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Review Article

Traditional Ecological Design in Libya: A Study in the Sustainability and Environmental Adaptation of Local Architecture

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Abstract

This paper examines how traditional design solutions contribute to adapting to the harsh and diverse climatic conditions in Libya, with a focus on coastal, desert, and mountainous environments. The study analyzes the environmental design strategies used in traditional architecture, such as the inner courtyard, the malqaf, and the adjacent building blocks, by studying architectural models in cities such as Tripoli, Ghadames, and Gharyan. The paper aims to evaluate the effectiveness of these strategies in improving thermal comfort and reducing the impact of climatic conditions, by comparing different architectural characteristics within an environmental and climatic context.

Keywords: Traditional architecture, environmental sustainability, ecological design, Libyan house, desert, mountain, coastal climate.

1. INTRODUCTION

In light of the escalation of contemporary environmental challenges such as climate change, rising temperatures, scarcity of natural resources, and increased energy consumption, it has become necessary to reconsider traditional concepts of architecture that were essentially based on the principles of environmental sustainability before these concepts became a global trend. Traditional Libyan architecture constitutes a rich model that reflects the ability of man to adapt to the surrounding environment through intelligent designs that relied on local natural resources and construction methods that take into account harsh climatic conditions.

The importance of studying traditional architecture is highlighted not only to understand the cultural and architectural heritage, but also to draw lessons on how to achieve a balance between man and his environment. While modern cities are moving towards expensive technical solutions to deal with energy and climate problems, we find that traditional architecture provides natural and simple solutions that have proven their efficiency over centuries of use. Analyzing these models provides valuable insights into ecological design strategies such as natural ventilation, the use of internal courtyards, orienting buildings to benefit from natural light, and thermal insulation techniques using local materials.

Therefore, understanding these principles and applying them in contemporary architecture can contribute to the development of more sustainable urban environments that are more suitable for current environmental challenges. This study also reinforces the importance of integrating traditional knowledge and modern technology to achieve sustainable architectural development that respects the environment and preserves cultural identity.

1.2. Definition of the Problem

Libya, like other countries in the region, faces increasing environmental challenges represented by rising temperatures, climate fluctuations, desertification, and scarcity of water resources. Despite the progress in modern construction techniques, many contemporary buildings are still unable to achieve effective environmental efficiency, leading to excessive reliance on industrial cooling and heating systems, and unsustainable increase in energy consumption.

Libya is characterized by a remarkable climatic diversity that includes a relatively moderate coastal climate, a hot and dry desert climate, and a cooler and

more humid mountain climate in some areas. This diversity imposed special challenges on traditional architecture related to the need to adapt to different environmental conditions, which led to the development of diverse and effective design solutions. Traditional architecture in coastal areas relied on taking advantage of the sea breeze to provide natural ventilation, while desert architecture resorted to using thick walls and natural materials to insulate heat, and buildings in mountainous areas relied on techniques that suit cold and humidity such as the use of local stones with insulating properties.

From here, this study sets out to answer the main question:
How did traditional design solutions contribute to adapting to the harsh and diverse climatic conditions in Libya?

This question aims to analyze ecological design strategies in different Libyan climatic environments (coastal, desert, and mountainous), and evaluate their effectiveness compared to modern designs. The study also seeks to explore the possibility of re-employing these traditional principles in developing a contemporary architecture that is more sustainable and connected to the local environment.

1.3. Theoretical Framework

The Concept of Ecological Design and its Importance in Architecture.

Ecological Design is defined as a comprehensive approach in the field of architecture and urban planning that aims to achieve a balance between built systems and the natural environment. This concept is based on the fundamental principle that buildings are not isolated entities, but rather are part of a broader ecosystem that must interact harmoniously with them. Ecological design is based on understanding the dynamics of the local environment such as climate, topography, natural resources, and lifestyles, while employing these data in developing sustainable architectural solutions that reduce negative environmental impact and enhance human well-being.

1.3.1. The Importance of Ecological Design in Architecture

Environmental design in architecture aims to achieve a balance between buildings and the environment, which enhances the efficiency of natural resource use, reduces energy consumption, and improves the quality of life within architectural spaces through natural ventilation, lighting, and thermal insulation. Focuses on several points that are listed below:

- Ecological design plays a pivotal role in addressing contemporary environmental challenges such as climate change, depletion of natural resources, and environmental pollution. It contributes to achieving sustainable development goals through:
- Achieving energy efficiency: Designing buildings that use energy efficiently, relying on renewable sources such as solar and wind energy, and thermal insulation techniques to reduce the need for artificial heating and cooling systems.
- Water resource management: Developing rainwater harvesting systems, reusing gray water, and adopting water consumption reduction techniques.
- Enhancing indoor environmental quality: Improving natural lighting and indoor air quality using non-toxic materials and natural ventilation systems.
- Reducing the carbon footprint: Using local and sustainable building materials, and reducing energy consumption throughout the building's life cycle.
- Preserving biodiversity: Integrating green spaces, vertical gardens, and green roofs to support biodiversity.

1.3.2. Examples of pioneering ecological designs in the world:

- **Bahrain World Trade Center:** integrates wind turbines between its twin towers, contributing to generating a large proportion of its renewable energy needs, (Figure 1).

- **Passive House (Passivhaus) in Germany**: relies on advanced insulation techniques, triple-glazed windows, and mechanical ventilation systems with heat recovery to reduce energy consumption, (Figure 2).

- **Gardens by the Bay in Singapore**: a sustainable urban project that combines green spaces and environmental technology using “supertrees” to generate solar energy and collect rainwater, (Figure 3, 4).

- **Museum of the Future in the United Arab Emirates**: combines innovation and environmental engineering, relying on solar energy and recycled materials, with a smart ventilation system that reduces energy consumption, (Figure 5).

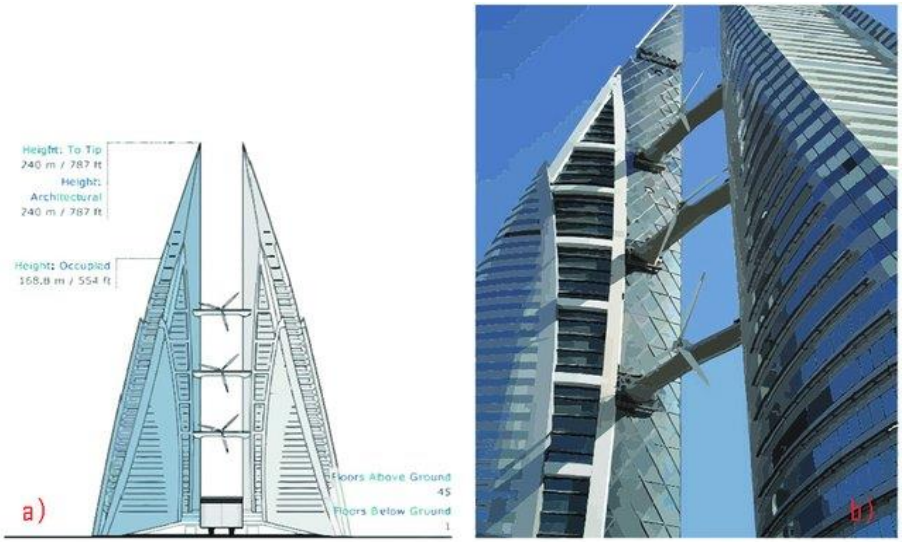

Figure 1: Wind turbines integrated in between the Bahrain world trade Center towers; elevation view (a) and a general view from the pedestrian level (b)

Figure 2: Passive House (Passivhaus) in Germany

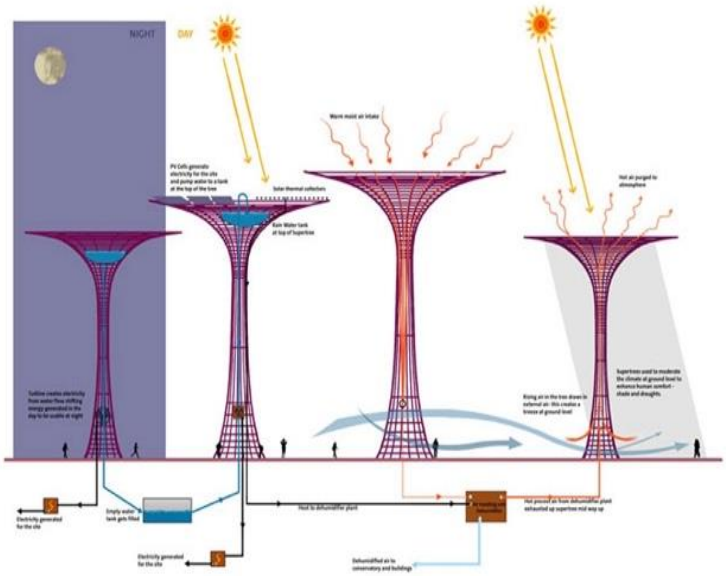

Figure 3: Gardens by the bay_eco - diagram of superstreets

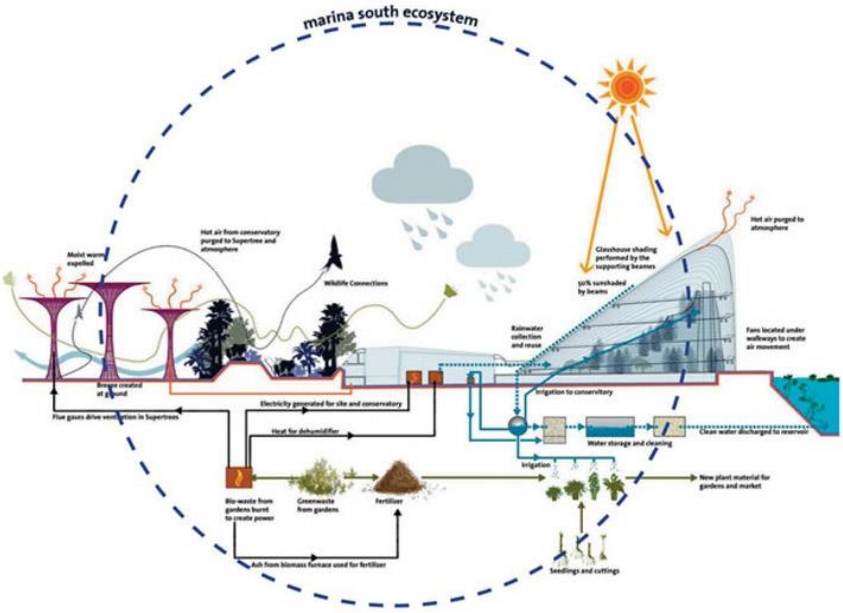

Figure 4: Gardens by the bay_eco - diagram of superstreets and sustainability

Figure 5: Museum of the Future in the United Arab Emirates

1.4. STUDY OBJECTIVES

This study aims to analyze and understand the ecological strategies that traditional Libyan architecture relied on to adapt to the country's climatic and environmental diversity. Based on the importance of traditional architecture as an integrated system that combines cultural and environmental aspects, this study seeks to achieve the following objectives:

1. Analysis of environmental design strategies:
   Studying traditional architectural elements such as internal courtyards, air openings, natural ventilation methods, and the use of local building materials, to understand how they contributed to achieving thermal comfort and reducing dependence on external energy sources.
2. Evaluating the effectiveness of traditional solutions in climate adaptation:
   Comparing the performance of traditional buildings in coastal, desert, and mountainous areas, and determining the efficiency of each strategy in facing harsh climatic conditions such as high temperatures, drought, and humidity.
3. Extracting lessons for application in contemporary architecture:
   Exploring how to integrate traditional ecological design principles with modern construction techniques to achieve sustainable architecture that meets the needs of the present without compromising the cultural and architectural heritage.

4. Raising awareness of the importance of traditional architecture: Highlighting the environmental and cultural value of traditional Libyan architecture as sustainable solutions, and contributing to reviving the concepts of local, environmentally friendly construction within contemporary urban development plans.
5. Providing recommendations for future research: Opening horizons for future studies focusing on the possibilities of developing sustainable architecture in Libya by benefiting from traditional knowledge and modern technologies.

2. METHODOLOGY

The methodology of the paper studied is based on a multidimensional architectural analysis of the environment and traditional practices in Libya and how they adapt to climatic conditions. Here the methodology used in the study can be summarized as follows:

- **Descriptive-analytical approach:** Analyzing traditional architectural designs in Libya across different environments (coastal, desert, mountainous) to understand how they adapt to climatic conditions.
- **Comparative analysis:** Comparing traditional solutions with modern designs to evaluate their effectiveness.
- **Case studies:** Analyzing traditional architectural examples such as coastal, desert, and mountainous houses.

This methodology enables a comprehensive understanding of the interaction of traditional architecture with Libya's different environments, helping to explore opportunities for its re-employment in contemporary architectural design.

"AI tools, were used for text editing and refining the manuscript. However, all outputs were reviewed and edited by the authors."

2.1. TRADITIONAL ARCHITECTURE AS AN EARLY MODEL OF ECOLOGICAL DESIGN

Before the emergence of ecological design as a scientific term, traditional architecture in various parts of the world, including Libya, applied the principles of environmental sustainability instinctively. It relied on: The use of local natural materials: such as clay and limestone in desert houses that provide natural thermal insulation. Climate-adapted design: such as the use of internal courtyards (hosh) to provide shaded areas and natural ventilation. Smart orientation of buildings: to take advantage of cool winds and avoid direct exposure to sunlight in the desert climate.

Notable Libyan examples include: The desert palaces of Ghadames: which feature a design that maintains moderate temperatures throughout the year using thick walls and narrow passages to reduce the impact of the sun. Mountain dwellings in the Nafusa Mountains: which used natural stone to provide effective thermal insulation that suits the mountain climate

2.2. TRADITIONAL ARCHITECTURE AS A PROTOTYPE FOR ENVIRONMENTAL DESIGN: A STUDY ON ENVIRONMENTAL ARCHITECTURE IN LIBYA (THE LIBYAN TRADITIONAL HOUSE).

Studying traditional architecture in Libya is essential to understanding the complex relationship between the environment and the cultural and social factors that have shaped the identity of Libyan society over the ages. Traditional architecture is not just an aesthetic form, but rather an expression of human adaptation to its environment and its interaction with the climate and natural resources surrounding it, making it a living model of sustainable ecological design.

The traditional architectural form in Libya is the result of an evolutionary process in which the entire society participated, as this collective participation contributed to building an urban identity that reflects the cultural and social values of Libyan society. This is evident in the diversity of Libyan cities in terms of desert, mountainous and coastal environments, but the common denominator between them is the success of local architecture in meeting the environmental and social needs of the population through effective ecological design solutions.

Traditional builders realized the importance of the environment in shaping architectural designs, as they relied on local building materials that are compatible with harsh climatic conditions, such as the use of clay, stone and plaster. They also focused on the continuity of aesthetic heritage by incorporating traditional decorative elements that reflect cultural identity. Although these builders did not have formal academic education, their accumulated experience over generations gave them a deep understanding of the principles of sustainable environmental design, which contributed to the development of effective architectural strategies to adapt to climate challenges.

Traditional Libyan architecture is characterized by an urban layout that enhances social interaction and maintains privacy, as narrow, winding alleys are oriented inward, reducing the impact of strong desert winds, providing shade, and lowering temperatures. Building facades are often closed from the outside with limited ventilation openings, while they are open inward to provide natural lighting and enhance ventilation. These characteristics not only enhance climatic comfort, but also reflect a deep understanding of the relationship between man and his environment.

ACCORDING TO THE DIVERSE ENVIRONMENTAL CONDITIONS GOVERNING LIBYA, THREE MAIN TYPES OF TRADITIONAL HOUSES HAVE DEVELOPED, EACH REFLECTING AN INNOVATIVE RESPONSE TO THE LOCAL ENVIRONMENT:

- Coastal House: It is characterized by the use of moisture-resistant building materials with a design that allows natural ventilation to confront the moderate, humid climate, and relies on wide balconies and large windows to improve air flow.
- Desert House: It relies on thick walls and small windows to reduce heat gain, with internal courtyards that provide shade and ventilation, and is characterized by the use of domes to reduce the impact of solar radiation.
- Mountain House (Underground House or Greenhouse): It benefits from the natural thermal insulation of the earth to maintain moderate temperatures in summer and winter, and relies on designs integrated into nature to reduce exposure to harsh climatic factors.

This study seeks to analyze the ecological strategies used in traditional Libyan architecture, and understand how it adapts to harsh climatic conditions, which contributes to providing new visions for applying sustainable design principles in contemporary architecture. It also aims to highlight the importance of integrating environmental and cultural values in modern designs to address current global environmental challenges. To achieve this, the researcher presents the three environmental buildings in more detail:

2.2.1. OLD CITY OF TRIPOLI (COSTAL HOUSE)

The old city of Tripoli is one of the oldest cities in the world, witnessing hundreds of years of history and successive civilizations. The old city represents a living artistic model that reflects the interaction of man with the environment throughout the ages. This city is located in the far northwest of Libya, on the Mediterranean coast, where the moderate climate and sea winds play a fundamental role in shaping the architectural environment in the region (Figure 6).

Figure 6: Built in the north of Libya in the Mediterranean coastal areas Where moderate degree heat. The adjacent houses contribute to the formation of narrow, shaded alleys, which help to moderate the atmosphere and reduce the effect of the sun's heat, providing

Figure 7: View of Tripoli old city. http://mirathlibya.blogspot.com.tr

Figure 8: Tripoli old city plan. https://mirathlibya.blogspot.com

The traditional architecture of old Tripoli, especially in the " Costal house ", represents a unique model of ecological architecture, which takes advantage of the elements of nature to provide comfort for users. This model is based on the principle of the courtyard, which is the beating heart of any traditional house, as the courtyard surrounds most of the rooms, allowing light and air to be distributed naturally within the architectural spaces. In addition, "Malqaf" (or ventilation channels) are used to allow air to pass through the houses in line with the prevailing wind direction, which enhances the ventilation of the houses and reduces internal temperatures.

Figure 7: The Hosh is a type of traditional Libyan house, characterized by its linear design with a longitudinal extension parallel to the street, and surrounded on the sides by neighboring houses that vary in height. The structural elements with repeated arches cast shadows on the walls of houses and alleys, which contributes to softening the atmosphere and reducing the effect of direct sunlight. In addition, these shoulders act as architectural supports that enhance the stability of the walls and support their structural structure

Ecological elements of Libyan coastal house

The elements of ecological architecture in the coastal house in the old city of Tripoli are determined by several main points that highlight its integration with the surrounding environment and its effectiveness in achieving environmental sustainability, namely:

- **The inner courtyard (Hosh):** The courtyard has multiple functions, it not only serves as an aesthetic element, but also contributes to regulating the indoor climate by creating a contrast in temperature between night and day. This contrast helps stimulate natural air movement, creating moderate air currents that cool the interior spaces. This effect is enhanced by the use of "malqaf" or ventilation channels that direct cool winds into the house, depending on the prevailing wind direction in the coastal area. It is considered the pivotal element in the design, as it contributes to regulating the temperature through air exchange between the internal and external spaces. It enhances natural lighting and reduces the need for artificial lighting during the day. It provides a private space for the family that enhances privacy with good ventilation.

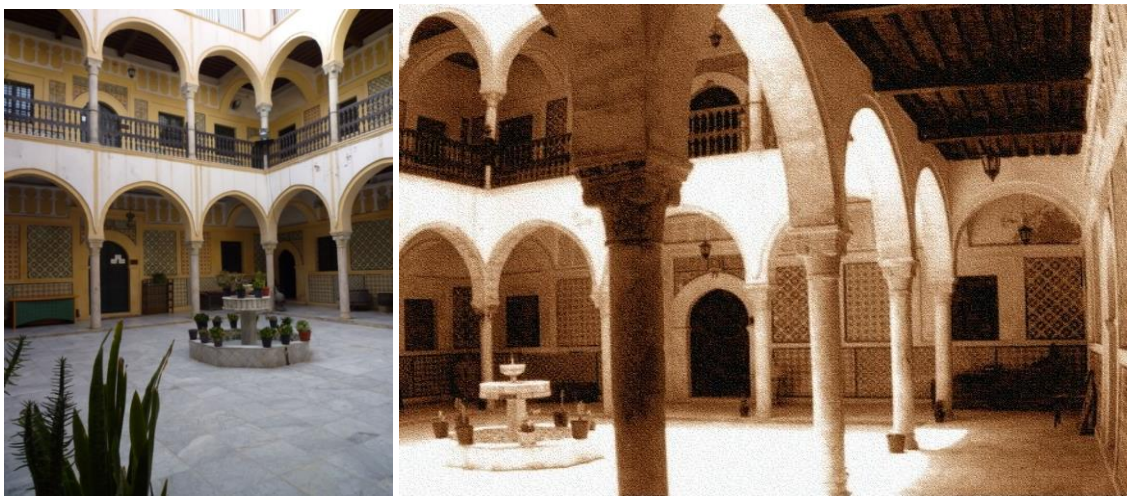

Figure 8: Qaramanli House - Old Tripoli, this house embodies the splendor of traditional Libyan architecture, with the design centered around an inner courtyard (hosh) that enhances natural ventilation and lighting, with decorative details reflecting the Ottoman character. It combines beauty and sustainability through the use of local materials and an environmentally friendly design that adapts to the climate of Tripoli

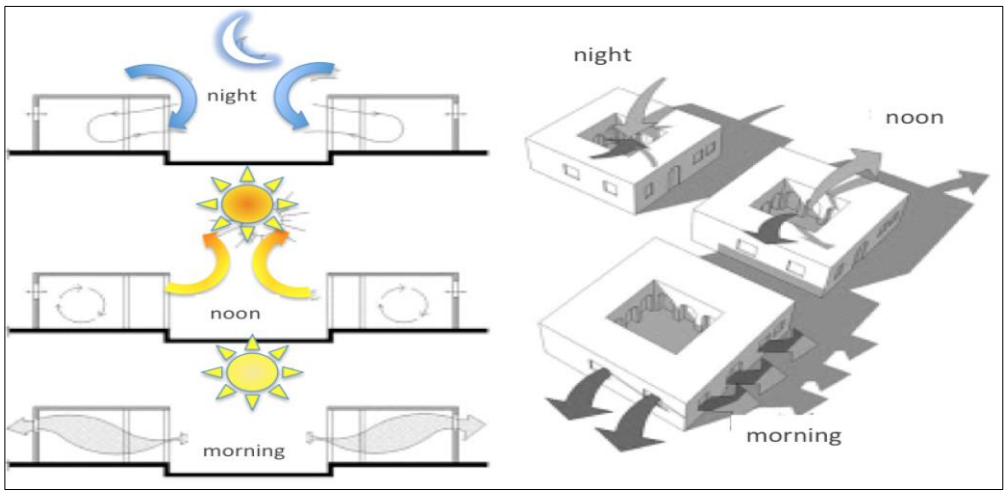

Figure 11: Courtyard house of old Tripoli came as a solution to the problem of climate; cools air through the night and day. http://mirathlibya.blogspot.com.tr

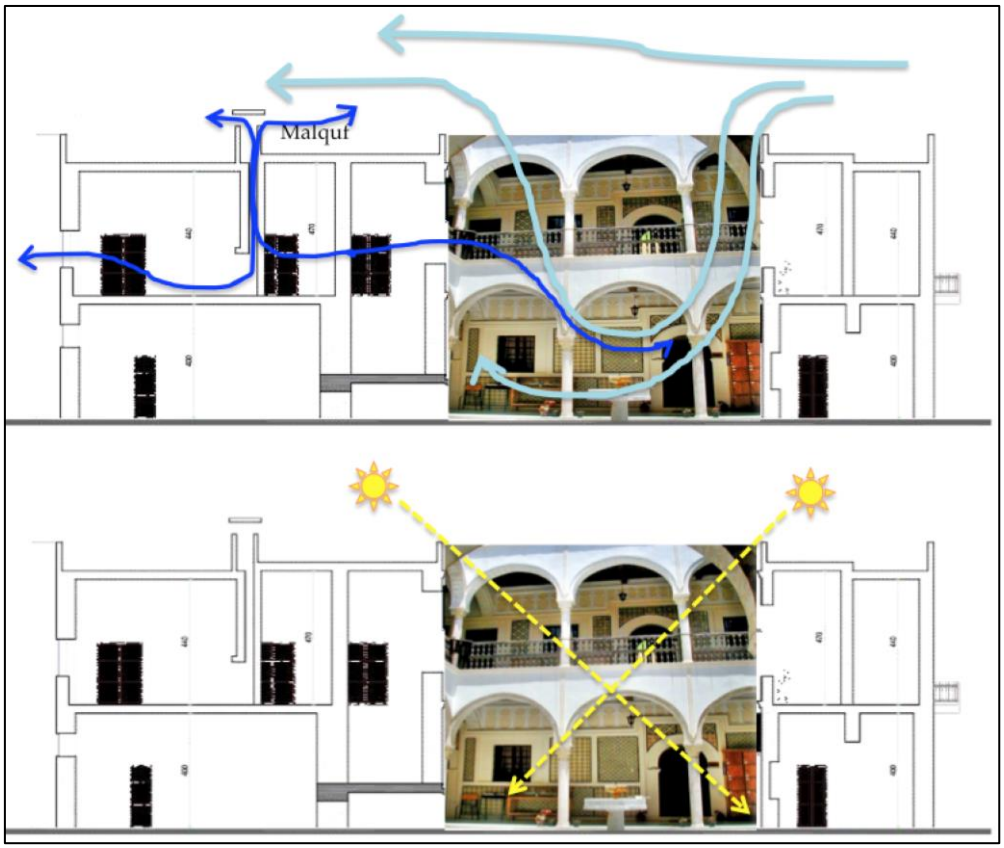

Figure 12: The courtyard in the Tripoli house reflects the ingenuity of the ancient engineer in dealing with the climate and interacting with the environment. Through the courtyard, the house is able to receive fresh, cool air, which contributes to cooling the interior and protecting it from the heat of the atmosphere. The courtyard also provides a shaded place during the day

- **The malqaf (ventilation channels)**: The Malqaf is part of the environmental strategy of Tripoli architecture that relies on natural materials and designs that interact positively with the environment. The Malqaf used to improve the internal ventilation of the house. The Malqaf relies on directing natural winds into the building, which helps in expelling hot air and bringing in cold air, thus improving the indoor air quality and reducing high temperatures. Usually, a ventilation opening or channel built into a house's roof or exterior wall, oriented in the direction of the prevailing wind. It has a simple and effective design, relying on natural air movement to provide climatic comfort inside the house.

- **Using local natural materials:** Clay and limestone are used as basic components, due to their thermal insulation properties that help maintain moderate temperatures inside the house. The walls are painted white to reflect sunlight and reduce heat absorption.

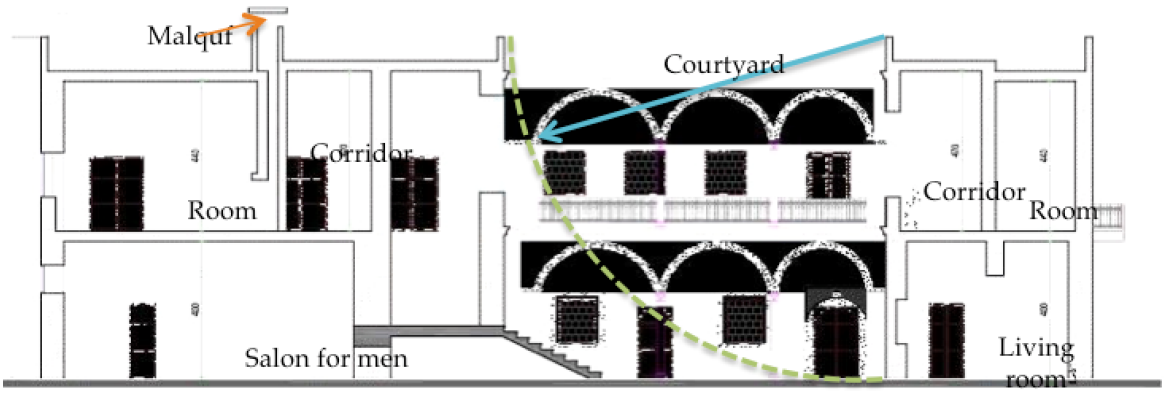

Figure 9: The shape of the courtyard is usually rectangular, and its dimensions range from 70 to 100 square meters depending on the area of the house. The ratio between the average size of the courtyard and the dimensions of the wall in the courtyard is 1:1, which helps ensure that the courtyard is shaded during most of the day. In addition, the Malqaf is used in the design of the courtyard, which is an architectural element that directs cold air inwards and expels hot air outwards, which contributes to improving ventilation and temperature inside the house naturally without the need for mechanical ventilation systems

- **Small windows:** Their limited size design reduces heat leakage and limits the effect of direct sunlight, while allowing moderate natural light to pass through. They are often placed in strategic places to facilitate air movement and distribute natural lighting.
- **Fountain or water element:** The fountain is used in the courtyard to cool the air through the evaporation process, which helps reduce ambient temperatures. It adds an aesthetic element that enhances psychological comfort and tranquility in the indoor environment.
- **Narrow alley design:** They surround the houses and are oriented according to the prevailing wind direction to direct the flow of cool air and reduce direct exposure to the sun. They help create shaded areas that keep the air cool even during hot afternoons.
- **Flat roofs:** They are used as multi-functional spaces, and help reduce heat absorption during the day and discharge it at night. They contribute to improving thermal insulation thanks to the materials used in their construction.
- **Relationship with the external environment:** Integrating the house with the surrounding environment through the harmony of colors, materials, and natural elements, which enhances its environmental and visual sustainability.

Figure 10 Old Tripoli city, Shading the narrow alley using Alsabat or arches

2.2.2. Ghadames old city (Desert house)

The ancient city of Ghadames is one of the most beautiful desert cities in North Africa, combining historical and architectural beauty with cultural richness (Figure15). Ghadames is located in southwestern Libya, 462 kilometers from Tripoli, near the borders with Algeria and Tunisia, making it a historical focal point on the trade route between the north and south of the Sahara.

Ghadames is an oasis of palm trees, a population of 25 thousand people, and is said to have convoys City main station of the remote time, and is one of the most famous cities on the trade route between the north and south of the Sahara and its historical relationship flourishing trade with Timbuktu in Mali. The old city has a population of around 10,000, mainly Berbers. The old part of the town, which is surrounded by a city wall, has been declared a UNESCO World Heritage site.

Figure 11: Built in the desert areas where very high temperature in the western of Libya. Design is based on the agglutination building blocks to work with some of the city and one as a bloc with the environment, using small windows for ventilation top of the wall, built of stone and mud. Top view of Ghadames. Eric Lafforgue photography

The design is based on assembling building blocks in a way that harmonizes with some parts of the city, to form a single block integrated with the surrounding environment. Small windows are used on top of the walls built of stone and mud, which helps in providing natural ventilation while reducing heat entry, thus creating a comfortable environment under the harsh desert conditions.

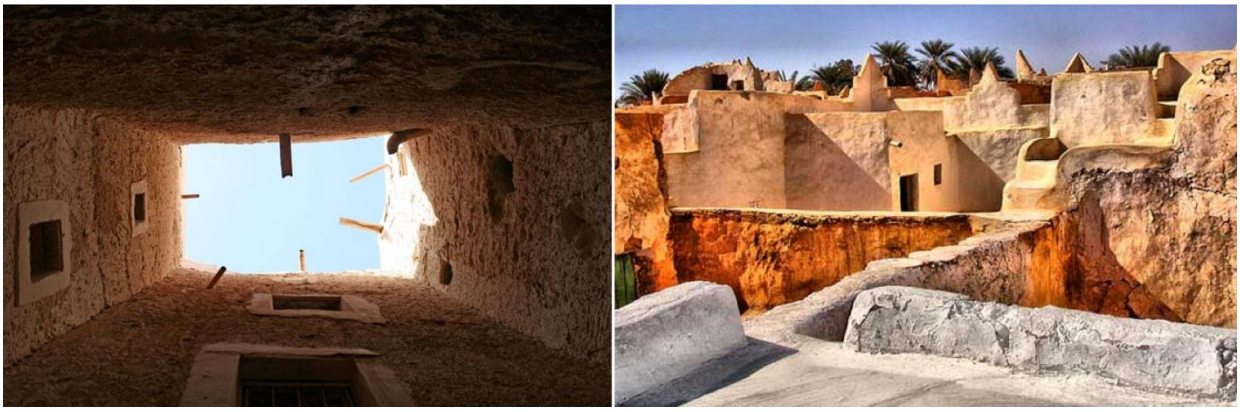

Figure 12: The building configuration in Ghadames is consistently connected, with construction being done vertically rather than horizontally. This design maximizes the use of limited spaces, and allows buildings to be less exposed to direct sunlight, helping to reduce the impact of desert heat

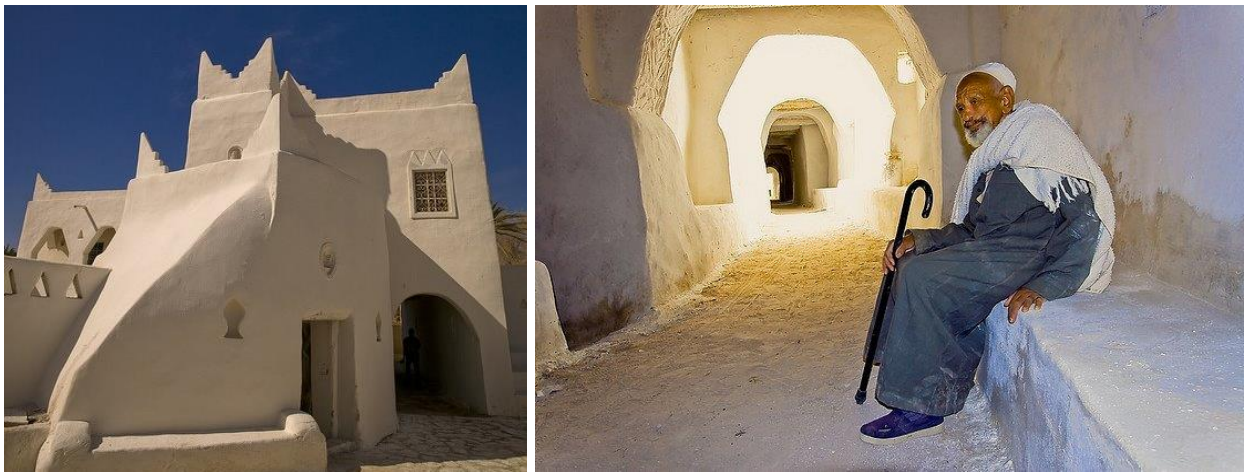

Figure 13: Jewel of Desert, Built in desert region where very high temperature in central and southern Libya. Traditional architecture in Ghadames, responds to the harsh desert climate through: protection, modification and adaptation

Figure 14: He explains that a tight cluster of houses in Ghadames city creates its own natural cooling system, with the streets protected from direct sunlight by the vertical and compact massing of buildings. This massing helps keep the temperature inside the streets and houses at relatively moderate levels, even on the hottest summer days, providing a comfortable environment for residents without the need for artificial air conditioning systems

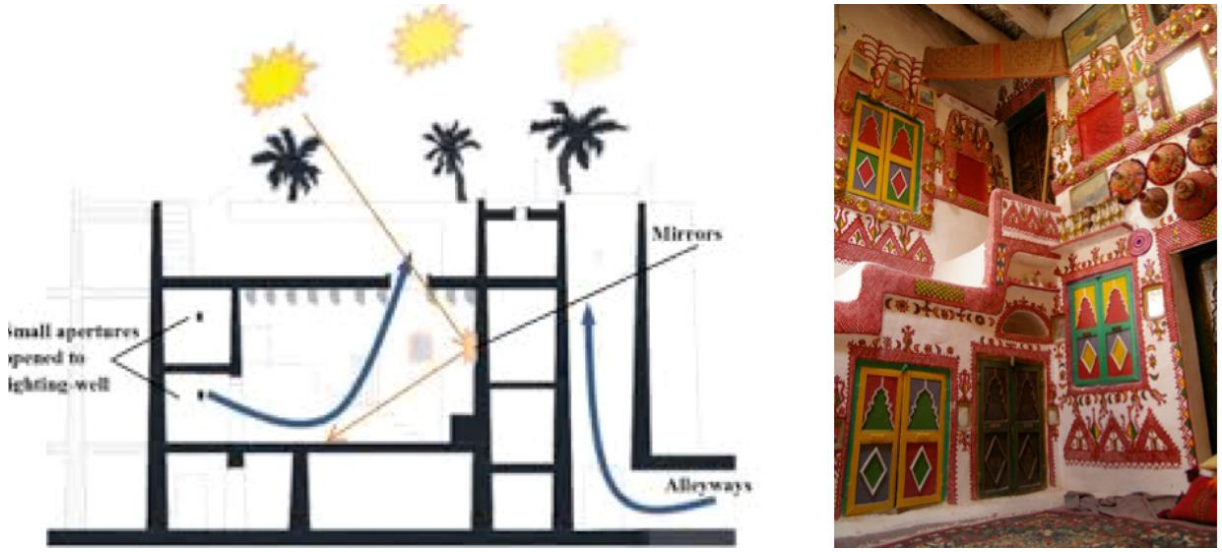

Figure 15: Lighting and ventilation method, usage mirror

- Ein Al Faras of Ghadames:

Ain Al-Faras is a water spring located in the city of Ghadames and is considered one of the most important landmarks in the city, as it is the first nucleus of the city's existence and continuity. This spring is considered the only source of water in the region, which made it the basis for the sustainability of life in Ghadames. The residents added great importance to the spring not only as a source of water, but also through the innovative system used in distributing water. The fathers developed an accurate method to benefit from every drop of water coming out of the "Ain Al-Faras", where five channels (or "Kadoos") were placed to distribute the water, and the system is characterized by a wonderful arithmetic successive distribution that is proportional to the size and capacity of each channel. This unique system reflects the ingenuity of the people of Ghadames in exploiting natural resources in a sustainable manner, which helped preserve the city and gain its historical and economic status.

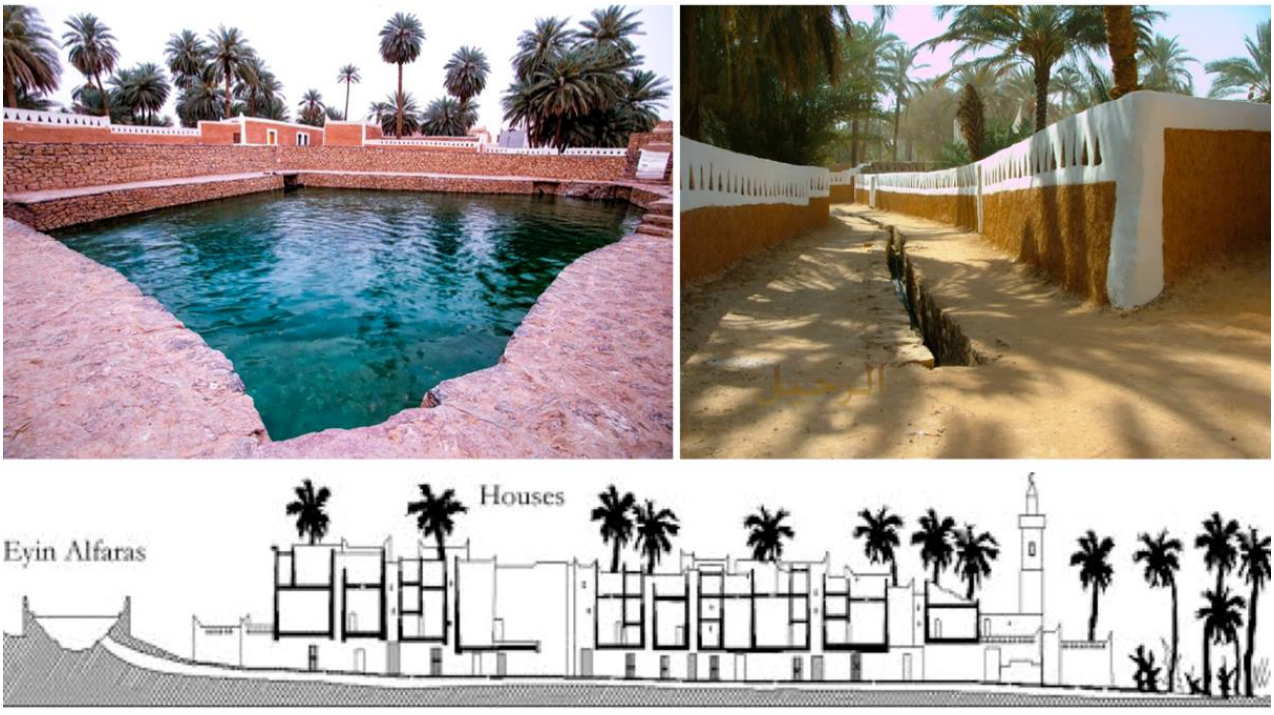

Figure 16: Ein Alfaras Water fountain and the method of distribution to areas of the city

2.2.3. The Old City of Gharyan (Mountain House) and Cave Houses

The city of Gharyan is located in the Nafusa Mountains, which are part of the Western Mountain in northwestern Libya, extending along the slopes of the mountains that meet the Mediterranean coastal plain or Jfara. The city is distributed over heights ranging from 968 meters at the highest peak, and gradually descends towards the south. The city is one of the most important population and cultural centers in the region, and has witnessed repeated expansions towards the west over the ages. The architectural style of Gharyan is considered part of the heritage of the Nafusa Mountains, as many cities of the Western Mountain such as Gharyan, Ifrane, Jadu, Zintan, Nalut and Kabao share the same architectural features due to the similarity of the environment and population. This style is characterized by the use of mountain houses and cave houses as creative architectural solutions, which exploit the mountainous terrain in an intelligent way.

Figure 17: View of Troglodytes houses in (Baqala city - Western mountain)

Caves are a unique type of underground dwelling, used by communities in many desert villages in North Africa, such as Gharyan in Libya. Caves are among the oldest types of dwellings that have survived for thousands of years, providing a safe haven from harsh weather conditions and excellent thermal insulation.

This type of underground home remained inhabited until the 1960s, providing a haven that provided warmth and comfort in the winter and kept cool in the summer, making it an ideal place to live in a desert environment. In addition, they provided security and privacy, especially during periods of unrest and external threats.

These caves were a shelter for a number of communities, including the Amazigh and Libyan Jews, who used these places not only as places of residence, but also as sites for worship and meeting. The writer Hans Fischer notes in his texts that "many groups of Jews arrived in Libya during the Roman occupation, and they resided in temples built underground, such as the pit houses in Gharyan."

These caves are estimated to date back to around 1000 years BC, making them an important part of the historical heritage of Libya and the region in general, as they reflect how humans interacted with the desert environment and adapted their dwellings to the surrounding conditions.

Caves are vertically dug underground dwellings, and their porous earth foundation is a major factor in the construction of this type of dwelling. The main motivation behind building underground homes instead of traditional above-ground homes is the warm climate in the summer, where normal ventilation and insulation cannot keep out the high temperatures. Caves provide the perfect shelter in such conditions, providing a cool environment inside them even on the hottest summer days.

In the winter, caves have also proven their great value, insulating their inhabitants from the harsh winter nights in the desert. By being built underground, these homes have effective thermal insulation that maintains moderate temperatures inside, making them a safe haven throughout the year.

In addition to the climatic benefits, caves were also used as protection against thieves and external threats, as they provided hidden entrances and were

difficult to access, making them a safe place for inhabitants throughout the ages.

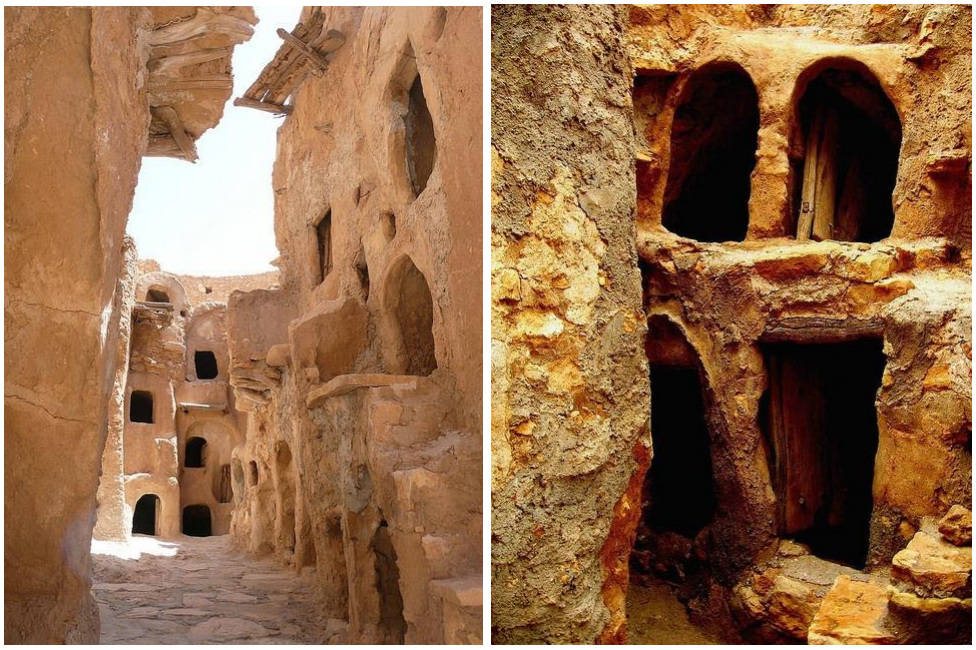

Figure 18: Nalut palace. http://www.tamatart.com

Figure 19: Troglodyte's settlement in Gharyan. https://libyan4native.wordpress.com

Libyans say that dummies are a type of cave dwelling, and the word "damus" is a Latin word meaning "cellar". Dummies are holes in the ground that are 1.5 to 2 metres deep and 3 to 4 metres long, and are equipped with ladders to access them.

These dwellings were used by people as a shelter for survival, as they provide moderate temperatures throughout the year, making them ideal for living in desert areas. The entrance to the dummies is usually through a ground entrance that gradually descends or via stairs to reach the lower courtyard, which ranges in area from 60 to 80 square meters. This courtyard is open to the dummies areas where the family carries out its daily activities.

It is noted that the engineering design of these caves is characterized by its concession in shape, and is closer to the rectangular shape, which reflects the adaptation of this construction to the desert environment and the requirements of the inhabitants of that region.

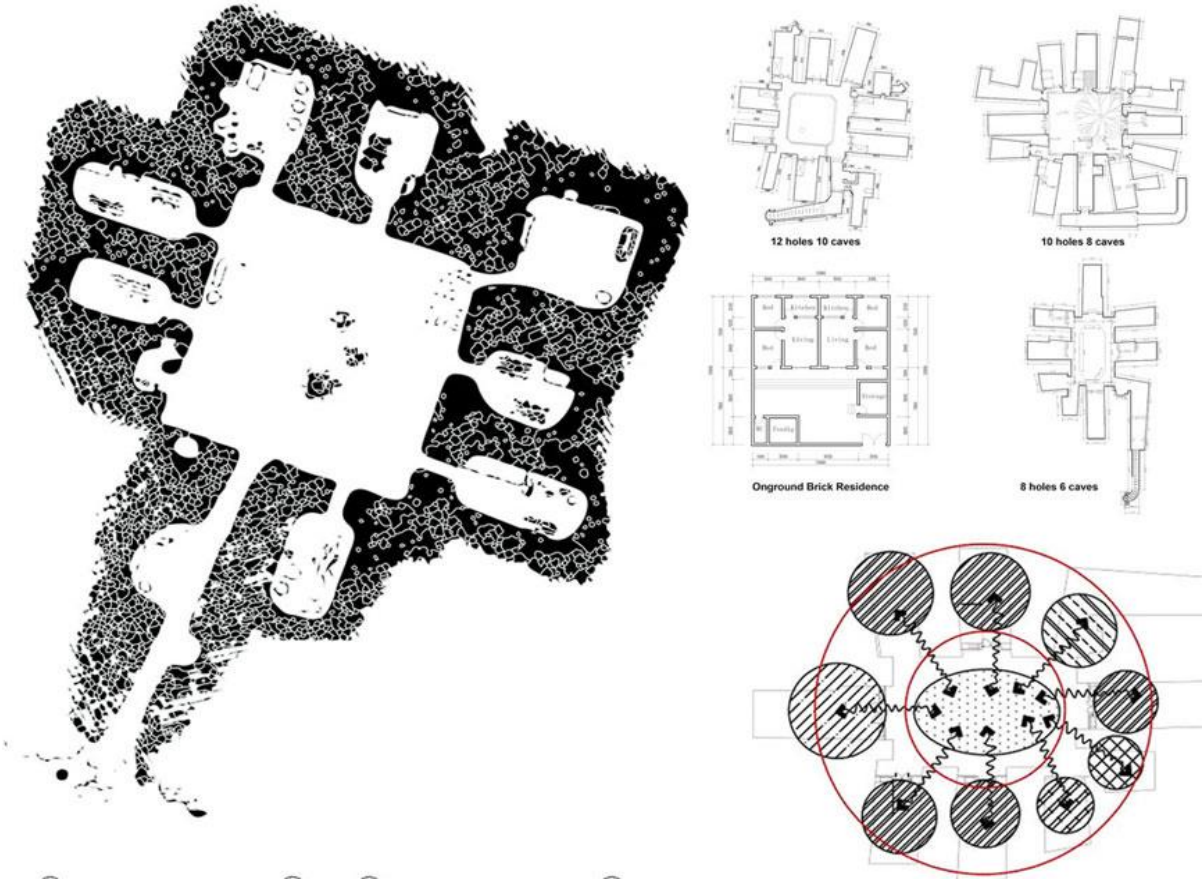

Figure 20: The Idea of Troglodytes (Damous) and the function of living. http://www.libya-design.com

Figure 21: Living room (Damous) and view to the court. https://anthonyaske w.wordpress.comctions/

2.3. INSPIRATION FROM TRADETIONAL ARCHITECTURE IN DESIGNING SUSTAINABLE ENVIROMENTAL BUILDINGS

Traditional architecture in Libya reflects intelligent responses to climatic and environmental conditions, with each region developing building styles that suit its nature. On the coast, buildings were characterized by heat-reflecting materials, while the deserts relied on thick mud blocks to insulate heat, and mountainous areas were characterized by taking advantage of the terrain to create protected and climate-stable spaces.

This comparative analysis (Table1), aims to explore the most important elements of traditional architecture in each of these environments, while explaining how they can be used in the design of modern sustainable buildings that preserve natural resources and achieve high environmental efficiency.

Table 1: Traditional architecture in Libya is a profound reflection of its surrounding environment, adapting greatly to different climatic and geographical conditions. Architectural styles vary according to coastal, desert, and mountainous areas, with architects

Element	Coastal Architecture	Desert Architecture	Mountain Architecture	Application in Sustainable Design
Materials used	Limestone, clay, wood.	Ambi bricks, dried clay, some stones.	Local stones, clay to bind the stones.	Local & renewable materials (compressed bricks, green concrete, & recyclable materials).
Climate adaptation	Internal courtyards for ventilation, small windows to reduce heat.	Thick walls, very small windows to reduce heat absorption.	Houses integrated into the terrain, shading balconies.	Natural ventilation design through high and low openings, plant walls and green roofs to reduce heat.
Spatial organization	Grid layout, narrow alleys to provide shade and ventilation.	Organic layout, close proximity of buildings to protect against storms.	Tiered houses on mountain slopes to take advantage of slopes.	Sustainable urban planning that minimizes terrain modification, introduction of green spaces to reduce heat islands.
Passive ventilation and cooling	Medium sized openings with internal courtyards.	Very small windows and insulated walls.	Natural ventilation across elevation differences.	Integration of natural ventilation systems such as wind towers, use of smart glass to control heat entry.
Water Management	Some simple water conservation systems.	Design of courtyards to collect rainwater.	Relying on mountain water sources and storage.	Rainwater harvesting systems, greywater recycling, smart irrigation networks.
Aesthetic features	Gypsum decorations, decorated wooden doors, light colors.	Flat surfaces, limited decoration, earthy colors.	Simple designs, solid construction, small windows.	Preserving cultural identity, local decorations and designs inspired by the environment.

A comparative analysis of traditional architecture in coastal, desert, and mountainous areas in Libya reveals effective adaptation strategies to the environment and climate, which can be used in the design of sustainable environmental buildings. Coastal architecture is characterized by the use of heat-reflecting materials and open planning to enhance natural ventilation, while desert architecture relies on thick walls and interior spaces to control temperatures and reduce moisture loss. Mountainous architecture, on the other hand, takes advantage of the natural topography to create terraced spaces that provide protection from the elements.

These traditional principles can be integrated into modern design by using local and sustainable building materials, improving natural ventilation strategies, employing passive shading techniques, and enhancing water and energy efficiency. This integration allows for designs that preserve architectural identity and provide effective environmental solutions for the future.

3. CONCLUSION

Based on the findings of this research, traditional design solutions used in different climatic environments in Libya have proved very effective for adaptation to different climatic conditions-in both extreme and diverse cases-in other words coastal, desert, and mountain.

In the coastal environment, traditional houses intelligently operated with the sea winds and sunlight by means of specific applications, like courtyards and malqaf, to provide the comfort level of a clean natural living environment. In the desert region, caves and subterranean dwellings provide ideal protection against extreme temperatures in both extremes. In the mountainous region, the use of local materials such as stone and clay limits the effect of extreme climate, as the building completely integrates with its surrounding environment.

Unlike modern designs, traditional solutions excel in many sustainability features close to the environment in which they exist. Whereas contemporary designs may majorly employ modern technologies that consume high energy resources, traditional architecture relied upon low-cost and low-energy consuming natural technologies, more so sustainable in certain contexts.

These principles provide solid solutions for environmental adaptation and, at the same time, some real opportunity for reuse in contemporary architecture. It has been suggested that traditional architecture could be fused with current technology to develop sustainable architectural designs that embody cultural identity, while making advancements in energy and environmental efficiency. Thus, modern architects and designers should study traditional architecture and re-use it in accordance with the increasingly contemporary environmental dilemmas in their practice in order to strike the right balance between technological developments and environmental sustainability in future buildings.

RESOURCES

Books:

1. Bioclimatic housing design to desert architecture: A case study of Ghadames, Libya, Jamal Alabida, Ahmed Takib
2. In Ernst Haeckel's (1866) footnote where the term ecology originates, he also gives attribute to Ancient Greek: χώρας khōrā "χωρα", meaning "dwelling place, distributional area" - quoted from Stauffer (1957)
3. Ecology From Individuals to Ecosystems. Michael Begon, Colin R. Townsend, John L. Harper. Fourth edition, 1986, 1990, 1996, 2006 by Blackwell Publishing Ltd
4. Schulze et al, Tansley (1934); Molles (1999), p. 482; Chapin *et al.*, (2002), p. 380, (2005); p. 400; Gurevitch et al. (2006), p. 522; Smith & Smith 2012, p.G5
5. Fundamentals of ecology, Odum, EP (1971), third edition, Saunders New York
6. Ecological Design, By Sim Van der Ryn, Stuart Cowan, Published by Island Press, 2007.
7. An Ecological Overview, in The Future of the Future, John McHale (1969), New York; George Braziller
8. Design for the Real World: Human Ecological and social change, Victor Papanek (1972), Chicago: Academy Edition, ix
9. Design for a Sustainable World, Design Issues, Victor Margolin (1997),
10. Design as a Society Significant Activity: An Introduction, Design studies, Clive Dilnot (1982)

Researches:

1. General studies about the City of Ghadames, and designing the neighborhood unit, general plan, Ahmed, S., Ph. D. Theme, 1985. (Unpublished)
2. Materials and Techniques of Traditional Construction in Old City of Ghadames, Bash-Imam, H., UNDP, 1999.
3. Influence of Building Materials and Methods of Construction on the Architectural Expression in Libya -Local Architecture, Almansuri, A. (2000) unpublished research. Thesis Ain shams university, architectural department.
4. "Libya". CIA World Factbook. Retrieved 20 September 2015.
   Statistics Canada. "2011 National Household Survey: Data tables". Retrieved 11 February 2014.
5. B.R. Mitchell. International historical statistics: Africa, Asia & Oceania 1750-2000. CIA - The World Factbook -- Libya (English) Ethnologue report for Libya, Languages of Libya

Websites:

- https://en.wikipedia.org/wiki/Ecology
- http://ecology2.weebly.com/level-of-organization.html
- http://visual.ly/ecosystems-world
- World Population Prospects: The 2010 Revision http://araratinternational.com/libya/
- http://www.archello.com/en/project/rebolo-eco-park#
- *http://www.e-architect.co.uk/singapore/editt-tower*
- *http://www.autoblog.com/photos/vail-pass-wildlife-crossing-proposals/#slide-261872*
- http://www.ctbuh.org
- http://whc.unesco.org/en/statesparties/LY/
- http://www.tripoli-libya.climatemps.com/
- http://www.kwintessential.co.uk/resources/global-etiquette/libya.html
- http://www.thenational.ae
- http://mirathlibya.blogspot.com.tr
- http://www.ar-tr.com/m-arabic/about15.php
- https://libyan4native.wordpress.com
- http://www.libya-design.com
- https://anthonyaskew.wordpress.comctions/