Learning Lessons From Matmata

Mamdouh Mohamed Sakr
The Prince's School of Traditional Arts, Egypt

Abstract

North Africa is blessed by its innovative and spectacular vernacular architecture that has been developed through centuries of adaptation to the harsh climate and the barren environment. The troglodytes (earth-sheltered dwellings) are considered to be one of the most unique examples of North African vernacular architecture. A troglodyte can be simply described as a vertical shaft dug by man into soft sandstone, forming a circular courtyard, and then rooms are dug into the walls created by the courtyard. Matmata has many of the best examples of troglodyte architecture in the world.

Matmata's troglodytes are appropriate building types that served the functional and aesthetic needs of its inhabitants. These earth-sheltered dwellings are remarkable instances of human beings successfully adjusting to an often-inhospitable environment. This achievement has resulted from continuous experimentation and experience that has been passed from one generation to the next. Matmata dwellings area great example of sustainable architecture, they are energy efficient, environmentally friendly, and economical. They are a great source of inspiration for a number of fields such as architecture, environmental studies and even eco-tourism; these dwellings can easily ensure the economic sustainability of the whole settlement. This paper aims not only to analyze the dwellings of Matmata but also to re- introduce the concept of earth-sheltered architecture in the Middle East in a way that responds to the needs and problems of the inhabitants of the 21st century.

Keywords: *Matmata, Vernacular Architecture, Troglodyte, Earth-Sheltered Architecture, Sustainability, Tourism*

1 Vernacular Architecture and Sustainability

Cultural heritage is a non-renewable resource, and vernacular Architecture is the fundamental expression of the culture of the community, of its relationship with its territory and, at the same time, the expression of the world's cultural diversity. Moreover, vernacular built heritage can be seen as 'the essence of sustainability, being constructed with local materials and the minimum waste of resources. Despite this, in most countries the vernacular built heritage is neither protected nor considered worthy to be conserved.

Nowadays Vernacular architecture and Sustainability are two widely used terms they have a number of definitions, among which are the following:

Vernacular Architecture, "A term used to describe structures built by people whose design decisions are influenced by traditions in their culture".

Sustainability, "A term used to describe the process undertaken to meet the needs of the present without compromising the ability of future generations to meet their own needs".

Due to our present global crises, population expansion, natural resource depletion and ecological disasters, there is an urgent need to align development and the practice of architecture with the concept of sustainability. This idea of sustainability is not only creating a place which is self-sustaining but also being sensitive to local community needs and concerns; involving and recognizing the importance of all the peoples in the decision-making processes. Sustainability also considers the sensitivity of local history and culture, which means respecting the local materials, vernacular designs as well as being sensitive to the existing built environment of the given location. It also includes giving priority to the conservation and preservation of old buildings as cultural beacons in the history of a place.

The whole concept of sustainability encourages us to return back to, appreciate and analyze vernacular architecture and its concepts. Vernacular architecture varies widely with the world's vast spectrum of climate, terrain and culture. It contains inherent, unwritten information about how to optimize the energy performance of buildings at very low cost using local materials. Over the course of time, vernacular dwellings have evolved to respond to challenges of climate, building materials and cultural expectations in a given place. Vernacular traditions have been gleaned through a long period of trial and error and the ingenuity of local builders who possess specific knowledge about their place on the Planet. Accordingly there is a great value in understanding and applying attributes seen in ancient vernacular architecture to new buildings (Oliver, 2003).

2 The Relation between Vernacular Architecture and Sustainable Tourism

Architecture and tourism are closely interrelated; in fact architecture can shape and enhance the image of a tourist destination or destroy it altogether. Similarly, tourism, if developed in a responsible, balanced, participatory and sustainable manner, can become a driving force for environmental protection, heritage conservation and cultural pride. In other words, Sustainable environment requires Sustainable design solutions for the continuity of the traditional architectural environment.

Tourism has been a rapidly growing sector and a wide-sweeping socioeconomic phenomenon with broad economic, social, cultural and environmental consequences. It is likely that tourism will continue to dominate the international scene for many years to come. Environmental protection has become a major issue in the recent years, and as a result of environmental consciousness, a great number of alternative forms of tourism have been developed in the last two decades. Various names are utilized to demonstrate the typologies of the environmental tourism, 'Green', 'Soft', 'Eco', 'Sustainable', 'Responsible', or 'Alternative' are some of the terms to describe the new trends. These new trends prefer the places, which are not destroyed by the "mass of tourists". So today, the tourism industry proposes an ever-wider range of destinations and there are few spots left in the world, which are out of the reach of tourism. Moreover, the growing awareness for culture has set a tourism movement driven by a widespread desire to discover new places and different cultures.

Accordingly, the tourism industry is putting more and more emphasis on the uniqueness of the experience provided by each destination. Vernacular architecture contributes greatly to the fulfillment of this current tourism movement because it is at the very heart of the identity of a community or of a country. Indeed, vernacular architecture is the reflection of a lifestyle, of a social organization, of artistic practices, and of the architectural adaptation to climatic, geographical, cultural and religious factors. Respect for the sense of place, traditions, and cultures are paramount for the well being of the populations and the sustainability of tourism and of its quality. The sense of place depends on the use of specific materials found locally and the adjustments of architecture to societal customs and needs as well as to the environment. It is by respecting these aspects that one can ensure the specificity and uniqueness of the tourism offer.

Now there are many examples of traditional settlements all over the world that became major tourist attractions. The aim of this paper is to focus on earth-sheltered architecture; a vernacular building technique that can be adapted to our contemporary needs. Matmata's architecture will be discussed in depth to understand its characteristics and advantages, which led to the success of the town as a whole on the social, economic and cultural level. Today, Matmata is a

well-known tourist attraction; crowds of tourists come especially to see and even experience living one night in one of its troglodytes (earth-sheltered buildings). A number of the big houses were turned into hotels and most of the population lives on tourism and folklore exhibitions in their homes (Figure 1). Matmata is one of the great examples of how the preservation and adaptive reuse of vernacular architecture in addition to the respect for the principles of sustainability and cultural diversity lead to a huge commercial success. So, how a local community can fully benefit from its cultural and artistic heritage, is a lesson to be learnt from Matmata.

Figure 1. A courtyard of a Troglodyte Hotel, Matmata
(Source: Author)

3 Earth Sheltered Architecture

Earth-Sheltered architecture is one of the passive energy solutions that exemplify man's struggle to survive and shelter himself against stressful climates and to achieve safe and comfortable living environment. For centuries these indigenous designs have been used by residents in different parts of the world, from the provinces of Henan, Shanxi, and Gansu in Northern China to different parts of the Mediterranean region, such as Sicily, Santorini and the Goreme Valley of Cappadocia in central Turkey. Matmata in southern Tunisia is a prime example of a whole settlement of earth-sheltered buildings. This paper aims to focus on its dwellings or what is known as the Troglodytes, which are exceptional examples of the architecture that melts within its environment. Their designs are adapted to the needs of their inhabitants and their way of life, and that is simply the true essence of vernacular architecture

Matmata and its Troglodytes

The history of this extraordinary place is unknown, except from tales and legends carried from generation to generation. The most probable one says that underground homes were first built in ancient times, during the Roman period. It is said that the Roman ruler sent two tribes to settle in the Matmata region, after one of the Punic wars, with permission to kill every human being in their way. The dwellers of the region had to leave their homes and dig caves in the ground to hide from the invaders. Yet other sources claim that these troglodytes were dug as a reaction to the Arab invasion. Whatever the real reason was, these underground settlements remained hidden in a very hostile area for centuries, and were only discovered in 1976. This was because of intensive rains that flooded the troglodytes, and forced the dwellers to seek help from the authorities in the nearby town of Gabes. Thus, the secret of Matmata was revealed to the whole world, and gradually the "Nouvelle Ville" was built few kilometers away from Matmata, but only few families moved to the new surface dwellings as most of the people continued their lives in their underground homes.

As Matmata is an arid region, and temperatures regularly exceed 50 degrees in summer, these dwellings were the inhabitants approach to escape the harsh climatic conditions, and their abundance was due to the favorable soil conditions. Matmata's terrain is hilly and the small valleys between the lime stone mountains contain deposits of loess (almost 20 meters deep), which are composed of clay with enough gypsum to act as a binding agent. This provides a firm and stable but easily worked material for excavating rooms (Kempe, 1988). The softness of the soil material is both the reason for troglodytes being possible, and for never becoming very old (Figure 2).

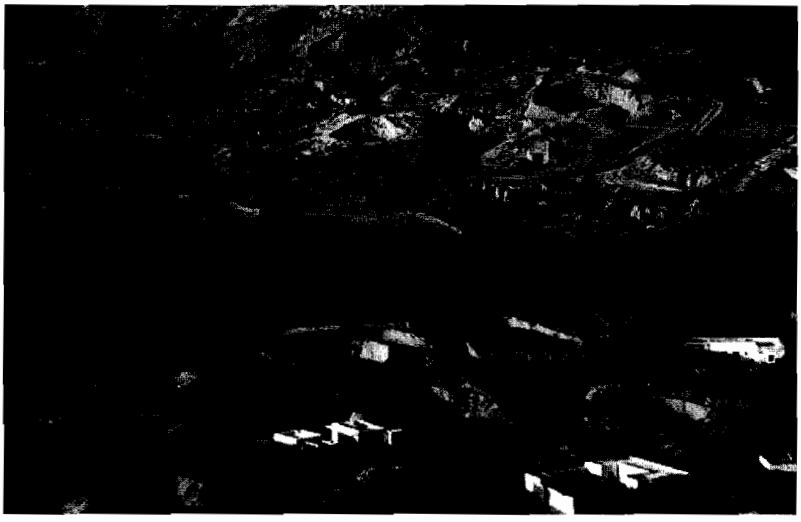

Figure 2. Matmata's Landscape dotted with Troglodytes (Source: Postcard)

The Matmata Troglodyte is a very common type of the various types of subterranean dwellings. It is a vertical design of a deep courtyard open to the sky and surrounded by walls and rooms. This sunken courtyard building is an underground structure that closely follows the introverted design of the famous traditional aboveground courtyard building. The troglodytes are isothermal; their temperatures are warm in winter and cool in summer, and stay relatively constant year round, as earth as a building material stabilizes the extreme temperature swings, both daily and seasonally. The shape, size, and other design details of a sunken courtyard dwelling vary between regions and even among households in the same region depending on the socio-cultural background, financial standard, and environmental features such as geomorphologic configurations, soil type, climatic pattern, and hydrological systems. However, the overall basic design remains similar.

4 Analysis of the Troglodytes

The design of the troglodytes depended on the courtyard, the central focal point where all the rooms and other spaces of the dwelling are distributed around it. Courtyards are usually semi-circular in shape ranging from 5 to 10 meters in diameters with a depth measuring about 10 meters from the ground level to the floor of the courtyard (Figure 3). The digging starts in the courtyard and after sharpening its edges, the openings of doors and windows are carved as a start to dig the rooms. The rooms are long and narrow in the lower level, and smaller in the upper level (if the soil strength permits). The ceilings are usually vaulted, to bear the loads of the soil above it and to accommodate day lighting and ventilation needs. The typical dimensions of the rooms in Matmata are 4 to 5 meters wide and 8 to 10 meters long with a height of about 3 meters for the large rooms, and between 3 to 4 meters wide and 4 to 5 meters long with a height of 2.5 meters for the smaller ones. The soil cover from the ground level to the room ceiling in Matmata ranges from 6 to 7 meters. Such thickness eliminates any potential for water leakage caused by possible heavy rainfall and it significantly reduces the heat gain and the heat loss rates into and out of the building (Golany, 1988).

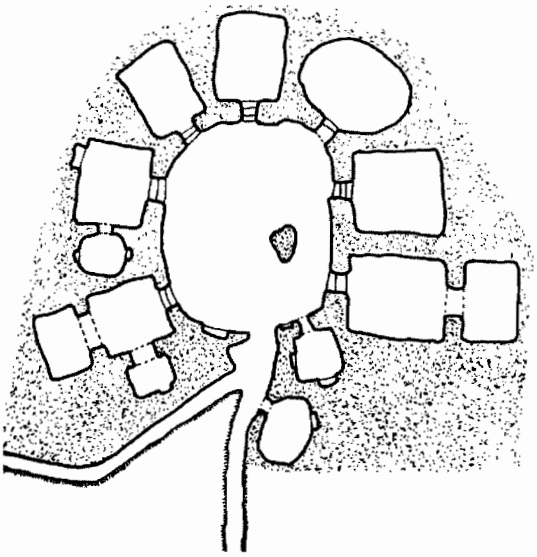

Figure 3. A Typical plan of Matmata's Troglodytes
(Source: Golany, 1984,Earth Sheltered Dwellings in Tunisia)

The number of rooms around the courtyard varies depending on the size of the family and its way of living, which may dictate a certain number of storage and utility rooms. There are also granary rooms, which are high rooms excavated on a height of 2.5to 4meters from the ground of the courtyard and their width ranges from 2 to 2.5 meters (Figure 4). Each room has an upper opening in the ceiling (close to the ground level) where grains are dropped directly. Usually there is a cistern in the middle of the courtyard for gathering rainwater. The courtyard is protected from the rainfall by building a short fence around its circumference using the clay that resulted from the excavation. The entrance of the dwelling is above the ground and is about 10 meters away. To ensure the safety and protection of the unit, the entrance is fortified and sloped downwards to the central courtyard through an excavated tunnel. The underground tunnel is gradated in height and for more protection the last part of the tunnel changes in direction, and there is usually another curved entrance. After this curved entrance there is a storage room for storing agricultural instruments and sometimes for sheltering sheep and goats.

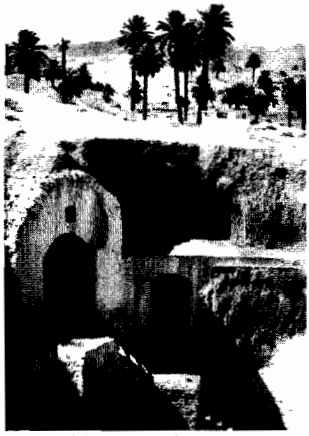

Figure 4. A Courtyard in one of Matmata's Troglodytes
(Source: Postcard)

Building materials such as stone and gypsum are available from the ambient environment and they are used for the finishing coats of the internal walls and some of the fixed furniture (beds and storage cabinets). While olive trees, which are widely planted in Matmata, are used for doors and some simple furniture. It is also used for supporting the roof of rooms and subterranean entrance tunnel.

5 Contemporary Earth-sheltered Buildings

The simple yet genius design of an earth-sheltered dwelling whose spaces are gathered around a central courtyard became a source of inspiration for many architects. Since the 1940s, underground building constructions have been adopted in contemporary building designs all over the world for various purposes ranging from defense to preservation of landscape. The concept of using underground buildings received more widespread attention after the energy crisis in 1973 primarily due to its suitability as a climate control strategy and to the subsequent energy savings it provides, among others. Housing and military installations have been popular in the United States; shopping centers in Japan and Stockholm; oil storage spaces in Norway and Sweden; and parking spaces, theatres, libraries, and other examples of public and private underground buildings can be seen throughout the world (Golany, 1983). Examples of contemporary sunken courtyards can be found in large-scale projects such as the UNESCO buildings in Paris, the undergraduate library at the university of Illinois, the state capital of Texas at Austin, and the expansion of the Louvre museum in Paris (Al- Mumin, 2001).

Also, this building technique was used in residential houses such as the celebrated John Barnard's ecology house prototype in Massachusetts, which is an excellent example of a contemporary earth sheltered building, to the extent that it is even called a modern version of a Matmatan earth-sheltered courtyard dwelling (Baggs, 1991) (Figure 5). It was built in 1973 to test Barnard's idea of

earth-sheltered living; and it all started when he had asked himself the question: How to make a house that resembles a park?" The house has a belowground central courtyard, which is the first of its kind in the United States. The sunken courtyard is one story high (3 meters) rectangular in shape, with 5 to 6 meters in dimensions, and the soil cover is about 0.5 to 1.0 meters in thickness. The internal courtyard is not only the visual and functional focus of the building, but also a climate modifier, because of its geometry, a thermal buffer zone is created. The resulting microclimate is less harsh and more tolerable than the outside weather conditions (Etzion, 1997). Thus, while the outside is hot, dusty, and harsh, the courtyard by contrast can be moist and cool producing an outdoor living space useable for most part of the year.

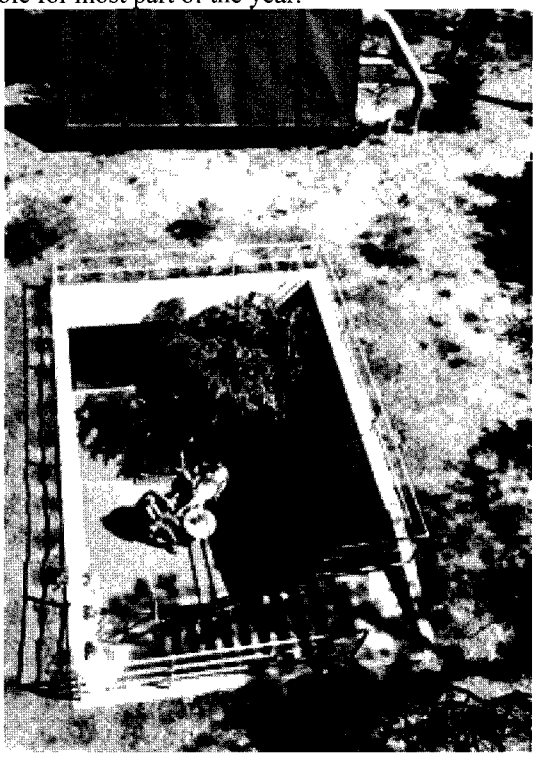

Figure 5. John E. Barnard. Ecology House, Osterville, Massachusetts, 1973
View into courtyard with solar panel
(Source: www.we-make-money-not-art.com/archives/2009/08/sorry-out-of-gas-architectures.php)

5.1 Advantages

It has been proven by historical, as well as modern precedents, that earth sheltered or underground construction is a viable alternative to conventional design, because of the resulting microclimates and the general reduction of temperature within the units, especially in climates with harsh climatic

conditions. The hot-arid climate is understandably the primary cause of large cooling energy consumption. However, the subsurface climate is much milder than the extremities of the aboveground environment. Being cooler than the ambient air for parts of the year, the soil enclosing an underground building has the potential to lessen the cooling energy needs of a building by reducing the heat transfer from its surroundings.

Carmody and Sterling speculate that even at very shallow depths, the ground temperature seldom reaches the outdoor air temperatures in the heat of a summer day, conducting less heat into the house due to the reduced temperature differential. Not only is the temperature difference between the exterior and interior reduced, but the building is also protected from the direct radiation of the sun (Carmody and Sterling, 1984). In addition to its ability to create a pleasant microclimate, there are many advantages to living in an earth-sheltered home, such as:

5.1.1 Land use and Aesthetics

One of the more common motivations for building an earth-sheltered structure is to blend the building in with its natural surroundings. This is often the case on rural sites where the owner wishes to build a dwelling but also retain the 'untouched' beauty of the natural landscape. Although retaining the beauty of a suburban block is not often of much importance, once the earth shelter has been built the area of land available for growing plants is greatly increased over that of a block with a conventional building on it. This double use of the land, means that earth sheltered houses can be built on smaller blocks than conventional houses and still have sufficient space for outdoor living. This makes earth-sheltered housing particularly useful for medium-density housing developments, an area of construction that will no doubt increase in the future as the world population grows and cities become larger and larger.

5.1.2 Cost Reduction

Reducing the Cost of the building and there are several reasons for this:

A- Reduced Energy Costs

This is the main area where cost is reduced in an earth-sheltered house when compared to a conventional home. One of the key advantages to earth sheltering is a stabilization of temperature inside the building. Because of this, depending on the climate and the design of the building, some earth shelters can be lived in perfectly comfortably all year without any need for heating or cooling. This may not apply for the whole year in some parts of the Middle East, but it is certain that the amount of heating/cooling required in an earth sheltered building will be reduced, which automatically leads to a reduction in electricity costs.

B-Reduced Maintenance Costs

This is based on the sheltering effect on much of the exterior building envelope by the earth mass. Therefore, the building envelope is less likely to be weathered by various climatic elements. The earth-sheltered structure is

subjected to smaller temperature fluctuations than surface buildings. The effect of this reduced fluctuation is less expansion and contraction in building materials, which minimizes thermal cracks, which are common in concrete blocks and paint. The gentle conditions under soil cover increase the structural longevity of building materials, which are protected from the various exposed conditions in harsh climates and its weathering effects.

5.1.3 Privacy

Earth-sheltered houses also provide the privacy, serene environments and social unity, which are essential in the conservative societies of the Middle East. However, in general they are appreciated for their effect in reducing the amount of noise surrounding the building. Accordingly it is possible to build earth-sheltered dwellings in places where conventional structures would be virtually impossible (for example: next to major roads or in airline flight paths).

5.1.4 Safety and Protection

Earth-sheltered housing offers a uniquely safe living environment in the face of naturally occurring disasters in comparison to conventional homes. The reinforced structure of an earth-sheltered home, surrounded by and covered with earth, provides maximum protection from high winds, hail storms, lightning strike, tornadoes with their accompanying damage from flying debris, and other natural disasters. Earth-sheltered structures will be less prone to collapse in an earthquake, which is when most loss of life occurs. They also offer a substantially better fire-retardant structure than aboveground houses, should a fire occur, the structure is likely to sustain less fire damage.

5.2 Disadvantages

It should be stated that earth sheltered buildings (as any type of alternative construction) also have some potential limitations and disadvantages, such as:

5.2.1 Public Negative Response

Several authors mention that there are some social and psychological problems to overcome if earth sheltering is to be implemented on a wide basis. They consider that the greatest hindrance to the consideration of earth-sheltered housing is that the public will not accept living in earth-sheltered buildings, especially if they are not aware of the benefits these houses provide (Golany, 1983). The fact that underground structures have few or no windows also contributes to the conclusion that they may be unsatisfactory due to the psychological feeling of isolation. The absence of windows for direct contact with the outside environment, and the subsequent lack of stimulation from the variety of changing weather conditions and sunlight, can add to the sense of confinement or claustrophobia. A windowless building also induces a lack of spatial orientation since exit points are not visible, creating a fear of not being able to escape in an emergency. However in the hot arid climates of the Middle East the solar radiation is intense for much of the day and shutters are used on the windows to reduce glare and solar gains. For inhabitants of these areas,

psychologically speaking, the darker the room, the cooler it seems and minimal day lighting is accepted. Therefore, it is generally best to keep the sunshine from entering the building in these regions.

5.2.2 Construction Costs

Most people assume that the construction cost of earth-sheltered structures is higher than conventional buildings, yet this is still a controversial issue. It seems that the main reason for the increased costs is due to the added structural materials required to withstand the weight of the soil on the roof, and the use of reinforced concrete structures. However, it is not conclusive that the construction cost of every earth-sheltered building will be higher than its aboveground counterpart. Many architects and engineers have proven that the cost to construct an earth-sheltered house is similar to a conventional house, even when earth-sheltered homes are larger than typical aboveground houses; the total building costs are generally competitive. Other architects argue that earth-sheltered construction in many instances is less expensive than equivalent above ground structures (Terman, 1985). It is important to mention that as building with reinforced concrete became the most popular construction technique in the Middle East, one realizes that the increased structural requirements for underground buildings may not represent a real cost increase. It is important to understand that the increases that occur out of necessity in earth-sheltered construction can often be offset by reductions in other areas. For example, with much of the building's façades in contact with soil, exterior finishing costs are reduced.

5.3 Recommendations

Based on the above-mentioned advantages and the suitability of the earth-sheltered buildings to the harsh climate of the Middle East and the cultural and social preferences of its people, the implementation of such a building technique is highly recommended. Unfortunately this subject is lacking sufficient research, feasibility studies and pilot projects specific to the region.

The architectural design should not only take into account the social and cultural context, or the usual architectural design decisions like layout, level of fenestration, etc, but also apply appropriate solutions that alleviate some of the negative psychological effects related to underground buildings discussed earlier. Accordingly an earth-sheltered courtyard design - based on Matmata's Troglodyte - will be a clever response to such problems and concerns. All of the main living spaces of the house will have windows opening onto the courtyard, while the outside walls and roof are completely covered with earth. This configuration can provide the living spaces with natural light, view, access, and ventilation when needed. In this manner, the external courtyard provides a visual connection with the outside world, creating a feeling of spaciousness, minimizing the negative feeling associated with entering an underground building by alleviating the various psychological concerns about orientation, natural light, and view.

Another design consideration that needs to be resolved is the depth of soil cover on the earth-sheltered building. Depth of soil cover needs to be considered with respect to thermal performance, structural economy, and other economical considerations. Although deep soil cover means greater thermal mass, it also means more expensive excavation process and roof construction. Therefore, there is a trade off between the overall thermal effect of added soil mass and the extra strength necessary to support the added weight. A recommended earth cover of 1 meter over the roof will still be able to stabilize daily temperature fluctuations, meaning that average conditions, rather than extreme climatic conditions will affect indoor conditions (Giovani, 1994).

Finally, even if there is some debate between architects and developers as to the initial cost of earth sheltering, there is no disputing that there are large savings in the long term. However, there has been lack of studies that quantitatively measure the acclaimed benefits in energy and economy as well as the occupants' attitudes and satisfaction expected from this concept, especially in the desert climate. Such information is vital for the policy-makers to seriously consider adopting this new/old concept.

This paper aims to reintroduce the idea of earth-sheltered buildings in the Middle East. Such Passive building technique can be applied as an answer to a number of critical problems that are facing the metropolises of the 21st century. For example in a country like Egypt, the use of earth-sheltered should not be only for the sake of reducing energy consumption, as such building technique can help in:

Increasing the amount of green spaces within the densely built cities.

Creating new settlements for desert reclamation projects.

Preserving the natural landscape and scenery in a number of locations, where the presence of modern buildings will ruin the scenery (e.g. visitors centers in National Parks)

Creating appropriate buffer zones around certain monuments, heritage sites and Temples, instead of being surrounded by the dense urban fabric.

6 Concluding Remarks

Vernacular Architecture needs more attention, appreciation and studies; many examples of vernacular architecture are great sources of inspiration for a number of fields such as architecture, environmental studies, sustainable development and even eco-tourism. Among such examples are the earth-sheltered dwellings, which are remarkable instances of human beings successfully adjusting to an inhospitable environment. This achievement has resulted from continuous experimentation and experience that has been passed from one generation to the next.

While the problem of energy consumption has never been previously defined

or faced as what is happening now, Matmata's vernacular architecture has utilized some passive design methods and made the maximum use of the potentials of its region and the limited resources of its environment. Accordingly, modifying and adopting a number of vernacular construction techniques could be the answer to a number of environmental and urban problems that face us in the 21st century.

The people of Matmata did not succeed only in preserving and maintaining their architectural heritage, but also in establishing a sustainable community benefiting from Tourism and other related services and crafts, these dwellings now ensure the economic sustainability of the whole settlement. Matmata is a famous tourist destination where architecture and environment complement each other. Such an approach should be analyzed and applied in many places throughout the World.

References

Al-Mumin, Adel (2001). Suitability of Sunken Courtyards in the desert climate of Kuwait. Energy and Buildings, Volume 33.

Baggs, JC (1991). Australian Earth-covered Building, NSW University Press, Kensington.

Carmody, A. & Sterling, R. (1984). Design considerations for underground buildings. Underground Space, Volume 8

Carmody, A. &Sterling, R. (1985). Earth Sheltered Housing Design. Van Nostrand Rheinhold Company, New York.

Etzion, Y. (1997). Adaptive Architecture: Integrating low-energy Technologies for Climate Control in the Desert, Automation in Construction, Volume 6.

Givoni, B (1994). Passive and Low Energy Cooling of Buildings, Von

Nostrand Reinhold, New York.

Golany, Gideon (1983). Earth-sheltered Habitat, Van Nostrand Reinhold, New York.

Golany, Gideon (1988). Earth-Sheltered Dwellings in Tunisia: Ancient Lessons for Modern Design, University of Delaware Press, Newark, New Jersey.

Kempe, David, (1988). Living Underground, a History of Cave and Cliff Dwelling, London.

Oliver, Paul (2003). Dwellings, The Vernacular House World Wide, London.

Terman, M.R. (1985). Earth Sheltered Housing: Principles in Practice, Van Nostrand Reinhold, New York.