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## LIVING IN HOT ARID ENVIRONMENTS; AN OVERVIEW OF THE SOUTH AFRICAN EXPERIENCE

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## LIVING IN HOT ARID ENVIRONMENTS; AN OVERVIEW OF THE SOUTH AFRICAN EXPERIENCE

### Abstract

One of the most significant challenges facing the world today is the ever increasing tension between technical development and the environment. High environmental quality is a key term that researchers are striving to accomplish, in view of the catastrophes the world is now facing. Our nation and the world have an enormous need for Sustainable architecture. This demands that we rethink the extractive habits of our industry in countries, and reconnect them with the natural world and ecosystems that support life and look for advanced solutions for energy, water, and climate change. The driver of these needs is humankind. People all over the world are calling for a higher quality of the built environment, for improved environmental stewardship, energy and water management, and greater social equity... a better quality of life. Sustaining urbanism in hot and arid regions through social and cultural aspects is an essential factor in achieving optimum living conditions. This contributes mainly to the conservation of the human ecosystem and hence leads to the ability to adapt to cultural and environmental changes. Moreover, sustaining the environment in hot arid regions improves energy efficiency as well as the effectiveness and usability of dwellings. The idea introduced in this paper is handling the problem of cultural reflections on life conditions in deserts from a wider spectrum. The problem of inconvenient living conditions in such harsh environment is a complex one, requiring input across many disciplines to identify appropriate remedial steps and management strategies. Over the past few decades, there has been a greater demand in the field of architecture to achieve design strategies for comfortable living conditions in this challenging area, drawing on traditions and knowledge obtained from research into landscape development and the natural environment. This paper analyses the design strategies in hot arid regions through three main case studies in North African countries, sharing the same climatic conditions, where the inhabitants achieved effective management of their local resources in order to adapt to their climate and live in more appropriate, socially stable and healthy environment. The three applications are Matmata in Tunisia, Mizab Valley in Algeria and Siwa oasis in Egypt. The paper particularly focuses on the strategies that have been used to practice the techniques of controlling the environment conditions in terms of Climate Responsive Architecture, Indoor Comfort and Energy Efficiency, thus attempting at solving sustainability problems in hot arid regions, and improving the urban and environmental quality of its urban spaces for the well-being of inhabitants. In order to balance between the economic environment and the socio culture, there are Design strategies to be set to meet the demands of desert climate and character on economic basis and at the same time provide social equity. The Possible Methodology for applying these strategies can be summarized as: - The survey of existing built environments in hot arid climates. - Giving detailed examples of how they adapted their buildings in such climates; through introducing the house description in each case study and analyzing it. - Concluding lessons and design strategies that can be learned. Some simple design criteria can reflect how sustainable development can be achieved in desert architecture. For instance,

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# LIVING IN HOT ARID ENVIRONMENTS; AN OVERVIEW OF THE SOUTH AFRICAN EXPERIENCE

*Gaber, Riham Muhammed*<sup>1</sup>

## **ABSTRACT**

*One of the most significant challenges facing the world today is the ever increasing tension between technical development and the environment. High environmental quality is a key term that researchers are striving to accomplish, in view of the catastrophes the world is now facing. Our nation and the world have an enormous need for Sustainable architecture. This demands that we rethink the extractive habits of our industry in countries, and reconnect them with the natural world and ecosystems that support life and look for advanced solutions for energy, water, and climate change. The driver of these needs is humankind. People all over the world are calling for a higher quality of the built environment, for improved environmental stewardship, energy and water management, and greater social equity... a better quality of life.*

*Sustaining urbanism in hot and arid regions through social and cultural aspects is an essential factor in achieving optimum living conditions. This contributes mainly to the conservation of the human ecosystem and hence leads to the ability to adapt to cultural and environmental changes. Moreover, sustaining the environment in hot arid regions improves energy efficiency as well as the effectiveness and usability of dwellings.*

*The idea introduced in this paper is handling the problem of cultural reflections on life conditions in deserts from a wider spectrum. The problem of inconvenient living conditions in such harsh environment is a complex one, requiring input across many disciplines to identify appropriate remedial steps and management strategies. Over the past few decades, there has been a greater demand in the field of architecture to achieve design strategies for comfortable living conditions in this challenging area, drawing on traditions and knowledge obtained from research into landscape development and the natural environment.*

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## **KEYWORDS**

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## **HOUSES IN MATMATA, TUNISIA**



Figure 1: The Lars Family House. <http://theswca.com/travel/tunisia/matmata/matmata.html>.

### ***Climatic Adaptation***

Matmata is allocated in southern Tunisia; it is affected by intense desertification with dramatic consequences on the physical and human environment. The mountain town of Matmata is the home of distinctive underground dwellings of Les Troglodytes. Matmata is also home of Sidi Driss, where the interiors of the Lars family house are allocated. It is a complete village was built in mountains" under the ground", all the buildings built looked like caves. Houses interior climate was moderate, warm in winter and cool in summer. (<http://theswca.com/travel/tunisia/matmata/matmata.html>)



Figure 2: Building In The Mountains. <http://theswca.com/travel/tunisia/matmata/matmata.html>.

Figure 3: The Cave Homes of Matmâta. <http://theswca.com/travel/tunisia/matmata/matmata.html>.

The people adapted their house to this climate as they dug their houses under 7m, each room is dug even with the courtyard like the caves. There is a barn and reservoir on the ground, inhabitants do bathing and washing around the reservoir. The entrance is allocated at the same level of the courtyard. "Skifa" is used to connect the entrance and the courtyard, it is also used as a public space for service, dining and taking a nap. The lower part of the walls is often painted white. Several rooms are located around this crater, used for living, sleeping or storing food. From the north of the courtyard to the entrance is a gradual slope which prevents the courtyard from becoming puddles. Houses have second floors used as a granary (May Umi;2006).



Figure 4 &5: The Courtyard of the house. <http://theswca.com/travel/tunisia/matmata/matmata.html>.

The advantage that all walls and roofs are fully recessed is that the climatic conditions are better than houses fully exposed to sun in this hot arid climate. The kitchen is small in size and very simple in design. All cooking stuff are put on built in tables of small height. Bed rooms also small in size and always allocated on the second floor. The roof is dome shape for better cooling (<http://theswca.com/travel/tunisia/matmata/matmata.html>).



Figure 6: Master Bedroom. <http://theswca.com/travel/tunisia/matmata/matmata.html>.

Figure 7: The kitchen of the house. <http://theswca.com/travel/tunisia/matmata/matmata.html>.



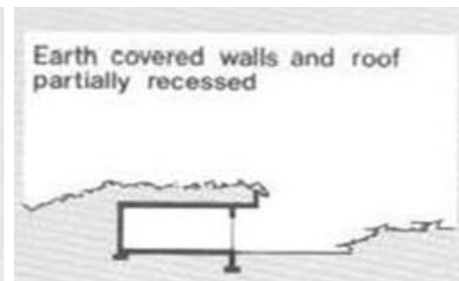
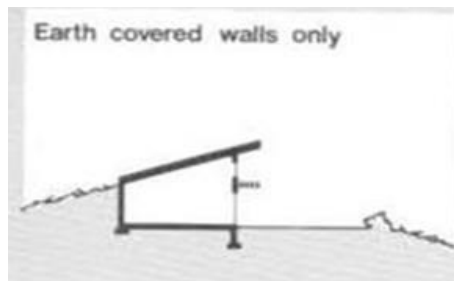
Figure 8: Living Room In The House. <http://theswca.com/travel/tunisia/matmata/matmata.html>.

### *Cultural Adaptation*

Matmata is a name of Berbère origin, indeed several thousands of years ago this village was a refuge, and the berbères of this area lived in special house dug under the ground to escape from high heats of the days of summer and from the cold of the night. The current inhabitants of the area are mainly the Berbers, influenced by the Arab culture, and slightly by the tourist activity that knows this place. Their Arab culture was expressed on their buildings in the way they built their homes in a way of privacy and separation of the sitting areas from bedrooms. The main living room, where all the family gathers, consists of cushions on the ground and built in fire place to be used in winter ([http://www.xcess.info/matmata\\_tunisia\\_aen.aspx](http://www.xcess.info/matmata_tunisia_aen.aspx)).

### *Building with Local Materials*

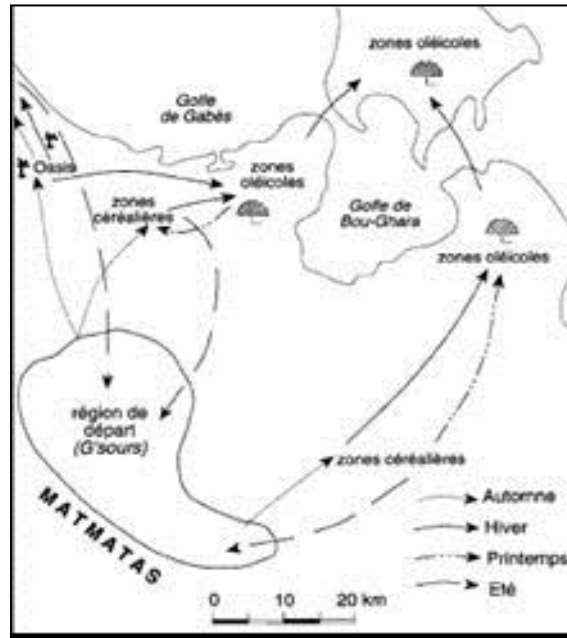
Inhabitants of Matmata built their homes in mountains, hence their local materials were the materials of mountains, i.e, their dwellings are built with earth. They intended to build their homes totally covered with earth, even the roof, to escape from the direct exposure to sun radiations. This gave their dwellings cooling properties of earth and thus better indoor living conditions (Gideon Golany;1998).



**Figure 9: Shows That Earth Covering Walls And Roofs Gives Better Living Conditions Gideon Golany ;1988.Earth-sheltered dwellings in Tunisia: ancient lessons for modern design.**

### *External Environmental Adaptation*

In the Semi-nomadic or colonial period, the colonial authorities declared the part of Jeffara and Nefzaoua to be a “military area”, so that the protectorate army had to control the movements of tribes, in order to keep them under control. Such a policy was to trigger off a process of destruction of production systems and nomadic social structures. Consequently, the environment could not feed the whole population, the imbalance forced people to migrate according to the seasons (individually or in groups), in order to look for food, mainly to regions producing olives, dates and cereals. This led to the development of a semi-nomadic method of production resulting in the appropriation of lands and in an intensive use of the environment in Matmata. (May Umi;2006)



**Figure 10: Cycle Of Traditional Migration Mayumi OHI ;2006. Field Measurements On Thermal And Air Environments Of Underground House In Matmata, Tunisia.**

Matmata adaptation to climatic conditions created a unique housing strategy which adapted well to their Arab culture and at the same time best benefiting from their natural unique environment in attracting more visitors, and hence promoting their economic status, which helps them in improving their inhabitants financial status. This makes Matmata application a successful application of vernacular architecture which ensures the well being of its inhabitants.

## **HOUSES IN THE MZAB, ALGERIA**

### *Climatic Adaptation*

The climate in Algeria is considered to be hot arid climate, typical desert climate, temperatures in summer average between 21° C and 24° C and in winter drop to 10° C to 12° C. Winters are not cold, but the humidity is high and houses are seldom adequately heated (<http://en.wikipedia.org/wiki/M'zab>).

In Mzab, the summer is hot and dry, as well as long, owing to the subtropical location of the region. In most places, the wind sweeps dust and sand for several months of the year. The winters are short and cold, particularly at night (<http://www.britannica.com/EBchecked/topic/15001/Algeria/46507/Climate>).

This means that the living conditions for people are very difficult in hot-dry climates. However, they can be improved by using an appropriate housing design. The people were to benefit from summer breezes and to promote natural drainage, while providing shelter from the sun and adapting generally to severe local climate.

They were to benefit from the high inertia of the construction, shading, night ventilation and evaporative cooling. As self-shading and thermal inertia are important for indoor comfort. The intense solar radiation is generally controlled through the use of deep courtyard configurations and the extreme clustering of houses. In the winter season, provision for sunshine is recommended with heat storage capacity. The winter conditions are improved with the southern orientation of the semi-outdoor living spaces on the terraces (galleries) and by taking advantage of the heat storage capacity of the buildings. Air movement occurs through small openings in the walls, and doors are left open most of the time. Thermal differences between the cool street, the house and the warm terrace may promote indoor ventilation (Tahar Bellal; 2007).



**Map 1:** Shows the Climatic Conditions In Africa, and the Subtropical Dry Summer in Algeria. <http://en.wikipedia.org/wiki/M'zab>.

The house design further controls radiant heat and glare through the use of superimposed courtyards. The courtyard is the main source of light as the outside facades generally are windowless. On ground level, there is a skylight that can be covered with a lattice screen. This level and underground spaces are refuges during the hottest time of the day. Moreover, the walls made of stone and gypsum together with their whitewashed colored surfaces further prevents daytime summer overheating.

The Mzab valley, for example, supplies water and shelter from the hot winds. In some places, they build their dwellings on rocky mountain peaks, which overhang the valley, in order to prevent flooding. They used the trees to intercept solar radiation, reduce wind speed and filter the Saharan dust. The evaporation and evapo-transpiration from the soil and the vegetation, respectively, increase the air humidity (Tahar Bellal;2007).

The typical house was designed to adapt to this local climate, where houses are characterized by having three openings to the alley: the door, a hole for the arm to manipulate the door lock and atop light above the door, giving to the upper floor guest room. The entrance door opens into an angular entry called "taskift", containing the weaving loom, and leads to the courtyard, which actually is a patio, receiving air and light through a small sky light. Usually there are four pillars the terrace above.

A large opening gives to the reception and prayer room called "tizifn" to replace an iwan. A latrine is locked away in a corner. The stairway leads to a first floor gallery, with the open yard, usually on the south side. The roof is reached by ladder, from where women like to walk to adjacent buildings. The extreme closedness of the houses, their low ceilings and limited depth, make them appear like built up cave dwellings. Sculpted walls enhance that impression. Particularly, the town of Gharadia, demonstrates the transition from troglodyte dwellings to the courtyard house (Friedrich Ragette; 2003).



### *Cultural Adaptation*

Centuries ago, the Barbarian people withdrew to the desert 500 Km south of Allergies. Five towns were built on isolated hills with the mosque on top. In a situation of extreme climate and insulating the settlements is particularly dense and introverted. Houses are limited to nuclear families of 5 to 6 persons, have covered patios with grilled sky lights and rarely occupy 10x10 m in area, or exceed 6m in height. Combined with stepped hill arrangement and pure mud construction, this architecture acquired rare unity and sculptural quality. The urban fabric is characterized by the organized settlements surrounded with palm trees ([http://www.archnet.org/forum/view.jsp?message\\_id=188795](http://www.archnet.org/forum/view.jsp?message_id=188795)).

Only the rooftops and a few facades are exposed to the intense solar radiation. The streets are very narrow and shaded by the neighboring walls, in some places also covered or further protected from the sun with trellis, cloth and awnings. A solar right is rigorously observed where no house may be cut-off from the direct solar radiation by the neighbouring houses in the cold season. Therefore, the building height is limited by the maximum height attained by the sun in winter ([http://www.archnet.org/forum/view.jsp?message\\_id=188795](http://www.archnet.org/forum/view.jsp?message_id=188795)).



Figure 11: Vernacular Architecture In Mizab [http://www.archnet.org/forum/view.jsp?message\\_id=188795](http://www.archnet.org/forum/view.jsp?message_id=188795).

Figure 12: Urban Fabric In Mizab Valley <http://www.travel-images.com/algeria24.html>.

They use of light colors (houses are generally whitewashed or painted in light colors) would further increase the urban reflectance, allowing, on one hand, a minimal conduction of heat indoors, because of a high diurnal heat storage capacity, and on the other hand, a rapid night-time release of heat ensured by a large sky view factor (Friedrich Ragette;2003).

### **Typical House Description**

Typical Mizab house has an Islamic identity. It doesn't exceed 100 sq. area, and often double floor houses with open roof and under ground floor. The first architectural element is at the entrance gate, the "ataba", a rocky step in front of the entrance door of 10 cm height. The function of this step is to prevent the entry of wind carrying sand from desert, or rain water or harmful insects from entering the house.

The entrance lobby is corridor ending with a wall to prevent pedestrians from seeing the house inhibitors, which helps them to let the door open; making sure that this l-shape entrance provides the needed privacy (<http://ag.arizona.edu/OALS/ALN/aln28/solieman.html>).

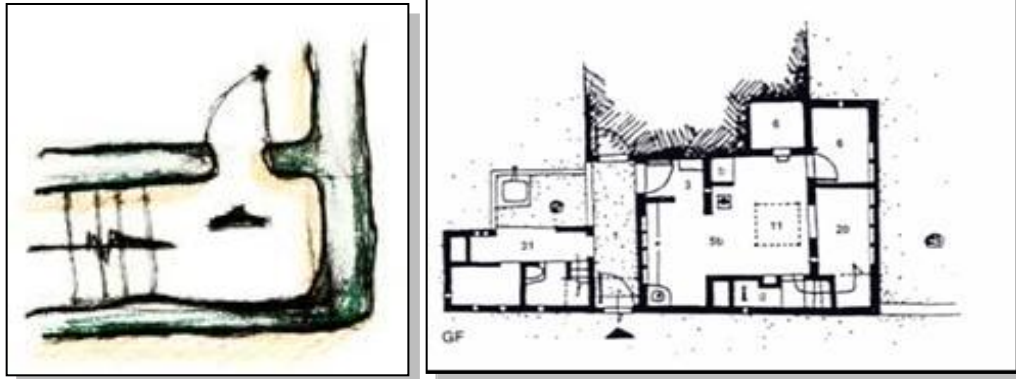


Figure 13: The L-Shape Entrance Providing Privacy. Prepared By the Researcher.

Figure 14: Built Up 80 Sq.m Area House With Annex . Taher Belal, İstanbul, 2007. Spatial Interface between Inhabitants and Visitors In M'zab Houses.

By the end of this corridor, behind the confronting wall, the family living area is allocated called "sqifa" where they sit on built in seats made of stones of a small height. On one of the corners of the living area, the grain grinding machine is allocated. An atrium is centralized in the house to provide natural lighting and ventilation (Friedrich Ragette; 2003).

Cross ventilation is created through the small openings in the rooms of the upper floor. Women have their own sitting place around the centre of the house in a large room called tizfri, the gate of this room is wide and has no door, and it is directed towards the praying direction for best light utility. In this room, women sew their woolen clothes. The kitchen is small in size and open on one of the atrium sides.

The master bedroom is on one of the house corners, beside which, built in table is often there to hold drinking water jars. Beside the main entrance of the house, a small toilet is allocated and a place for the goats to stay. Bedrooms are always in the underground floor, where best ventilation during summer and winter (<http://ag.arizona.edu/OALS/ALN/aln28/solieman.html>).

### ***Building With Local Materials***

Builders in Mzab are inspired by the organic form of the pilgrimage chapel at Ron champ in France. Earth as a building material was the only available materials to the early settlers. Sun dried earth bricks were the form in which they used earth in their construction (Gernot Minke; 1916).

### ***External Environment Adaptation***

Water availability and protection from hot and dusty winds are important considerations when choosing a site for habitation. Also choosing the valley of Mzab for habitation was for protection purpose from flooding and preservation of soil fertility. Spaces within the houses have to be non-specialized or duplicated (e.g. being able to cook both indoors and outdoors). During summer when thermal conditions are extreme, people will move to their summer houses in the cooler palm grove. They also tend to go outside either early in the morning or in the late afternoon, when the solar radiation is less intense (D. Ouahrani;2006).

Street orientation and aspect ratio (or height-to-width ratio, H/W) were found to be the most relevant external environmental describers. According to this theory, different measurements of the buildings heights were taken in the market place of Mzab to show how air temperature and humidity is affecting the transfer of heat induced by surfaces of buildings and how temperatures are affected in shaded streets.

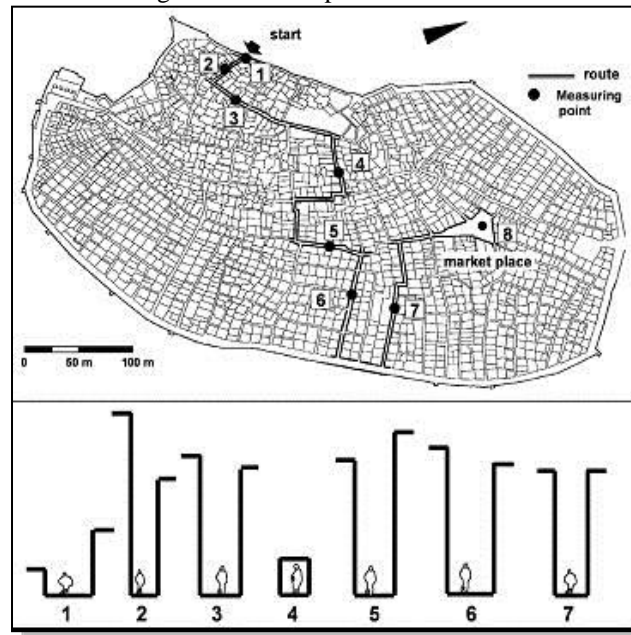


Figure 15: Route With The Measuring Points At Different Street Geometries And At The Market Place In The Old City Of Beni-Isguen, Mzab Valley, Algeria. Fazia Ali-Toudert, May 24;2006. Outdoor Thermal Comfort in the Old Desert City of Beni-Isguen, Algeria.

The results show a high thermal discomfort in a non-shaded location and how temperature is almost always associated with increased shading and hence lower irradiances (Fazia Ali-Toudert; 2006).

## DWELLINGS IN SIWA, EGYPT

Siwa is located in Egypt's remote Western Desert. Environmental Quality International, the principal financier and catalyst, brings technical expertise and economic development that respects Siwa's natural assets and revitalizes its unique cultural heritage. Community and local authority partnerships, cultural and environmental knowledge, build political support for the project. Ecotourism and the development of a cottage industry engage women in the community, and revitalizes Siwa's traditional handicrafts and artisanship.

### *Climatic Adaptation*

It was realized that earthen houses provide healthy, balanced indoor climate. However, it is superior to industrial building materials such as concrete, brick and limestone. Courtyard houses also could be a good example of how to provide comfortable living environment. The courtyard is called "hosh" and it is located in the center of the house, that's why it is considered to be the nucleus of house planning in the desert climate. It serves a common circulation space from inside the house and acts as another private entrance which achieves privacy. It is naturally lightened by skylight. Fruit trees are vegetated at the walls and tree shades cover the middle and flower basis are put at the entrance. Fountains are included also in this courtyard and sometimes covered outdoor sitting area is also included.

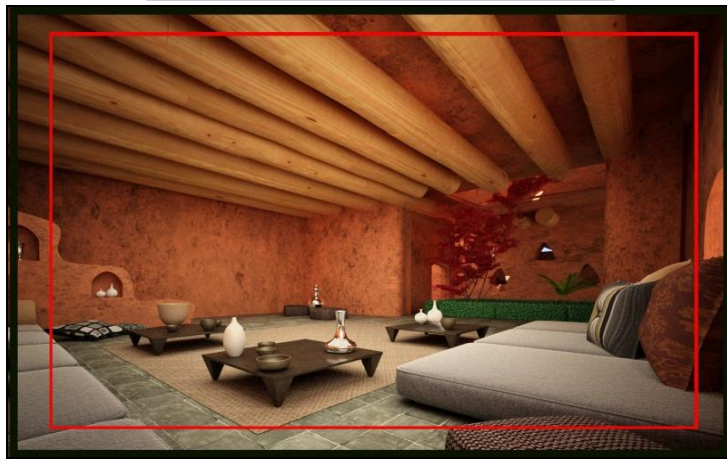
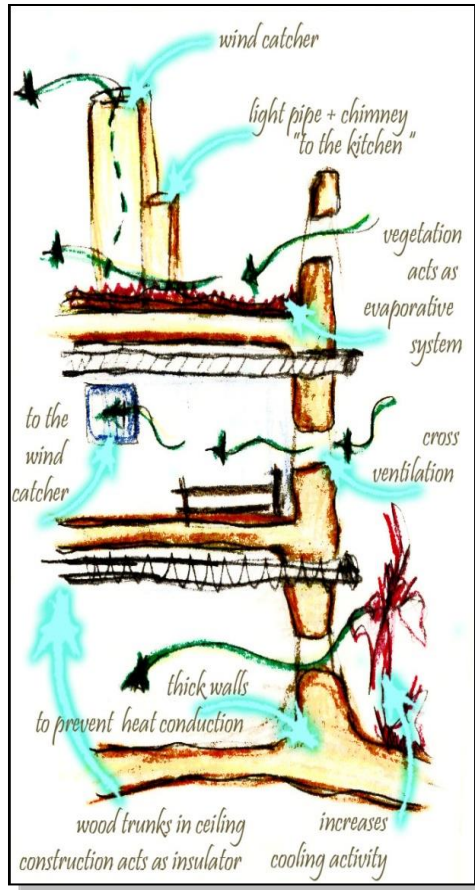
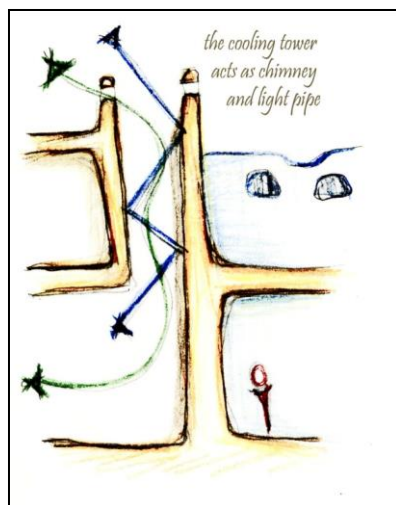


Figure 16: Analytical diagram of adaptation to the climatic conditions within the Siwaian house. Prepared by the researcher.  
Figure 17: Interior View of the Main Living Area Opposing an Interior Court in the Proposed House. Prepared by the researcher.



**Figure 18: The Cooling Tower Acts as Light Pipe for Better Lighting System. Prepared by the researcher.**

The placement of the buildings with respect to the sun path, prevailing winds and driving rains together with a good design and careful location of the openings. This leads to a better zoning and distribution of rooms to their functions and help creating a comfortable indoor space.

### *Cultural Adaptation*

#### **Typical House Description**

It is mainly double height floor buildings with an area for men outside the house called "khos", it is rectangular in shape. The entrance hall consists of 3 rooms. First of them is the guest room "almarbouaa". It consists of cushions to sit on and small carpet "kleem" on the floor. Another room is the storage room where they store their agriculture tools.

The third room is the kitchen which leads to backyard fold which is not too far from the house. The second floor consists of large hall called " estah nammas" derived from which large number of rooms ( bed rooms, living room, kitchen, toilet, shower room) . They meet in this large hall. One of these rooms called " astah entabent" un-roofed room, where they cook. "tabent" is the name of the furnace that's why they called the room by estahentabent". On the other side toilet exits, with sand on floor to absorb the water and coal to absorb the smells. It is called composting toilet.

Beside the toilet, shower room for taking shower only. An important room in the house is the "winter room" where one only window opening is in the room for minimal ventilation. They put fire place in the corner for heating. They use the roof for palm trees drying as fertilizers and sitting area in summer.

#### **Building With Local Materials**

The Siwaiian building material is called "karshif" with "Tlakht" as filling material. "Tlakht" consists of fermented wet mud, left for week or two. It might be green or yellow or red. Each of them needs certain amount of sand to hold the mixture and sometimes it doesn't need sand to be added.

Karshif is that salt bricks extracted from very wet soil after evaporation leaving salt. These salts are mixture of different components. Hence they are irregular in shape and it can be re-cut.

Now they are using the typical white blocks and cement because it is much easier building method and because it takes less time in construction than the local old method. The building height is 3m high. Thickness of walls is 50cm starting from the first row reaching 30 cm thick in the last row.

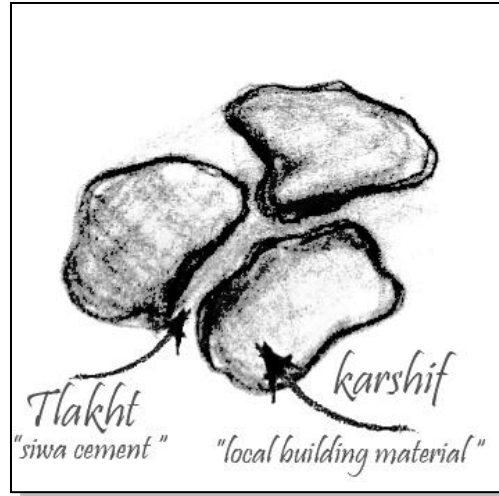


Figure 19: The Local Building Material in Siwa. Prepared by the researcher.

## BUILDING TECHNIQUE

First, it is very important to choose the best soil away from humidity and water. They build 50 cm high concrete wall to isolate the ground water from Karshif. First they determine the area of the room they want to build, then for each wall of this room they mark axis on the ground using wood. Afterwards, they put the thick Karshif blocks and Tlakht in-between till he reaches the desired height. They repeat this for each single wall. Since there is no strong connection between walls, the buildings end with curves.

In case they need sharp edges buildings edges; they support their walls with palm wood trunks connections. This is more expensive but they are using wood trunks as decorative element too.



Figure 19: One of the Workers Laying Karshif Blocks to Form a Wall. Taken by the researcher.

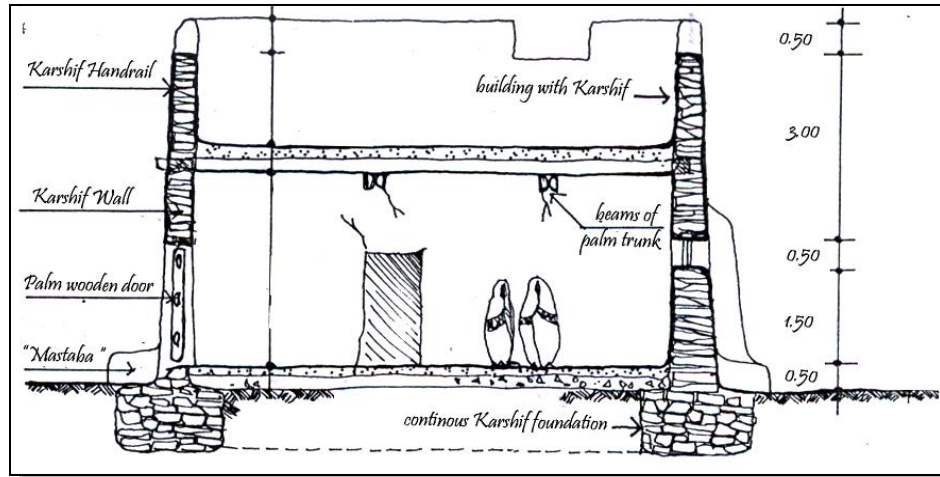


Figure 20: Section through Karshif Walls Showing Heights and Thickness. Dr. Hatem, 1998.

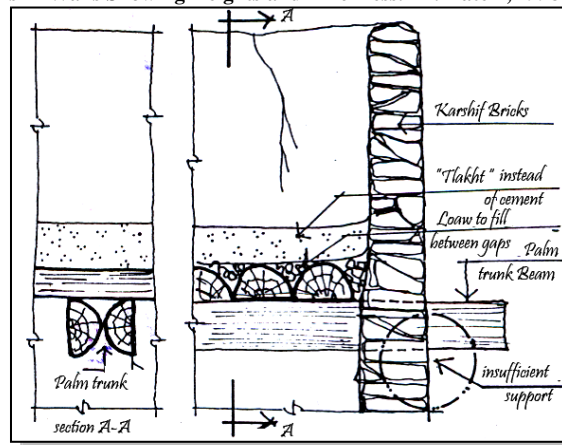


Figure 21: Section Showing Palm Trunks in Building the Siwaian House. Dr. Hatem, 1998.

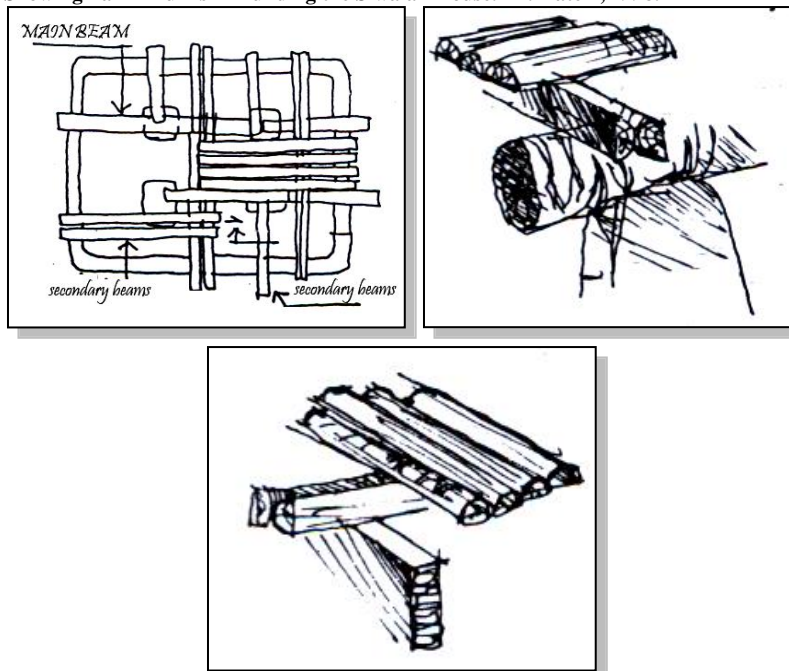


Figure 22: Ceiling Structure Showing the Main Beams on which Secondary Beams are Laid. Dr. Hatem, 1998.

Figure 23: Two Layers of Secondary Beams are Laid on the Main Beam. Dr. Hatem, 1998.

Figure 24: Secondary Beams are Laid on Main Beams. Dr. Hatem, 1998.

Building process cannot be done except when the karshif brick is in solid form. The ceiling is supported by olive tree trunks; they might use "gazorina" instead. It is seen also that doors and openings are small in size, ranges from 40 cm to 50 cm high, including the frame. This is to regulate the amount of heat entering the building especially in summer as temperature might rise to 45 degree.

### External Environmental Adaptation

The placement of the buildings with respect to the sun path, prevailing winds and driving rains together with a good design and careful location of the openings.

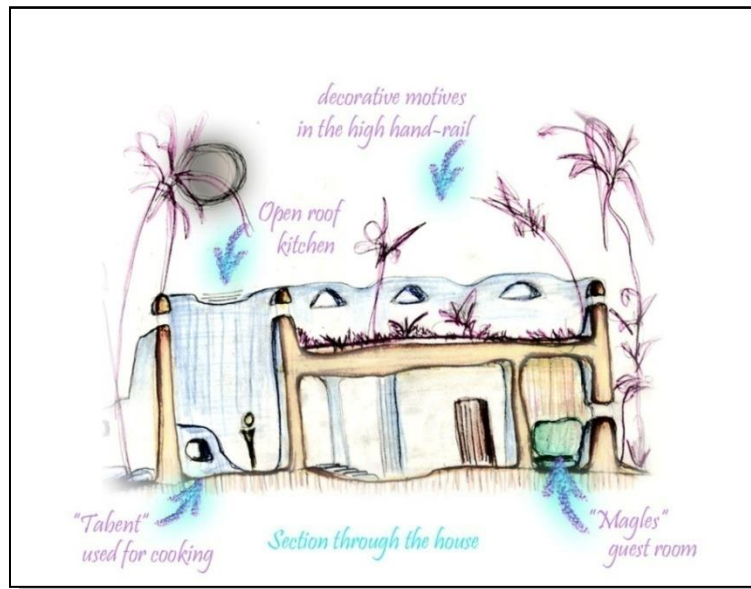


Figure 25: Section through the House, Showing the external environment Adaptation to the Surrounding in a Single Floor House. Prepared by the researcher.

## CONCLUSION

Since housing affordability and environmental design were compatible, being environmentally friendly does not mean expensive housing solutions, but it does require good integrated design. Architects, builders and planning authorities should be looking at new and innovative ways to decrease the environmental footprints of buildings. The best way to achieve this is by separating this development from others and offering an integrated vision of a landscaped village, cost effective housing and excellent environmental design.

Going through the paper, a group of conclusions were formulated; General Strategies for Satisfactory Performance:

- The conventional and modern designs of wind towers can successfully be used in hot arid regions to maintain thermal comfort.
- Application of simple passive cooling measure is effective in reducing the cooling load of buildings in hot and humid climates.
- Proper maintenance to prevent decay of wooden materials
- Construction with robust architectural forms:
  - Regular floor plan (shape-distribution of walls)
  - Uniform openings (small and well-spaced)
- Minimizing the usage of openings, and allocating them in the upper parts of walls.
- Plants and vegetation utility in the inner courtyards.



## REFERENCES

- Ali-Toudert, Fazia; Published May 24. Outdoor thermal comfort in the old desert city of Beni-Isguen, Algeria.
- Belal, Taher, (2007). Spatial Interface Between Inhabitants And Visitors In M'zab Houses, İstanbul.
- Eltawil, Hatem; (1998). Siwa Architecture Msc, faculty of Fine Arts, Architecture department, Alexandria University.
- Golany, Gideon; (1998). Earth-sheltered dwellings in Tunisia: ancient lessons for modern design.
- MayUmi OHI; (2006). Field measurements on thermal and air environments of underground house in Matmata, Tunisia.
- Minke, Gernot; (1916). June. Building with Earth, Publishers for Architecture Birkhauser.
- Ouahrani, D.; (2006). Light and housing in the desert: Case study of Ghardaia, Algeria .
- Ragette, Friedrich; (2003). Traditional domestic architecture of the Arab Region.
- <http://theswca.com/travel/tunisia/matmata/matmata.html>
- <http://theswca.com/travel/tunisia/matmata/matmata.html>
- [http://www.xcess.info/matmata\\_tunisia\\_aen.aspx](http://www.xcess.info/matmata_tunisia_aen.aspx)
- <http://en.wikipedia.org/wiki/M'zab>
- <http://www.britannica.com/EBchecked/topic/15001/Algeria/46507/Climate>
- [http://www.archnet.org/forum/view.jsp?message\\_id=188795](http://www.archnet.org/forum/view.jsp?message_id=188795)
- <http://www.travel-images.com/algeria24.html>
- <http://ag.arizona.edu/OALS/ALN/aln28/solieman.html>