Comparison Study of Traditional and Contemporary Islamic Dwelling Design in Hot Climates, with Reference to Benghazi, Libya

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Abstract

In Benghazi, Libya, the rising population and increased housing demand has led to high energy consumption in order to provide comfortable conditions. These contemporary dwellings make use of outdoor open spaces and a high glazing ratio of the building envelope, leading to significant underperformance with respect to heat gains and cooling loads when compared with more traditional dwellings. The aim of this paper is to investigate the main features of traditional Islamic houses, which can enhance environmental comfort and reveal insights when compared with contemporary houses. The methodology will consist of reviewing previous research regarding traditional Islamic houses in order to find the main climatic features, as well as a case study that will involve evaluating contemporary houses in Benghazi, Libya. Furthermore, 60 questionnaires were distributed in order to determine the main problems relating to both residents and housing design in terms of enhancing housing thermal comfort and decreasing energy consumption. The comparative study shows that the majority of traditional Islamic houses have sustainable features that can be integrated into contemporary houses in order to provide thermal comfort whilst minimising energy consumption. These features include internal open spaces (such as courtyards), and small, high openings in the external façade, together with shading devices and specific building orientation. The research likewise displays that 89% of contemporary Islamic houses in Benghazi not only lack the integration of these sustainable features as internal open spaces, but also shows that all of the local residents depend on air conditioning when facing the hot days. Additionally, the survey illustrates that just 15% of architects are responsible for designing these houses, and this has led to window designs with a high glazing ratio, and all of the windows being located in the hottest façades of the houses. The implication of the outcome with regards to sustainable designing of contemporary Islamic houses is discussed in order to help produce guidelines for designers that would respond to both the climate and to local people's needs.

Key words: hot climate, thermal comfort, privacy, traditional Islamic houses, contemporary houses, energy consumption, Libya.

1 Introduction

The Islamic religion has a great effect on housing design in terms of many traditional dwellings, as Islamic society has generated an especial design for houses where the plan of the house focuses on the interior, with simple façades (external walls) to enhance visual privacy. Furthermore, climate design in traditional houses features the ability to modify and moderate indoor temperature El-Shorbagy [2]. Also, these designs take into account the need for privacy through their design elements – for example, windows are placed inside the internal open space (the courtyard), helping to provide a house with natural light and air ventilation Susilawati, Al Surf [4]. Evidently, the western design has been imported to many Islamic countries. For example, in Libya's Italian colony, a new housing design was established with regards to housing development. However, this development has not met the social-cultural requirements of an Islamic country, and it has essential principles that should be considered as well as climate conditions Al Sayyed [5]. After 1969, the Libyan government started to construct new and large housing projects in order to meet the increasing demand for houses, but without understanding the social-cultural needs and climate conditions in Libya. Although privacy is one of the more important requirements in Islamic houses, it is ignored in most contemporary house designs Nabavi and Goh [7], Mahgoub [7], and Sharif, Zain et al. [2]. Furthermore, Khalaf [2], Ajaj, Pugnaloni [2], Khoukhi, Fezzioui [2], and Leylian, Amirkhani et al. [5] indicate that contemporary Islamic houses lack in climate design elements because no studies were conducted of the impact of microclimate on the strategy of design process and the form of a building.

2 Thermal comfort dimension in traditional Islamic architecture in hot climates

Traditional Islamic architecture displays many of the ideas that can be used in present time in order to help the problems concerning housing conditions in some Islamic countries where there is a hot climate. The thermal comfort principles will be demonstrated through traditional Islamic houses Ajaj, Pugnaloni [2].

2.1 Orientation

It is beneficial to have sunshine in your house, without having the damaging effects of extreme temperature and glare. With this in mind, the courtyard house does well under the rotation of the sun. In a traditional Libyan house, empirical methods were used to measure the sun projection angles in courtyards. These angles were:

i) The sunbeam angle is the vertical angle between the sunbeam and its horizontal shade.
ii) The azimuth angle is the angular distance extending from the sunbeam shade to the north in a clockwise movement, as seen in Figure 1: Different spaces for family according to direction of the sun, Ground floor plan of a home in Diyarbakir, and Edwards [1].

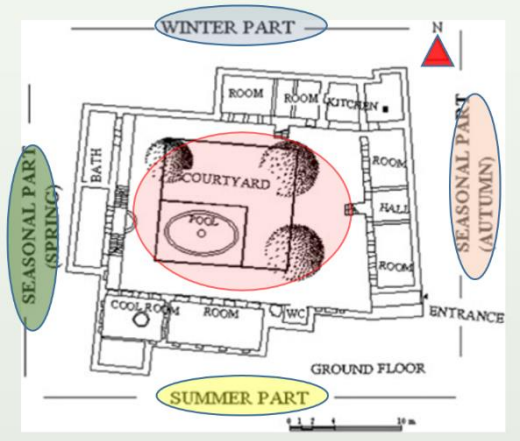

Figure 1: Different spaces for family according to direction of the sun, Ground floor plan of a home in Diyarbakir.

The sun projection angles change at different times throughout the seasons, and these provide the degree of solar penetration in many spaces of the house. Therefore, the best orientation for courtyards is on the east-west axis, with the longitudinal elevation being to the north, for the following reasons:
• The sunlight projection is towards the longitude elevation – for example, south.
• The south elevation receives the largest amount of heat in winter and the least in summer Edwards et al. [1].

2.2 Natural ventilation

One of the passive cooling strategies used in traditional Islamic architecture is natural ventilation, and this can enhance indoor climates by evaporative cooling. In addition, the orientation of traditional houses can respect prevailing winds and sunlight, therefore, solid façades are oriented in order to protect the outdoor living zones from the hot winds, simultaneously allowing sufficient winter sunlight to enter the living areas. The main natural ventilation elements when it comes to courtyards are wind towers, or malqafs. The design of these wind towers can encourage airflow in house spaces Bekleyen and Dalkiliç [2]. The different

temperatures cause wind circulation, and there are differences in temperature between solid and void elements. These elements can cause differences in air density that can subsequently lead to the following air circulation:

- Between the interior courtyard and the exterior space.
- Between the courtyard and the interior space of the building.

As a result, the wind can be effective in reducing temperatures due to the nature of courtyard architecture. Also, wind-cooling can decrease day-time surface temperatures, which then benefits the night-time conditions Edwards et al. [1]. Additionally, for natural lighting and ventilation, openings and windows are essential. However, in summer, the absence of any openings helps to minimize heat gain, especially on the west side. The openings should be shaded from direct rays and placed high on the walls in order to be away from ground rays Ajaj and Pugnaloni [2].

2.3 Shading

Solar radiation is a major source of heat gains in a building. Adequate shading decreases air temperature, radiant heat, and glare effectively. The most important ways of using shading include having protrusions and cornices on the outer façades, as well as on the inner courtyard walls Ajaj and Pugnaloni [2]. The amount of shade is determined by the size and shape of the building. In traditional dwellings, there would have been a large area of shade because some parts of houses had more than one story, thus the shaded area increased as the complexity level of housing design increased (Edwards [1]). Also, another important device for providing shading is Mashrabiya, which has many significant functions, such as:

- Controlling the passage of light,
- Controlling the air flow,
- Decreasing the temperature of the air current,
- Increasing the humidity of the air current, and
- Ensuring privacy.

Also, its design filters the sun and makes beautiful light and shade patterns by changing the sizes of the interstices (the spaces between adjacent balusters) and the diameter of the balusters Ajaj and Pugnaloni [2].

3 Problems with contemporary houses

3.1 Housing design changes

Traditional houses are often well adapted to climatic and environmental considerations. In addition, they have evolved to fulfil the socio-cultural dimension. In spite of all these benefits, however, most of the features of traditional houses have disappeared when it comes to contemporary house developments in Islamic countries. Mahgoub [7] pointed to the theory that the re-emergence of courtyards in dwellings has shown to be valid in the architecture of Islamic countries, which has witnessed fast developments and changes since 1950,

after the discovery of oil and the economic wealth generated by its sales. Many cultural and traditional architectural features were changed by new elements and ways of life Mahgoub [7]. Most Islamic countries, including Libya, have had a fast growth in the economic sector, with an increase in population. This change resulted in an increase of building modern houses, which were influenced by western designs. In other words, the designs of modern houses have changed, heading away from the concept of traditional houses in which the occupants met their requirements for socio-cultural and environment aspects Al Aali [4]. These contemporary designs are generally seen in high-rise blocks and individual houses Ahmed [2]. The majority of buildings in cities – for example, in Benghazi – are houses, and according to SBB, residential buildings represent the highest proportion of buildings, with 40.61%. Most of these houses make use of modern western ideas instead of many cultural and architectural ideas; for example, outdoor spaces in modern villas were used instead of indoor spaces found in traditional courtyard houses, big and glassed windows were used instead of high, small openings, and concrete and steel were used instead of the traditional building materials Gabril [4]. During different stages of Islamic countries' architectural development, the disappearance of traditional house characteristics was a consequence of the transformation of the housing design. Nowadays, the houses are re-oriented to the street and have become less responsive to the residents' social situations, privacy, and thermal comfort. The courtyard houses have changed from prioritizing privacy, where the residents positively utilize the inner spaces that are organized around open and sheltered central space, to an exterior space, where inhabitants lose a function and role of the house's spatial form Mahgoub [7]. Most of the outdoor spaces – such as balconies, verandas, and gardens – are not used effectively because they don't provide privacy, and with time, they have become non-functional spaces Shawesh [4].

3.2 Energy consumption

El-Shorbagy [2] indicated that climate acts as a complementing and moderating factor for society and religion requirements when providing privacy, therefore, it is important to consider the climate role in Islamic architecture El-Shorbagy [2]. Local climate and energy consumption issues are, furthermore, mostly ignored in contemporary architecture designs of Islamic housing. A rise in indoor temperature has led to the use of air conditioners, which contributed to an increase in energy consumption for cooling, heating, water heating, and CO2 emissions within the surrounding environment Gabril [4]. According to UN Statistics Division/CDIAC, in terms of carbon dioxide emissions, Libya was recorded as the 11th country in the world, with 1.98 tonnes of carbon dioxide emissions per capita. This is higher than the global average of 1.13 tonnes a year Gabril [4]. In addition, because of the rapidly growing demand for electric power in Libya, power shortages are widespread, and this demand is increasing fast, at a rate of about 6–8% per year. For example, in 2002, demand for electricity was recorded at 13.414 billion kWh, while in 2010, it reached 5.8 GW, and it is expected to reach 8 GW by 2020 Gabril [4]. Therefore, there is a need to study, investigate, and try to find solutions to reduce the energy consumption, and this research will focus on

residential buildings as they consume the highest electricity rate among all sectors. According to the General Electric Company of Libya, "GECOL", the highest energy consumption comes from houses, with the energy being used for cooling, heating, and water heating, making up 39% of Libya's total energy consumption GECOL [7].

4 Aim and methodology of the research

The research investigates contemporary dwellings in Libya, as well as meeting the inhabitants' needs according to socio-cultural and climatic factors. Contemporary house designs in Benghazi will be used as a foundation for the research, using the results of the study to design sustainable houses for Islamic cities with the same climate. The research will assess how much the contemporary Islamic dwellings provide comfort and the requirements necessary for residents in Benghazi. In order to achieve the aim of the research and draw a clear picture for determining and analysing the problems, a multi- method approach is adopted to contextualise this work on comfort and design in hot climates, referring to the specific Libyan case study. Necessary information will be reviewed from previous research with regards to traditional Islamic houses in order to find the main climatic features. In addition, contemporary Benghazi houses will be investigated as a case study in order to determine the main architectural design elements that affect the thermal comfort and increase of energy consumption. To support the research, a survey has been conducted to determine occupants' opinions on housing comfort, as well as their views towards their general satisfaction regarding the environmental perspective of contemporary private housing sectors in Benghazi, Libya. Furthermore, the survey was distributed randomly in two different neighbourhoods (to both apartments and villas). Out of the 60 surveys that were distributed (30 for the apartments and 30 for the villas), 51 completed questionnaires were returned: 24 questionnaires from the apartments and 27 questionnaires from the villas. The survey was divided into five sections: general information, house information, house design, house elevations, and cooling demand.

5 Benghazi background

According to the Libya National Statistics Office projections (LNSO), Benghazi has a population of 631,555, making it the highest population density out of all other Libyan cities, with 2000 inhabitants per square kilometre Agll and Hamad et al [5]. Benghazi is considered a magnet for the migration of people from different regions of Libya – from the south, east, and even from the west – due to economic prosperity and increased job opportunities. Therefore, this has led to an increased population growth and an increased demand for housing. According to the National Physical Plan, the yearly demand for housing will grow regularly from 24,000 units to 38,000 units between 2000 and 2025 Mohamed [4]. This increase in housing construction is offset by an increase in the use of air conditioning, which leads to energy consumption and the emission of carbon

dioxide. According to the General Electric Company of Libya (GECOL), houses in Benghazi are responsible for a majority of energy consumption, with residential buildings consuming energy at 36% in 2012 GECOL [7]. Besides the houses in Benghazi lacking with regards to climate conditions, they also lack in terms of the provision of social requirements, such as privacy between residents and neighbours, despite the high cost associated with building outdoor gardens Al-Jamea [5]. Therefore, it is necessary to study how we can apply the concept of society, and environmental sustainability, to housing in Benghazi Almansuri [5]. In Benghazi, contemporary house types can be classified into two different models: apartments, and private houses (terraced houses or villas). According to the National Census (NSA) and the Benghazi Planning Study conducted by El-Emara Engineering Consultants, the majority of houses are private houses (villas and terraced houses) at 60.5%, as villas are preferred by most people in Benghazi Mohamed [4]. Benghazi dwellings have a distinguished exterior form, without considering interior spaces or the relation between outdoor and indoor, and orientation. For instance, windows are directed to the outdoor space rather than to the indoor space (the courtyard), as shown in fig 2, where the courtyard was working as a centre for family life and climatic control.

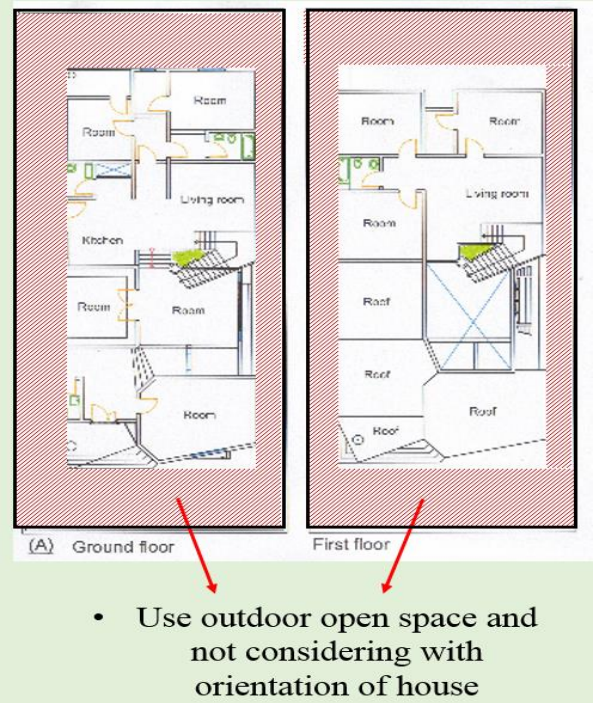

Figure 2: Plan of private house with outdoor open space surrounding the building

Subsequently, air conditioning is used instead of mashrabiya, which can reduce solar radiations with cool ventilation because it is an enclosed window with an engraving wooden lattice, formed and located on the second floor of a building. In addition, the mashrabiya has another role besides its climatic role, which is providing privacy to residents. Furthermore, the designs of modern houses allow a greater amount of solar radiation to enter through the exterior façades (large glazed windows), without considering the best orientation. This type of design is not appropriate to the climate of Benghazi. Thus, windows in Benghazi houses have two negative impacts, socially and climatically. In addition, many verandas and balconies in current houses are closed, used for storage, or are not used at all, as the balconies cannot provide the privacy required to residents in both types of dwellings (apartments and villas).

6 The main findings

6.1 House design

6.1.1 Open spaces

Regarding the location of open spaces in villas (indoor, outdoor, or both), 89% of villas feature an outdoor open space, while 7% have both kinds and just 4% have only indoor open spaces. In addition, in terms of how these spaces are used as shown in fig 4, all open spaces are used for parking, with the highest percentage of use being for play areas, storage, and seating areas, with 85%, 78%, and 74% respectively. Plants are not common – just 48% have plants in their houses –while pools and fountains are non-existent. Therefore, when it comes to traditional houses, outdoor space cannot play the same role as internal space in terms of providing a comfortable, domestic place for families with an acceptable climate.

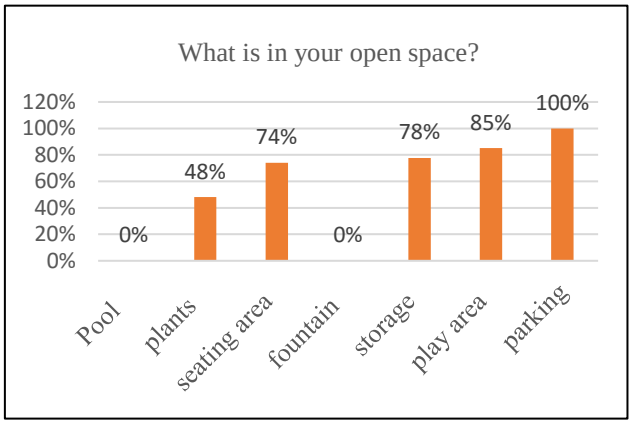

Figure 4: Usage type of open spaces

According to the time when the open spaces are used, the most preferred time is in the afternoon, with 81%, whereas no one uses the open space during noon time

due to the hot climate not allowing residents to use that space effectively. Therefore, most residents are using their outdoor open spaces for parking and for storage.

6.1.2 Openings and balconies

According to the answers to the question, 'Who designed your house?', repeat design and contractor are the main sources of private house design, with 33% and 30% respectively, whilst architects are generally not responsible for designing private houses, with just 15%. Therefore, the majority of windows are located on the hottest façades, which are in the east and west directions. As seen in fig 5, there are approximately 100 windows on east façades and 94 windows on west façades, and this illustrates the importance of the role of architects in designing houses.

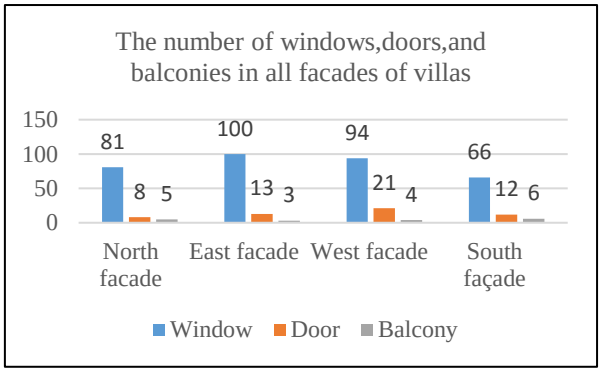

Figure 5: Number of openings and balconies in facades of private houses (villas)

6.2 Cooling demand

According to fig 6, all residents of the flats and villas use air conditioning as a cooling mechanical system. Therefore, it was important to find out the BTU (the cooling capacity of air conditioning) used in these buildings. The results were as follows: 18,000 BTU is the most common usage in both the flats and villas, with 16 and 21 respondents respectively, then 24,000 and 26,000 BTU are the second most common usages in the flats, while in the villas, 24,000 and 28,000 BTU are the second most common usages. In addition, 30,000 BTU is being used in villas (with 7 respondents) but in the flats, it is not used. Therefore, the area of the house has an effect on the cooling capacity of the air conditioning.

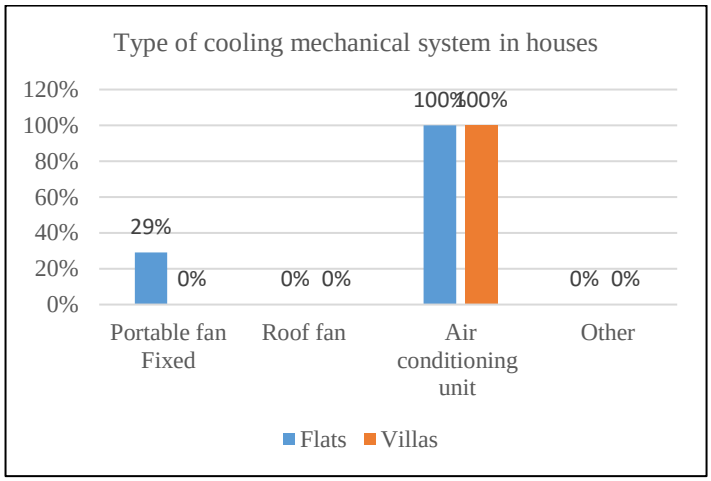

Figure 6: Type of cooling mechanical system in houses.

According to the question, 'In which season(s) is the air conditioning system used?' the highest use of air conditioners is found throughout the summer season in all of the flats and villas. Also, in the villas, the air conditioning is heavily used throughout the spring and autumn seasons, with 89% and 70% respectively, indicating an increase of air temperature during these seasons.

7 Conclusion

This study was concerned with reviewing the main features of traditional Islamic houses, which can enhance environmental comfort and reveal insights when compared with contemporary houses in the hot climate of Benghazi, Libya. The study also used the questionnaire – which was conducted in January 2016 – to gather preliminary data in order to serve further work, leading to the achievement of appropriate principles for thermal comfort in such hot climates. The results of this study can be concluded as follows:

1. It is important to take into consideration the courtyard concept of some traditional Islamic houses as an important environmental element in modern design (which can provide an acceptable indoor environment that can be used as a private family place). In addition, it is also important to provide ventilation through regulated air movement between the internal open spaces and the external small openings, providing maximum shading of direct and reflected sun radiation in the hot season.

2. With regards to the architectural issues in Benghazi housing, the contemporary private houses have different architectural elements, with traditional houses using outdoor spaces instead of internal spaces, as well as using external large glazed windows instead of high, small openings. These differentiations lead to an increase

in indoor temperatures in the current houses in Benghazi, subsequently forcing residents to use air conditioning in order to reduce temperatures.

3. From the questionnaire results, it can be extrapolated that the majority of houses have outdoor spaces, with their main usage being for storage space as they lack an acceptable environment.

4. It is important that architects have the responsibility to design houses, with the users contributing to that design.

5. Due to the increase of the heavy usage of air conditioning in private houses, in the future architects should consider implementing traditional elements in contemporary houses, such as courtyards and openings in the façades.

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