with the overheated air outside, but through intermediate buffer spaces. They also mentioned that the northern orientation is perfect for the summer functional rooms, in traditional courtyard houses of Iraq [1].

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