LEARNING FROM THE PAST: ASSESSING SUSTAINABILITY STRATEGIES OF THE HERITAGE BUILDINGS THROUGH LEED RATING SYSTEM

(CASE STUDY OF GHADAMES CITY)

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ABSTRACT

In the recent dialogues of the sustainable buildings, the relation between heritage architecture and future development has taken an important standing. This because the techniques of traditional buildings have resisted all life and environmental conditions for thousands of years, where human's comfort and needs are Satisfactorily met through full response to natural resources and climatic conditions and still. However, various passive design strategies and features are not intelligibly incorporated into latest environmental designs and construction solutions. This can be ascribable to the unawareness of their ability to resist current conditions or those unconformity with future sustainability requirements. This study tries to advance the sustainability strategies of heritage buildings and encourage their utilization in the future development. The old city of Ghadames (OCG) will be involved as a study case to determine the extent heritage building features met satisfactorily to the current available sustainability rating systems. Many guidance have been emerged to achieve higher standards of sustainability in new

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buildings as well as measuring the environmental performance of the projects that involve historical places. In terms of achieving the paper aims, the researcher will use the Leadership in energy and environmental design (LEED) as a guidance of green building design to promote a framework for assessing the sustainability criteria of Ghadames city. LEED tools deal with sustainability of the sites, water efficiency, energy saving, materials and waste management, indoor environmental quality. The researcher will also consult relevant literatures in the field. The study concluded that Ghadames city is an outstanding example of an environmentally engineered desert city, and its sustainable techniques not only performed well against previous conditions but also can be used in both current and future sustainable development.

Key words: Assessment, Ghadames, Heritage Building, Leed, Sustainability, OCG, Thermal comfort.

1- Introduction

The Old city of Ghadames is an oasis town located in the western part of Libya, approximately 600 km to the southwest of the capital, Tripoli near the borders with Algeria and Tunisia. It is located in the desert region of the country, influenced by desert climate conditions and characterized by very hot summertime, low humidity, low rainfall , high temperature degrees during the daylight, and many sandstorms. In winter, the weather is extremely cold, especially at night. As a UNESCO world heritage site, Ghadames is known to be as "the pearl of the desert". The old city of Ghadames (OCG) provides an exceptional example of sustainable architecture, adapted to its site, prevailing conditions and locally available resources for over 4000 years and still. The population of the

city relied on natural environmental design strategies to fight the dramatic extremes in a desert climate. Passive cooling techniques such as natural ventilation, thermal mass, shades are all incorporated in the design of city as well as natural lighting in order to reduce the energy demand for cooling while maintaining thermal comfort. An understanding of traditional environmental architectures is fundamental for improving the architectural design of today. This places engineers, architects and city planners in real competition for the design and construction of buildings that are resistant to extreme climates, both now and in the future. In this paper, environmental design characteristic of OCG will be analyzed to determine where they will perform well or poorly under today's green building rating systems.

2- General Overview Of Sustainable Architecture Design Guides

Environmentally sustainable buildings are usually assessed under rating systems such as BREEAM, LEED, Green Star or CASBEE, according to K.M. Fowler E.M. Rauch "These rating systems require varying levels of specialized sustainable design knowledge to be effectively used. " All of them follow the general principles of protecting nature and natural environments, focusing on quality, eliminating toxic chemicals, limiting resource consumption, and recycling or reusing resources (Linda Shetabi, 2015). The LEED Rating System is a global Sustainable architecture design guide of the U.S. Green building council (USGBC) which focus on the design features of the project across a range of criteria in five credit categories: Sustainable Sites, Materials and Resources, Energy and Atmosphere, Water Efficiency, and Indoor Environmental Quality. In addition to existing categories, recently

released LEED v4 brought together existing and new credits and created two additional categories: original priority and innovation in design. However, "a LEED rating system designed specifically for the restoration and adaptation of heritage buildings is not usable. Instead, existing LEED rating systems like LEED Existing Buildings: Operations & Maintenance have been used to certify heritage buildings." (USGBC 2012)



Figure1: LEED Rating System tools

3- Assessing the sustainable design characteristic of the old city of Ghadames (OCG)against LEED rating system

LEED Existing Buildings Operations & Maintenance tools: Sustainable Sites, Materials and Resources, Energy and Atmosphere, Water Efficiency, Indoor Environmental Quality, original priority and innovation in design are used to analyse the environmental design characteristic of OCG in order to determine where they perform well or poor under today's green building rating systems.

3-1 Sustainable site:

The Sustainable Site category of LEED rewards decisions about the environment surrounding the building. It focuses on restoring project site elements, integrating the site with local and regional ecosystems, maximize Open Spaces, alternative public access as well as enhances the use of bicycle and pedestrian paths.

Old Ghadames' architecture is site-specific, adapting to tough environmental demands: harsh sun; high day and low night temperature (Abidi L, Alcorn A, BelloC). The discovery of ain alfaras was the reason for the settlement of people in this desert. The city built near this main source of water which was used in the construction along with the locally available materials such as Clay bricks, stones, gypsum ,and palm derivatives. The city of Ghadames naturally protected from the worst natural factors. 'The city's orientation, in a southerly north easterly direction, ensured protection from the dominant winds and maximum ventilation. The presence of a hill south of the city provided protection from the sandy southern winds which pass over the city to the oasis' Abufayed A(2003). While the other sides are planted by palm forests act like buffers to protect the city from sandstorms.

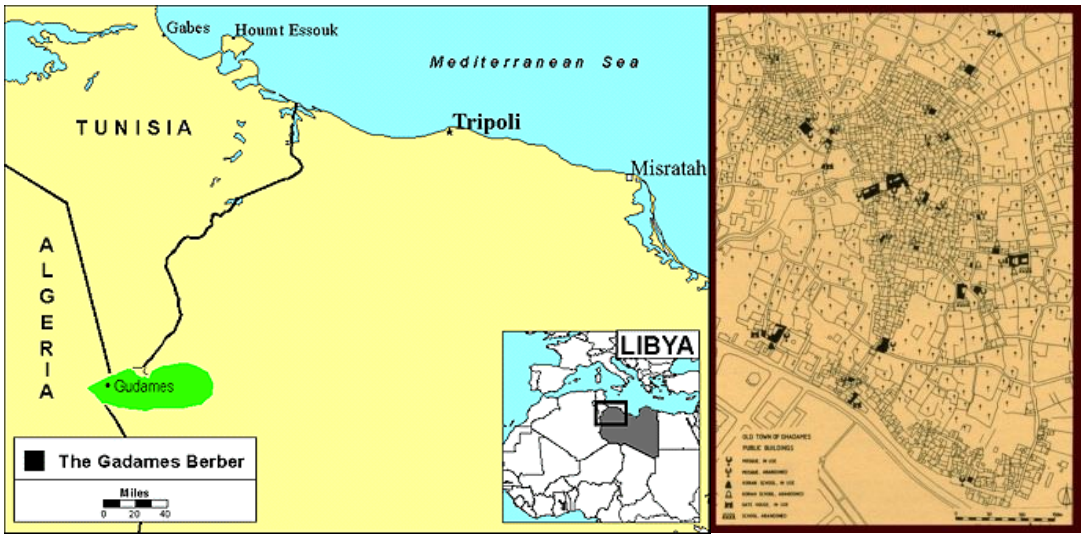


Figure 2: Old city of Ghadames map and location

From the top perspective the city is seen as one whole body and the External borders is the only component can be distinguished. This because city buildings are connected with each other. The city streets are covered in order to reduce the external surfaces exposed to direct sunrays as well as providing upper pedestrians bath ways to facilitate the movement of women from one place to another within the city.



Figure3: The compacted fabric of OCG

Women can visit their neighbours and relatives without having to get out. In other words, the movement of people is divided into two levels. Men walk bath takes place on the ground level while the upper level reserved for women. This division was in response to social and privacy considerations.



Figure4: Ghadames roof paths, strictly for women who use them to move from area to another.

THE OCG grew into seven integrated neighbourhoods. Each neighbourhood had its own social, religious and commercial facilities, public squares and gates. (Abufayed A & Rghei A 2005). A network of streets links the City together and allow pedestrian and bicycle to move comfortably, while cars are not allowed to enter the city as the population relayed on foot and animals in their mobility. However, "Some vehicle streets have been accommodated in the OCG, and other carefully located access points could be added without adversely disturbing the city fabric" (Abidi L, Alcorn A, Bello C).



Figure5: Streets network of the old city of Ghadames

Streets also have Seating along the way, for resident's particularly elderly people who need a break. These seats are mostly found under the existing lighting and ventilation openings on the ceiling in order to provide a comfortable environment thermally and visually during walking.



Figure 6: seating areas along the walk way

3-2 Indoor air quality:

Indoor environmental quality credits promote increased Ventilation, Indoor Chemical & Pollutant Source Control and access to daylight .Recent studies have shown that traditional passive buildings may be strong and healthy enough to provide comfortable conditions for several decades to come, even with the changing climate (Roaf S, Nicol F & Crichton D,2005:225)**.** The main energy consumers in building are heating and cooling load in summer seasons particularly. So, in extreme climate conditions, natural ventilation and day lighting designing poses a greater challenge to building designers. Littlefair et al. (2000) defined the role of urban morphology, street patterns, building geometry, and other local features like vegetation and natural ventilation. However, local builders of OCG have recognized such effect and adopted certain building techniques to maintain sufficient access of fresh air and daylight in dwellings throughout the year Alabid J, Taki A, Painter B, (2015)).The oasis of Ghadames surrounded by palm trees from all sides, making the oasis enclosed by shade cooling the passing wind before entering the city. The covered walkways and its openings catch the cold air and move it through the city as well as getting rid of hot air out.



Figure 7: The covered walkways openings

The house is so often surrounded by adjacent houses from three or four sides with light-wells (void) interposed in between. These light-wells play an important role in ventilation, especially during summer. Houses relay mainly on sky light openings and room voids in providing cross ventilation . Air penetrate the house through relatively small room voids approximately 15x25cm crossing all other spaces to leave the house by the 1m² skylight aperture. Conversely, cool air enters through the roof opening and warm air is extracted away via the same ventilation voids. Roof opening is covered by Sealed and porous plank shutters against climate conditions and insects that invading dwellings in summer time.

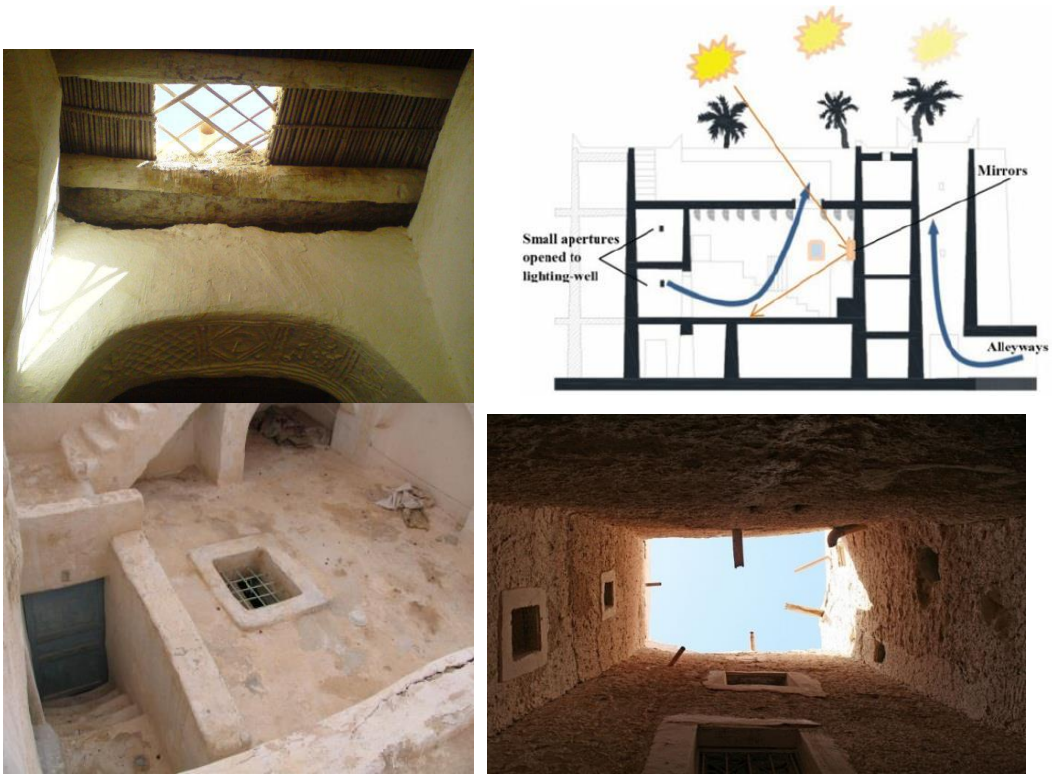


Figure 8: Ventilation strategies of the houses

For enhancement the indoor air quality, family traditional customs and cooking take place in roof level. Al-Zubaidi, (2002) also stated that the main reason that kitchen was placed on the roof is to extract heat and smoke away from the house and therefore there is no heat generated from home appliances and such activities inside the dwelling. In addition, indoor air quality also separated from where building materials do not release any toxic substances harmful to human health.

There is no doubt that the higher the size of the windows, the higher the amount of day lighting entering the interior spaces, at the same time, raising the indoor temperature. For this reason, local builders made the size of the openings as small as possible in order to reduce the proportion of heat gain. On the other hand, to enhance internal day lighting, reflective mirrors and brass motifs are employed to reflect the light that

penetrate through the skylight aperture in the roof and consequently to deliver the daylight into deep areas.



Figure 9: reflective mirrors and brass for daylighting efficiency

Alabid J, Taki A, Painter B, (2015) pointed out that these reflective devices on internal walls not only for decorative propose but rather to optimize indoor visual environment. Moreover, to intensify reflected solar radiation the roofs and internal walls are painted with white colour, as the lighter the colour the more reflective the surface. The graph below shows the influence of reflective surface on the internal visual ambience.

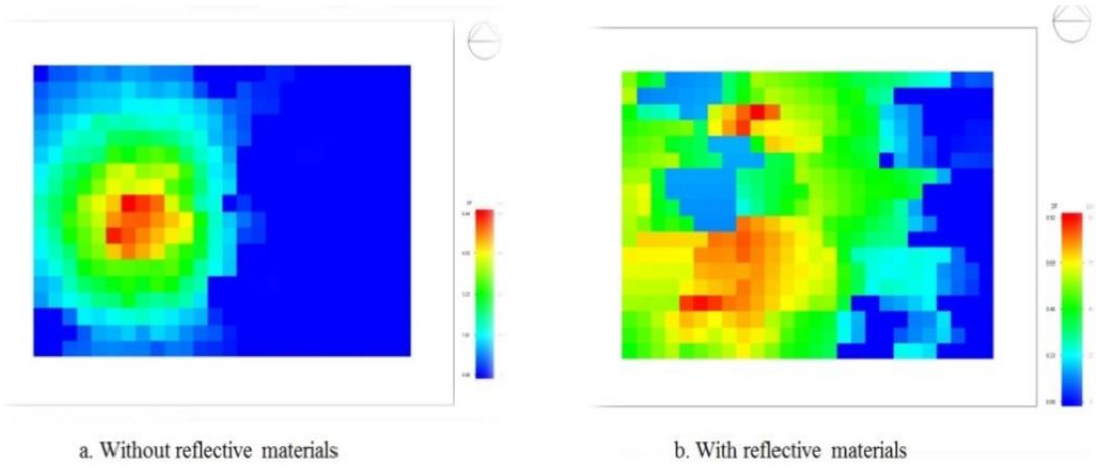


Figure 10: reflective surface impact on the internal visual ambience

3.3 Materials and Resources:

The Materials and resources credit category focuses on minimizing the embodied energy, the use of locally available materials and other impacts associated with the extraction, processing, transport, maintenance, and disposal of building materials. The city of Ghadames is filled with many natural resources such as the stones that are available in different types, for example, sandstones for construction, two sided stones of black and white for paving. There is also limestone for roofing, arches and domes. Lime is also available to whiten the walls, and clay. The city is likewise plentiful in its soil in various colors for making building blocks. Groundwater is also available in abundance, not to mention the vast palm forests that provide the most significant elements of resources, that is, wood and palm leaves.

Abufayed A.(2003) noted that "All building materials are available locally. Construction and rehabilitation are performed by local skills employing traditional methods developed over many centuries". These natural resources are renewable, environmental resources where they can be enriched and reproduced, and easily transported and used. These materials can be obtained from the local environment where the local people are superior to their use. Local building materials have a great role in the sustainability of the local architecture of the city of Ghadames where they reduced the risk and general damages because the environment is not greatly affected by the building debris that are attributable to the local and natural materials where they can be easily disintegrated and used again in the construction, the extent of carbon emissions from such materials is kept at a minimum as well. In terms of

heat capacity, the local building materials are of high thermal capacity depending on their thickness (the greater the thickness is, the heat capacity is increased) where they have the ability to store the thermal energy during daylight hours, then spread it during the night, that is, after the absence of the heat source, thereby it realizes the thermal balance between the heat gained and the heat lost, consequently it reduces the influence of external heat on the inside of the building. The insulating materials such as clay and wood were also used for heat insulation, particularly in the ceilings; meanwhile, the lime with its white color is a good heat insulator that reflects the sunlight and where it is used as polish for walls and for eliminating insects

3-4 Energy and atmosphere

The energy and atmosphere category addresses energy-efficient design strategies, energy use reduction, and alternative energy sources. Ghadames urban and architectural design provides an effective zero-energy climate control. Many streets are directed toward the oasis garden in order to temper the coming air by evaporating cooling before entering the city. The buildings are also carefully sited close to the prevailing wind direction. In addition, natural ventilation and day lighting strategies that are employed in house design led to reduce the total energy requirement. “Daytime lighting of covered streets, alleys, passage ways and buildings utilizing solar energy provided a clean and sustainable source of energy indefinitely” Abufayed A. Mud, rock, gypsum, water and data palm were the natural available construction materials available to Ghadamsi craftsman. All of which have been extracted or collected from the site of the city. So, there was no need for energy for materials, transporting or

for mixing material and construction as all done by hand. Moreover, Building materials are all zero-energy and zero-emissions, except for the gyps plaster, used internally and extremely that gives the beautiful white finish to the city. However, "A simple earth based doggie plaster, requiring no added energy, would be preferable. This would also make the Ghadames building materials entirely free of applied energy." Abidi L, Alcorn A, Bello C.

Passive solar energy and firewood were traditionally used as a source of energy. Firewood was used for making gyps plaster, in pottery making as well as in cooking while other activities are relayed in solar radiation or done with muscle power.

3.5 Water efficiency:

Water efficiency section addresses water holistically, looking at indoor use, outdoor use, specialized uses, and metering. The water spring of the Ein Al-Faras is considered as the first cause of foundation of this city. It is the core of the architecture center around which the city was founded. (Ealiwa, 2000) also agreed that The discovery of the artesian spring called Eyn El-lfaras (horse's lake) was the impetus of the town existence that built on an Oasis of an area of 310.3 hectares surrounded by massive sand-dunes and mountains. The city of Ghadames was marked by the optimal management of the water source where a water clock was placed for the Ein Al-Faras spring water for the equal distribution of water according to the need and priority. The water clock displays a hopper that takes the shape of a small structure of a cellar located under the Younis mosque, a cavity under which the water passes and from which it is

divided into five water streams in the order, that is, drinking water for human beings and animals, and farm watering and washing.



Figure11: Shows Elkadoos" and the person inside the distributor of water and the water tunnel.

One can notice that there are underground water-streams passing underneath the urban fabric of the town ending at green fields surrounding the town.

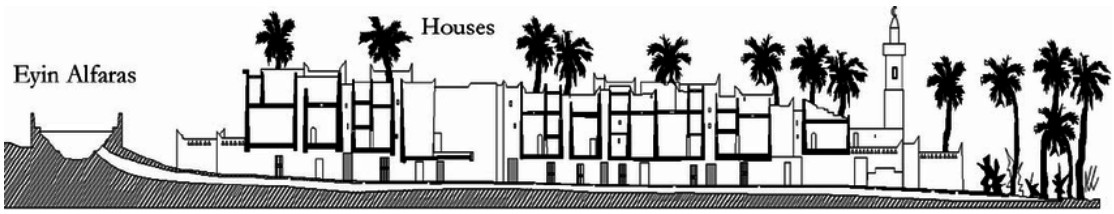


Figure12: underground water-streams

With regard to the other topic represented by recycling the black water and human waste, the toilet has been designed to pour its waste in a small room located under the toilet, and emptied once a year from a small side opening that exists on one of the external sides of the house, then it is

dried and becomes easy to crushing where it is used as an agricultural fertilizer.

3.6 Regional Priority:

The concept of regional priority Credits was introduced in the LEED rating systems to incentivize the achievement of credits that address geographically specific environmental priorities . Those who chose the location of Ghadames and founded on it this everlasting city is no more than two men, either an intellectual engineer and a skilled thinker or a good man that was given consciousness by God Almighty to reside in this fertile land that is free from severe natural barriers. One of the most important factors for the establishment of the city of Ghadames is the flow of water from the Ein El-Faras Spring, the economic hinterland and availability of the security factor. Under the very severe climate conditions, the Ghadamsi builder and thinker was able to create independent climate conditions inside the city as a result of his innovation of numerous unique techniques at the level of the desert construction. We find that the links between the Ghadamsi architecture and the regional trends are agreeable to the exchange scientifically. This becomes clear about how to coexist with the difficult climatic conditions and reflect its status internally (inside the city in general and the house in particular) where the direction was intended for the inside. This affected the city's shaping and planning where its architectural structure seems from the above as a single constructional mass infiltrated by certain open areas. As regards the planning aspect, it is of a compact organic pattern and this considered to be one of the best solutions for the improvement and quality of the inside environment by protecting the walls from the

temperature changes by exposing the lesser possible surfaces to the outside.



Figure 13: an aerial picture shows the city's architectural pattern as a single constructional mass

The streets are infiltrated by the city's structural mass, so that the pedestrian on these streets cannot feel the very hot climate outside because they were covered by the extension of certain rooms from the upper floor by an exchange between the opposing houses on both sides of the road to isolate them thermally from the outside. The streets are decorated by the celestial openings for the above from time to time forming that mixture between the shadow and the light in an amazing rhythmic harmony giving a lighting and occupying the pedestrian with excitement. In addition, from the security point of aspect and when there is any incident of attack on the city, the enemy loses his own way inside its dark lanes and streets where the inhabitants of Ghadames close the sky-blue openings so that their streets can be in full dark.

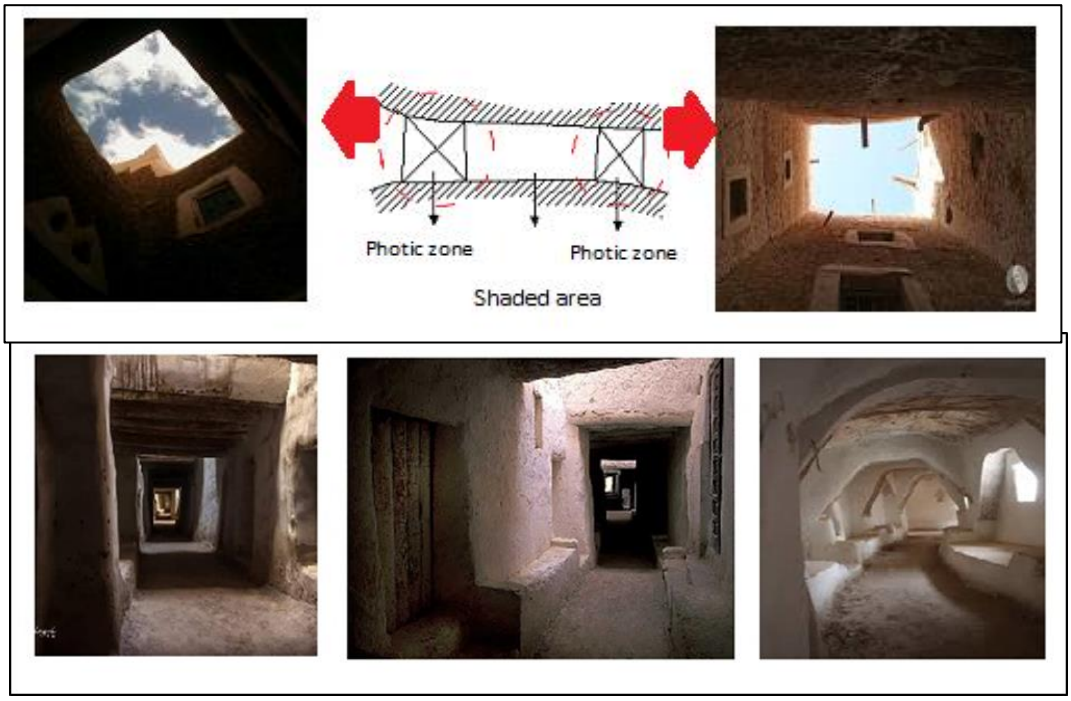


Figure 14: Photo shows the sky openings to the city roofed corridors

On the other hand, the width of the streets at one time narrows and at the other time widens to shape roofed and non-roofed areas. The strength of the refraction of the routes of the streets, sometimes strengthens and over time becomes straight. These privileges demonstrate the factor of surprise in the line of walk in which the winds break up and weaken their force to be interspersed with favored breezes. These breezes circulate horizontally from the streets and vertically from the celestial openings sending a movement of favorite circulation that softens the weather condition.

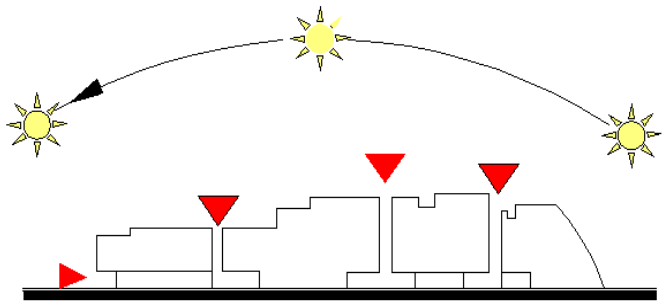


Figure 15: Section shows how the sun rays and air enter to the streets

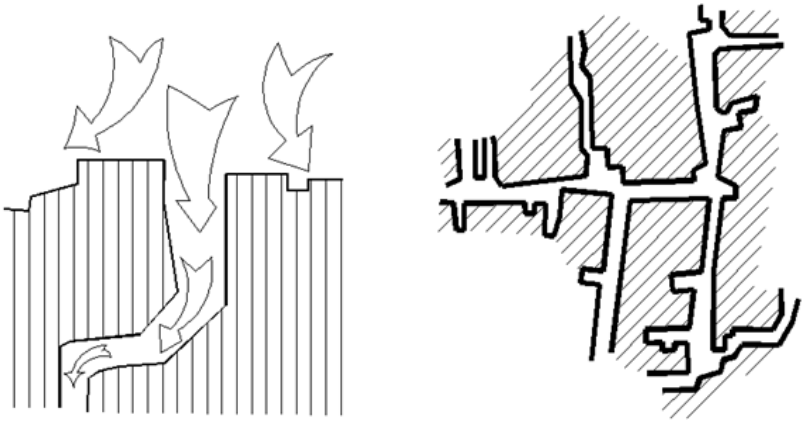


Figure 16: Refraction of the streets and the differences in width

The city is aligned from the outside by a 6Km fence for political and security purposes, in addition to palm forests and agricultural fields which play an important role in the protection from the summer's very hot winds that are seasonal winds carrying dust.

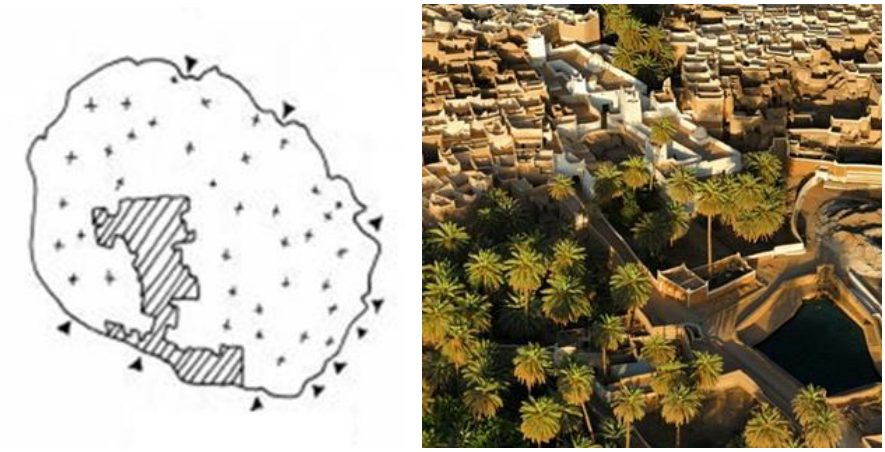


Figure 17: palm forests surrounding the city of Ghadames

3.7 Innovation and design process:

The purpose of this LEED category is to recognize projects for innovative building features and sustainable building practices and strategies. Maybe one of the most significant elements of innovation in the city is its collective formation as a whole. It is based on the protection from the hot desert climate and many sandy storms. Abufayed A.(2003) argued that "using the same architectural patterns and the same building materials in all buildings resulted in a unique Ghadamsi architecture that is original, simple, economical and attractive". Palm trees surrounding the location create shadows around it, and Ein Al-Faras water spring provides a flat area of water, Consequently, three elements, namely, the water, shadow and winds help one another to ease the climate of the area as a whole, where the winds enter and pass through the shadow and the flat area of the water to enter across the ventilation openings that exist in the streets and expel hot currents of air through the natural convection streams, also the covered passages for protection from the sun's rays and the openings

existing above to attract the cold air from the outside to flow inside these passages.

As for the inside of homes, the Ghadamsi thinker has created these upper openings in the form of a square-shaped windows in the ceiling of the main dining room the area of which is 75m2 to provide the lower vacuums with appropriate quantities of light, where the light falling from above is reflected on the brassware hanged on the walls, and the mirror that decorate the walls with large numbers. This who enters the house may be surprised of the large number of mirrors, they reflect the light falling on them and spread it in the interior vacuum to increase the quantity of the internal lighting. The upper opening is interlocked with palm branches to protect those who are present at the surface; therefore, the upper opening has several functions such as lighting and ventilation. It also protects the residents from the glare of the sun which is one of the problems prevalent in the desert climate. The existence of the opening in the ceiling makes it above the level of sight where the blueness of the sky emerges to delight the eye and significantly comfort it from looking at the direct glared sunlight that appears in the window's traditional status (through the walls).

As to the social point of aspect, the city of Ghadames is designed to observe the full separation between men and women in the external surroundings (out of the home) where the required social privacy is realized for religious and customary considerations. The skill of the Ghadamsi thinker is demonstrated in his innovation for the unique solutions in creating upper passages for women, connecting between the

homes from above the rooftop where roofing of the streets from the above has allowed the extension of such passages without interruption.



Figure 18: shows the upper passages for women

As to the men, they have had passages of the city in the level of the ground with seats for sitting on both sides of the road, either for older people according to their health or for men's different meetings, tribal or entertainment.



Figure 19: streets' meeting and seating zones

The Ghadamsi woman has given variable to the creating an internal environment. Upon entering the Ghadamsi home, one is surprised with the large quantity of ornaments of shining colors, the red prevails, blue, yellow and green are found in all walls with accurate details and with unique drawings, together with the emergence of the white color that gives color to all internal walls and most of the external ones, and also the shining brassware, small mirrors and hollow and prominent shelves. This environment is nothing but a move from the desert space of the neutral colors to create a world of charming beauty pressing for hope and life. The most important of all in the city of Ghadamis are those unique innovations that contributed to softening the city's internal climate and helped in making a sound environmental, social, religious and psychological life.

4- Conclusion

With regard to its construction and planning, the city of Ghadames is a good example for sustainability of its architecture where it resembles the environment by taking advantage of the natural resources by employing all the conditions and different factors surrounding the location to reach a sustainable environment.

The materials used in the construction of the city of Ghadames are distinguished by the consumption of energy, the cost savings and lacking of the negative influence on the environment. The optimal use of the construction materials complying with the environment and agreeable to the recycling and manufacturing is one of the fundamentals of the sustainable architecture.

Full dependence on the resources, local labor, the optimal exploitation of water resources by distributing them equally and justly and the exploitation of human waste have played a significant role in the city's sustainability and preserving its natural resources.

The sustainability was also achieved in the city through depending on the natural lighting and natural ventilation, and consequently abandoning the utilization of energy required for the operation of electricity and that utilized for running the A/C equipment.

According to the analytical study of the city of Ghadames and its evaluation with the modern sustainability standards, we conclude that the sustainability strategies applied in the city are not only appropriate for resisting the previous conditions, but also they can be used successfully in the current modern designs and in the sustainable future development.

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