# Chapter 7
# A Social-Environmental Interface of Sustainable Development: A Case Study of Ghadames, Libya

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## 7.1 Background

A house is the inhabited space that localises our memories in not only time but also surroundings (Coghlan 2010). The efforts to make buildings socially sustainable have been led by organisations such as Oxford Institute for Sustainable Development (OISD) but with difficulties in measuring the aspects of social sustainability (Lehtonen 2004). In vernacular architecture, the urban structure of the city is set according to the spatial location of locals' social structures (Bramley and Dempsey 2006). Glassie (1990, p.9) stated that "All architecture is the embodiment of cultural norms that pre-exist individual buildings. Vernacular traditions are characterised by a tight correlation between the understanding of these norms by designers, builders and users".

Yet, the remaining social image in traditional buildings and towns, therefore, represents the engagement and participation of man within a building, which is more or less based on an established sociocultural order. Glassie (1990, p.20) stated that "All buildings must be designed with specific cultures in mind. What is right for us is not necessarily right for another culture". However, in practice, the social and environmental dimensions have not been integrated into a holistic approach in the design process, especially in highly dense cities (Bay 2011). Many in literature, including Abarkan and Salama (2000), Chojnacki (2003) and Elwefati (2007) stated that these social and environmental dimensions have been neglected in some developing countries due to ignoring and misunderstanding the values of local architecture and community needs. Golubchikov and Badyina (2012) also believed that there is a reciprocal impact between housing development and the environment where both are related to the climate and ecological change, particularly in contemporary constructions.

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While these studies clearly show the economic benefits of the concept of compact cities, they also highlight the benefits to the city, human comfort, the indoor environment and living conditions. There was a sense of agreement that climate has been the major factor in shaping old settlements and being so often one of the most determinant in forming its buildings (Ben-Hamouche 2008 and Sundarraja et al. 2009). On the other hand, different groups believe that the cultural and local conditions, including materials and building methods, have a greater impact on how cities were built (Cofaigh et al. 1998). However, lessons acquired from previous generations in traditional architecture dictate that existing social aspects besides climate, materials, topography, land cover and economy should be integrated into the design process of any residential scheme. Yet, the debate of which factors contribute most to shaping urban settlements, specifically between climate and culture, has not been resolved. As such, assumptions rely on a number of variables including the context, the observation angle of the phenomenon and the background of the debater.

According to many in literature, vernacular buildings are more climatically receptive to the environment than modern constructions (Howley 2009). However, in most cases, climate has been the main driver for local builders to identify the traditional building methods and techniques to achieve optimum comfort conditions with limited use of resources (Sundarraja et al. 2009). It can be said that traditional architecture may reflect the vernacularity of a place (sociocultural and historical context of locals) but may not be sustainable if dwellers are not satisfied regardless of the use of locally available materials, methods and techniques, natural resources and addressing environmental issues. This chapter discusses the design priorities of desert architecture responsible for the long-standing nature of the local architecture in spite of harsh environmental conditions while retaining social values and cultural norms. Ghadames housing presents a good example of how humans have learnt balance between the need for culture-specific design and coping with extreme climate conditions, both in syncytium with nature in such way to represent sustainable practices.

## 7.2 Research Methodology

The methodology is qualitative in nature, using methods of field surveys to investigate existing traditional housing design methods and strategies employed to bring coherence between nature and settlers in consistent systems. A number of traditional houses were visited to evaluate the indoor climate (thermal and visual conditions) through temperature records, drawings and observations of design techniques and methods used in traditional housing. In addition, 12 interviews were conducted during the visit to the old town of Ghadames, to explore in depth, the locals' experience and perception of traditional settlements and whether it has successfully met their basic needs. Although the analysis of the case study is descriptive, a dynamic simulation analysis also is used in an attempt to understand the way these houses were designed to naturally maintain acceptable indoor thermal conditions.

**Fig. 7.1** Old and new towns of Ghadames

## 7.3 Ghadames

The case study is a town located in the Sahara Desert built over 400 years ago on an oasis that lies approximately 630 km to the south-west of Tripoli close to the junction between Libya, Tunisia and Algeria with an altitude of 340–370 m above sea-level (Chojnacki 2003). Although the town was inhabited thousands of years ago, the existing fabric of traditional buildings goes back approximately 200 years and remains as it was. The location between the three countries' borders is of importance to connecting the Mediterranean coast with central Africa. After local residents left the old town in 1985, it was added to the World Heritage List by UNESCO (Fig. 7.1).

According to Zifan (2016) Libyan climate is classified as six climatic zones as defined by the Libyan map of Köppen climate classification. Ghadames lies in the hot arid desert climate. It is characterised as having very low precipitation, far less than the potential evapotranspiration, with large temperature swings particularly during summer months, resulting in low humidity rates (Fig. 7.2). The hot dust-bearing wind known as Ghibli has been the most dominant concern for locals and their regional architecture. The old town settlements represent a basic form of wind-breaks erected in an inclined plane on the leeward of Ghibli surrounded by large green belt of palm trees to give some protection against undesirable summer winds.

## 7.4 Social Integration and the Spatial Planning of Old Settlements

Ghadames settlements have integrated design solutions that highlight the importance of family privacy long before Islamic rules mandated it. The houses are divided into different zones for both males and females with the ground floor allocated as semipublic, the first floor as semiprivate and then mezzanine and roof levels

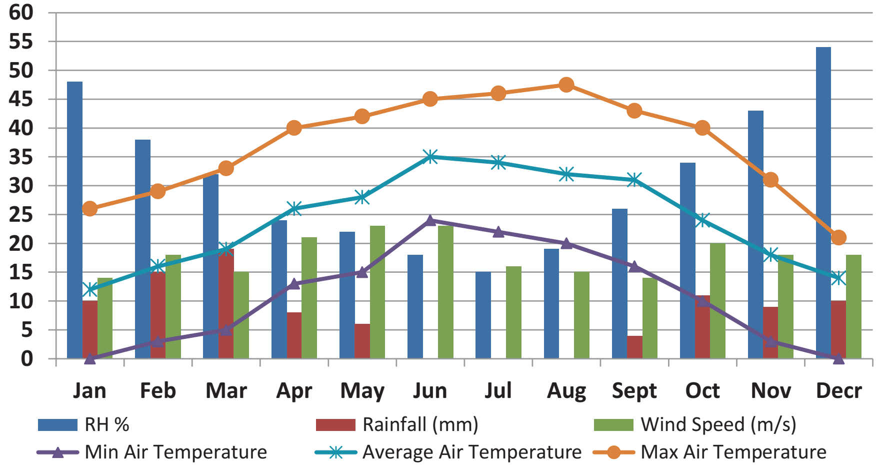


**Fig. 7.2** Climate conditions in Ghadames

**Fig. 7.3** Social practice and microclimate features in the old town of Ghadames

for family use only. Females so often spend time inside homes and use mainly roofs to move from one house to another (Fig. 7.3). Meanwhile, males spend most of the time outside either taking up commercial or agricultural activities using semi-shaded and shaded alleyways to move around the town. The old town is located in an oasis surrounded by farms with over 36 thousand palm trees (Ealiwa 2000). It can be said that the compact house design was successful in meeting locals' privacy and social needs and allows them to comfortably practise their cultural norms and beliefs.

The lifestyle and city structure necessitated the creation of public squares and baths, and later mosques were added in the vicinity of these town facilities including the market after the Othman invasion. This unique structure illustrated by buildings, streets, alleyways and squares represents the life of its inhabitants and interrelated social relations. It should also be noted that farms surrounding the town dwellings were also hedged by high and thick walls to protect them from being buried by sand. Each of these farms has a separate entrance leading to the main gates of the city, but also squares in between farms exist for meetings and for workers to rest and perform prayers.

In contrast, the new housing was not built according to the social structure and also has no relation to the natural surroundings. Almost each house possesses an outdoor courtyard that is hardly used for any purpose of social life. Although tradition is still strong in Ghadamesian society, the result of isolated dwellings has resulted in rapidly deteriorating social interactions. The connection to public spaces is lost among claims that walking to the mosque several times a day has become difficult. This civilisational and cultural change is taking place not only in Ghadames but across the Arab world and has affected the local communities in almost every aspect of life. Privacy is among the aspects sacrificed in contemporary houses with occupants now modifying their homes to suit their cultural way of life. This particularly resonates with residents of flats.

## 7.5 Building Form, Layout and Immediate Climate

There is an argument that building forms are required only to respond to the climate, while the climate can influence the building form but does not determine it (Cofaigh et al. 1998). This is in contrast with Konya and Vandenberg (2011) and Ben-Hamouche (2008) who believe that climatic conditions have the greatest influence on building form and design. They give an example of buildings found in the tropics which should differ from those situated in temperate regions. To a large extent, the sun's path determines the form of buildings, and similarly, the traditional compact design in hot regions has explicitly been adopted to provide protection from the harsh outdoor environment. In traditional urban settlements, the choice of building form, structure, construction methods and materials is clearly related to local climate conditions. The courtyard style of housing has been always the example of hot climate dwellings (Nikpour et al. 2012, Leylian et al., 2010, Abarkan and Salama 2000, and Edwards et al. 2006).

Understanding the features and ecological values of the microclimate early in the design process could help reduce energy expenditure and excessive reliance on mechanical systems of heating, cooling and other operational systems (Ralegaonkar and Gupta 2010). Traditional architecture in hot, dry territories is so often inwardly oriented, characterised by a central courtyard (Hyde 2008). The urban fabric of the old town of Ghadames is the epitomes of adaptation to the harsh and extreme climate conditions. The building form is highly compact and tightly interwoven, built on an incline, centralised to the south-west of the oasis, forming a large complex of townhouses (Fig. 7.4).

The form of the house and relatively small plot area (25– 50 $m^2$) allows for minimum exposure to solar radiation. The spatial organisation of rooms varies according to the privacy level and functionality. It is, therefore, constructed over three storeys

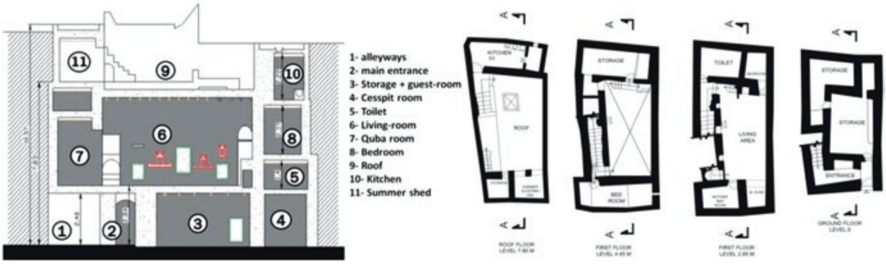


**Fig. 7.4** A typical traditional house in Ghadames

to accommodate a fully sheltered ground floor, consisting of the main entrance with stairs leading to the central living hall, guest room, storage and cesspit room. The first floor is a semiprivate family area centralised by a living room surrounded by a number of bedrooms. The central hall is built with steps leading to a mezzanine level consisting of other private bedrooms. Stairs lead up to the roof level where kitchen is found as well as shed space often used in the summer nights. It was noted that almost all houses in the old town are very similar in terms of space arrangement and organisation, and they only differ in size and number of rooms as well as the exposure level.

## 7.6 Climate and Comfort in Traditional Architecture

Enclosure in buildings can be a key design feature in promoting the microclimate and indoor comfort conditions and consequently have an effect on the heating or cooling loads (Straube 2012). Traditional dwellings are of three storeys intertwined above alleyways allowing natural daylight and ventilation to pass through regularly spaced light wells. The surrounding vegetation is integrated into the land to play a role in moderating the microclimate of the town and protecting it against sandstorms. The double height ceiling of the living room, ranging from 4 to 5 m, acts as moderator between the exposed roof and interiors. The roof aperture found in the living room is responsible for most of the daylight and ventilation brought to the house. According to Mezughi and Adawi (2003), the indoor environment of the old town is relatively cooler during daytime due to less direct solar heat gain and warmer at night because of the high thermal capacity of its building fabric. In addition, warm and cool air enters the house from different places within the passageways owing to the location of the light-well junctions and the fact that different pressure zones are created in street level due to variation in exposure to direct sun causing air movement driven by buoyancy force.

A considerable portion of solar radiation is reflected by the white external surface, and the remaining is absorbed by the relatively thick and high thermal mass materials. Shading methods also ensure less exposure to direct sun. Dwellings differ

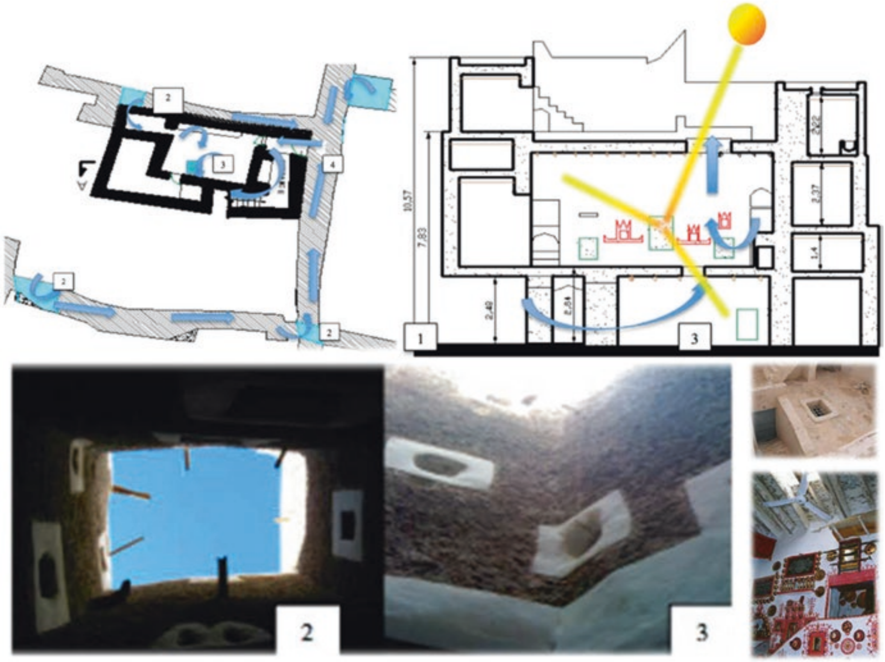


**Fig. 7.5** Natural ventilation during daytime in traditional settlements of Ghadames

in height and in the organisation of the rooms commonly found above roof level. These elements create and extend the time of shading, while parapet walls also act as shading devices (Fig. 7.5).

The first floor is noticeably larger in area than other floors as it extends to cover the pathway. The upper floor is allocated for the kitchen to ensure heat and smoke generated are driven away from the house, while the shed often faces north. The use of reflective materials such as mirrors helps distribute sufficient daylight deeper into the surrounding rooms. The relatively small openings and low ceiling height of rooms in vernacular architecture were commonly practised especially in hot climates. Cofaigh et al. (1998) stated that the height of a room must be controlled by its length to produce a better repose feeling. They also believed that if small windows are correctly placed in conjunction with white ceilings, daylight is optimally delivered across the room together with the maintenance of thermal comfort applicable throughout the year. Importantly, this concept saves the need for blinds, providing a good level of sunlight in the room while avoiding the heat of summer days.

The current study found that there are slight differences between the outside air temperature in old and new towns of Ghadames which may explain the difference in the microclimates of the two areas. Summer nights in the Sahara Desert are colloquially known as winter of the summer where temperatures sometimes drop to less than 10°C. It is therefore very important to minimise the absorption of warmth

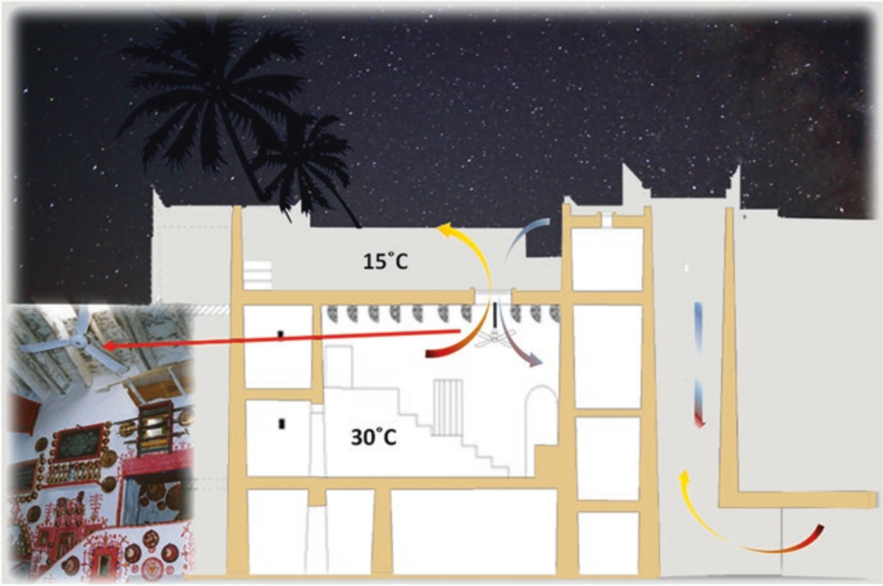


**Fig. 7.6** Night ventilation and thermal mass strategies

by fabric during the day through night purge ventilation and the use of fans to enhance air circulation. Cooler night air is heavier in density and therefore sinks down the house via the roof aperture, forcing warming air upwards with the assistance of fans (Fig. 7.6).

Natural light or sunlight is a vital component to life that plays a primordial function in humans' biological and psychological systems (Boubekri 2008). In fact, there are many considerable factors affecting the amount of the daylight available, including geographical location, weather conditions, time of the day and year and the building design form, layout and window design (size, position and orientation) (Alabid et al. 2016). The design principles of daylight should reflect the amount needed for the space as well as the expected heat generated. In addition, human well-being and productivity should be considered as a core concern of daylight principles and designers.

In the case of traditional dwellings in Ghadames, sunlight's light is often undesirable because of the heat, and hence direct sunlight is highly minimised, relying on diffused light instead. The roof skylight brings not only fresh air and daylight but also proximity to the solar cycle. Reflective surfaces compensate for the relatively small roof opening dispersing light into surrounding rooms. Windows integrated into roofs in this way ensure the daylight can enter the house with minimum exposure to outside. This also makes it possible for dwellings to stand wall to wall, further minimising sun exposure and maximising house size (Fig. 7.7).

At street level daylight is distributed in a way that maintains good visual connection to indoor and outdoor environment without compromising pedestrian thermal

**Fig. 7.7** Daylighting strategies in the old settlements of Ghadames

comfort. Semi-shaded alleyways mean that the sky is visible through light wells while protected pedestrians from its heat. The white finishing paint on the roofs and streets also contribute to increasing brightness of the space.

The water source, known as Eyin Alfaras, is a natural spring supplying the whole town with potable water through a number of streamline systems of canals that pass underneath the urban structure (Fig. 7.8). This water system plays a great part in the stability and creation of the microclimate in the old town of Ghadames. Water adds moisture to the otherwise dry climate and contributes to climate cooling in covered streets. Moreover, water flows by a gravity-fed system stimulating air current to circulate indoors, cooling and humidifying the indoor climate by latent heat exchange which in turn affects occupant thermal comfort.

## 7.7 Social-Environmental Equilibrium in Built Environment

Understanding local context and conditions (geographical location, history, economy, climate, topography and general environmental conditions) is key for appropriate design related to architectural form, space, structure and selection of materials and even creating sustainable communities. As a matter of fact, humans have developed physiological and behavioural attributes over millennia as a result of exposure to varied climatic regimes although it is subjected to culture, place or time. On both urban and building design scales, Ghadames traditional settlements showed to be highly climatically responsive and also fulfilled and respected the social values of local society at least for the time at which they were constructed. Old settlements provided considerable passive cooling strategies, good use of daylight and moreover a place where inhabitants are able to work and rest throughout the day, protected from the scorching sun and sandy hot winds. Sassi (2006) mentions strategies for sustainable architecture highlighting the significance of living in harmony with nature as it plays a fundamental part in improving quality of life.

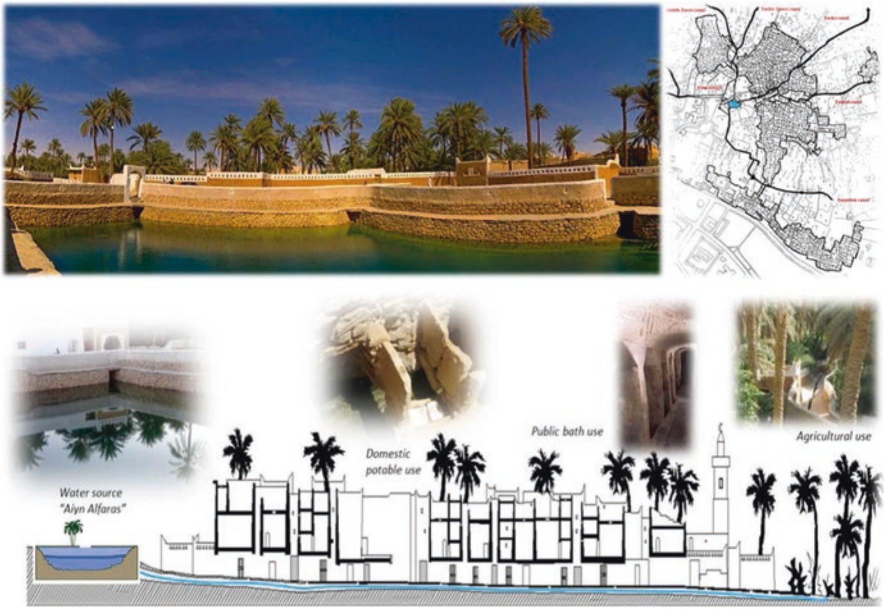


**Fig. 7.8** Natural spring water and microclimate in the old town of Ghadames

It is, therefore, clear that the builders of the old settlements thoroughly both the indoor and outdoor environments to be able to meet more than merely the basic needs. Indubitably, climate is one of the main driving and dominant forces in the solutions used to build old settlements in this oasis. However, there are other innate factors that must contribute to generate the forms of traditional architecture of the town. These consist of sociocultural and economic aspects, religion, constructive techniques, materials and resources available. The town indeed expresses its identity urbanistically, architecturally and behaviourally and is an ideal example of man living in harmony with nature (Fig. 7.9).

## 7.8 Indoor Environment and Occupants' General Perception

During the visit to the three case studies in the old town, interviews were conducted with a number of professionals. Furthermore, temperature was recorded and participants' thermal sensation was assessed. Temperature measurements were taken in the central hall on the same day as the interviews, every 15 minutes for an hour as demonstrated in Table 7.1. The Table readings are an average of all records over that hour. Dear et al. (2013) found that comfort can be achieved at temperatures between 25.5°C and 29°C with air velocity between 0.2 and 1.4 m/s. However, Arens et al. (2013) found that the majority of participants were comfortable at air speed ranging

**Fig. 7.9** Culture and environment balance in traditional settlements of Ghadames

**Table 7.1** Indoor temperature readings in traditional house

| Physical Parameter | Case 1 | Case 2 | Case 3 |
|---|---|---|---|
| Local time | 14:00 pm | 15:10 pm | 16:05 pm |
| Globe temperature | 30.0°C | 33°C | 31.0°C |
| Wet bulb temperature | 20.0°C | 21.5°C | 19.8°C |
| Air speed | 0.11 m/s | 0.04 m/s | 0.07 m/s |
| Air temperature | 31°C | 32.2°C | 31.5°C |
| Relative humidity % | 36% | 38.7% | 33.1% |

from 0.05 to 1.8 m/s, relative humidity of 60%–80% and temperature between 26°C and 30°C.

Surface temperatures of walls, floors and roofs were measured to find out the mean radiant temperature (MRT) that most likely denotes how thermally comfort the inhabitant is. Table 7.2 shows surface temperature records inside the living room during the visit to the *Dar Amazagra* house in the old town of Ghadames.

In some studies such as Ealiwa (2000) and Gabril (2014), comfort temperature was found to be highly dependent on outdoor temperature and also on surface temperatures. An equation has been derived to determine the comfort temperature based on MRT for Ghadames terrain as following:

$$T_{\mathrm{comf}} = 0.46T_{\mathrm{mrt}} + 16.7 \pm 2$$

**Table 7.2** Comfort temperature inside traditional dwellings of Ghadames

| Surface | $T_{wall\ 1}$ | $T_{wall\ 2}$ | $T_{wall\ 3}$ | $T_{wall\ 4}$ | $T_{Roof}$ | $T_{Floor}$ | MRT |
|---|---|---|---|---|---|---|---|
| Temperature | 31.9°C | 31°C | 29.4°C | 32.3°C | 31.2°C | 28.6°C | *31.7°C* |

**Table 7.3** Professionals' views on traditional dwellings

| Opinion | Reason | No. of interviewees | % |
|---|---|---|---|
| Agree | Reduces the building cost and land use<br>Suitable for climate<br>Similar concept has been already tested | 10 | 83.33 |
| Disagree | Unless considering the new space layout<br>More likely to be unaccepted in the society | 2 | 16.66 |

According to the MRT found in traditional houses, the comfort temperature can be estimated as

$$T_{\text{comf}} = 0.46 \times 31.7 + 16.7 \pm 2 = 31.28°\text{C} \pm 2$$

This result is in agreement with a previous study carried out in 2013 to investigate thermal comfort boundaries by surveying a number of traditional houses in Ghadames. Occupants were found to be most thermally comfortable at temperatures of 29°C–32°C (Alabid et al. (2014)).

During the interview with a number of householders, the possibility of reusing of the traditional house concept in future housing designs was discussed while illustrating how it could contribute to reducing the constructional and operational costs. 83% agreed to this and were convinced of its robustness as shown in Table 7.3. Only 17% disagreed with the reuse of the concept by the reasoning that the interior design and layout of the traditional house concept would have to be entirely changed to meet todays' requirements. Furthermore, they highlighted the fact that the younger generation are less likely to be able to adapt to this traditional way of life. The table shows interviewees' opinions and reasons for agreeing to the statements.

## 7.9 Conclusion

In vernacular architecture, culture and climate are no doubt the dominant concerns of building professionals. Together with other factors including availability of construction materials, resources and even the technical capacity, they have influenced the final outcomes of the local settlements. Builders of Ghadames old town are successfully dealing with one of the harshest climates of the Sahara Desert bringing harmony between natural and man-made systems while still representing local architecture and lifestyle. This study carried out field surveys to investigate how effective the old settlements of Ghadames are in addressing environmental and social aspects and, equally, the perspective of the locals regarding the current indoor and outdoor conditions. Interviews with locals highlighted the effectiveness of the old settlements with particular respect to social life and family privacy reflected in both the indoor and outdoor climates. Also, it should be noted that indoor thermal comfort was achieved, the majority of the time owing to the minimal exposure to sunlight both indoors and at street level. Furthermore, the combination of natural ventilation and thermal mass in the traditional homes together with night purge strategies helps maintain comfortable indoor temperatures. Water plays a significant role in moderating microclimate thermal conditions and creates a synergic system promoting community cohesion and outdoor interaction. Finally, the majority of building professions agree on the concept of reviving the old settlement design strategies and adapting them to modern life as a sustainable architectural method without compromising cultural values and traditions.

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