YAŞAR UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

MASTER THESIS

ALGERIAN VERNACULAR ARCHITECTURE IN THE CONTEXT OF SUSTAINABILITY: LEARNING FROM CASBAH AND M'ZAB

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Bornova-IZMIR
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I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and in quality, as a dissertation for the degree of Master of Science.

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ABSTRACT

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Algeria as a country of 2,381,741 square kilometers has three different climate zones respectively: Mediterranean, semi-arid and arid, in its three different regions: Northern, Central and Southern. Each region has developed its typical vernacular tradition; one that responded to climate, topography and life style. Following modernization and westernization of the country since one hundreds of years, traditional building practices started to be abandoned, leading to a radical transformation of the built environment. The current situation of the urban environment depends only on reinforced concrete construction that does not respond to the country's regional variety as it disregards nature, climate and lifestyles of many. This study explores the vernacular building types from the two geographical regions of the country; Casbah (Mediterranean) and M'zab (arid) in order to understand their sustainable architectural design strategies; their own responses to climate, and their fit with the people's lifestyle. The aim is to evaluate the degree of sustainability achieved on those traditional building practices. This will be concluded first by knowing the architectural design principles which should be in a building in order to call it sustainable. This research helps to

understand more about the architectural heritage of Algeria. It gives us a clear knowledge on design strategies of traditional houses in the two regions according to the climate, lifestyle, and local available materials. The findings show that, both case studies have precious sustainable methods, and powerful in the most sustainable criteria, when it comes to the three standards of sustainability: economy of resources, life cycle design, and design for humane comfort. These might be useful for designers and architects in using those sustainable strategies in their new building projects.

Keywords: Vernacular Architecture, Sustainable Architecture, Traditional Algerian Architecture, Vernacular Traditions, Vernacular Design Strategies, Mediterranean Climate, Arid Climate, Casbah, Mzab.

ÖZET

SÜRDÜRÜLEBİLİRLİK BAĞLAMINDA CEZAYİR VERNAKÜLER MİMARİSİ: CASBAH VE MZAB'DAN ÖĞRENİLENLER

Nadjla FELLAHI
Yüksek Lisans Tezi, İç Mimarlık
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Cezayir 2,381,741 kilometrekare yüzölçümü ile ülke olarak üç farklı iklim bölgesine sahiptir: Kuzey, orta ve güney bölgelerinde sırasıyla, Akdeniz, yarı-kurak ve kurak iklim hakimdir. Her bölge iklim, topoğrafya ve yaşam tarzına cevap veren kendi karakteristik vernaküler geleneğini geliştirmiştir. Ülkenin modernleşmesi ve batılılaşmasının ardından geleneksel yapı geleneği, yapılı çevrenin kökten bir biçimde dönüşümüne sebep olarak yavaş yavaş kaybolmaya başlamıştır. Kentsel çevrenin mevcut durumu, ülkenin doğa, iklim ve yaşam tarzını dikkate almayan, bölgesel çeşitliliğe cevap vermeyen betonarme yapılara dayanmaktadır. Bu çalışma ülkenin iki coğrafi bölgesinden vernaküler yapı tiplerini araştırmaktadır; Casbah (Akdeniz) ve Mzab (arid) kentlerindeki sürdürülebilir tasarım stratejilerini, iklime ve toplumun yaşam tarzına bağlı yapılan çözümleri sorgulamaktadır. Bu çalışmanın amacı söz konusu geleneksel yapı geleneğinde kullanılan sürdürülebilir unsurların derecesini araştırmaktır. Öncelikle bir yapıyı sürdürülebilir olarak nitelendirebilmek için olması gereken mimari tasarım ilkeleri tanımlanmıştır. Bu araştırma Cezayir'in mimari mirasını

daha iyi anlamaya yardım edecektir. Bu kapsamda iklim, yaşam tarzı, malzeme olanaklarına göre geleneksel evlerin tasarım stratejileri hakkında bilgi sağlanacaktır. Buluntular her iki bölgede de değerli sürdürülebilir metotlar olduğunu göstermiştir. Kaynakların ekonomik kullanımı, yaşam döngüsü tasarımı ve konfor ıçın tasarım, sürdürülebilirliğin en önemli üç standartıdır. Bu ilkeler sürdürülebilir stratejilerin yeni yapı tasarımında kullanılması için tasarımcılar ve mimarlar için kullanışlı olacaktır.

Anahtar kelimeler: Vernaküler Mimarlık, Sürdürülebilir Mimarlık, Geleneksel Cezayir Mimarisi, Vernaküler Gelenek, Vernaküler Tasarım Stratejileri, Akdeniz İklimi, Kurak İklim, Casbah, Mzab.

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To the greatest father in the world who named me, who steadfastly believed in me and infinitely, supported me. Even in the darkest moments when I lost my self-esteem, he was always there besides me. His words, his wisdom, his voice always inspired me and gave me the strength to pursue my goals. Simply, words can never express my gratitude to him, and needless to say, he is my hero. Also, to the best mother in the world who is the light of my life. Her love, her prayers, and her tenderness, have always been there to alleviate the difficult moments I have been through.

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The enormous thank is to Allah who granted me the strength, wisdom, and perseverance to have this work accomplished on time.

Nadjla FELLAHI

İzmir, 2016

TEXT OF OATH

I declare and honestly confirm that my study, titled “Algerian Vernacular Architecture In The Context Of Sustainability: Learning From Casbah And M'zab” and presented as a Master’s Thesis, has been written without applying to any assistance inconsistent with scientific ethics and traditions, that all sources from which I have benefited are listed in the bibliography, and that I have benefited from these sources by means of making references.

Nadjla FELLAHI

21/06/2016

TABLE OF CONTENTS

INDEX OF FIGURES

INDEX OF TABLES

1 INTRODUCTION

1.1 Subject of the Thesis

This thesis is about the principles of sustainable architecture in vernacular design and their impact on the environment at the present and in the future. The study looks into vernacular housing architecture which exists in Algeria. Specifically, it elucidates the architectural details of the interior design characteristics that are contingent with, on the one hand, the climate conditions present in Algeria, i.e. Mediterranean and arid, and on the other, the lifestyle which differs from one region to another.

Two case studies of Algerian vernacular architecture are identified and explored. These two cases cover different aspects of design characteristics such as traditions, climate, and availability of local materials, cooling and heating systems, interior spaces organization. Furthermore, definitions of sustainable architecture are discussed, along with its principles, importance, design strategies, and the impact on the environment. The Evaluation of the two Algerian vernacular cases studies, i.e. *Casbah* and *M'zab*, is based on their design strategies, lifestyle conditions, local materials and culture.

1.2 Statement of the Problem

Sustainability has become an important issue which needs to be taken into consideration in many subjects, including architecture. This is true mainly because of two reasons: First is the increasing demand for energy consumption in today's building sectors, and second pertains to the increasing world population which augments the pressing need for more housing. The role of architects and designers should come into play here in order to find suggestions and long-term solutions to solve this problem in a way that does not jeopardize the human and natural environment, but rather contribute to its protection over time.

The need to understand and benefit from both vernacular and sustainable architecture is unequivocal today. This premise forms the backbone of this

study. It primarily investigates the linkage between sustainable architecture and vernacular architecture in Algeria. These may in turn provide architects with insights about the possible strategies to be used in the building sector.

French colonization started in 1830. It brought about a wave of modernization and westernization of architecture in Algeria. This is so at least when it comes to the gradual shift away from the traditional building practices. This has led to a radical transformation of the built environment in the country. The vernacular architecture has since started to vanish, although its cultural impact remains and its economic benefits are still valid today.

Another underlying issue which provides a rationale to conduct this study is related to the fact that sustainable architecture is understudied in many developing countries like Algeria. This lack of knowledge may hinder any form of progress in facing the challenges to meet increasing needs of the populations, while protecting the environment. Hence, using sustainable strategies in architecture has become inevitable, and the thesis demonstrates the relevance of this concept in detail.

1.3 The Aim of the Research

The central objective of this research is to assess the vernacular architectural sustainable methods of two existing case studies in Algeria (*Casbah* and *M'zab*). It evaluates them according to a set of principles and criteria which define what constitutes a sustainable building. This analysis is based on the strategies which exist in vernacular buildings in relation to climatic conditions and lifestyles in these two localities. While *Casbah* is located on the northern Mediterranean coastline, *M'zab* is situated in the southern Sahara desert of Algeria. The different characteristics of the two examples enrich the study. At the societal and practitioners' level, the findings would open up new avenues for sustainable architecture and sustainable housing for Algerian architects and interior designers in their future projects.

1.4 Research Questions

The main question of this research is:

" Do the two vernacular case studies contain sustainable approaches and methods? If so, what is the evaluation of those principles according to the concept of a 'sustainable building"?

The specific questions are:

1- What is the definition and the importance of both 'Vernacular Architecture' and 'Sustainable Architecture'?

2- What are the architectural methods and principles needed in a building in order to call it "sustainable"?

1.5 Scope of the Thesis

Firstly, a clear definition of both vernacular and sustainable architecture is discussed along with the relevance of the topic, its potential, as well as the fundamental elements which have to exist in order to consider a building a sustainable one. Secondly, a clear and thorough analysis of the two houses vernacular case studies is explained by focusing on the sustainable methods they both demonstrate. Lastly, an evaluation of the vernacular cases of study in Algeria is made: are they indeed sustainable or not, and if so, to what extent are they so depending on the sustainability elements they contain?

1.6 The Research Methodology

The research methodology of this study firstly tries to understand the design methods and requirements of a sustainable building. Also, in the analysis of the two case studies; by focuses only on the sustainable principles each maintains. In addition to this, an evaluation is made of their degrees of sustainability.

This research contains qualitative data which was collected from the literature review of previous studies. It contains practices of the different parts of the present research; book, internet links and research articles from different academic journals, and previous theses. The two case studies help to provide valuable data to understand sustainable characteristics of the Algerian vernacular architectural.

1.7 Structure of the Thesis

The work presented in this thesis has been presented in the following five chapters. Chapter 1 provides an introduction to the study and includes the aims and the statement of the problem. Chapter 2 provides a clear definition of the concept of vernacular architecture and shows its importance. Chapter 3 defines the concept of sustainable architecture and its importance by elaborating on its architectural strategies and methods employed in this definition. Chapter 4 discusses the principles and the evaluation of the two case studies of vernacular architecture in Algeria (*Casbah* and *Mzab*). This is done according to the main sustainable approaches adopted in existing sustainable buildings. Chapter 5 lists the findings of the thesis, and provides some recommendations on using vernacular sustainable methods and principles in Algeria.

2 THE CONTEXT OF VERNACULAR ARCHITECTURE

2.1 Description of the word 'Vernacular'

According to Finizola et al., (2012) the term 'vernacular' is derived from the Latin expression 'verna' or 'vernaculus' which has three different significations: 1. Specific from the region in which it exists. 2. Unmixed language without foreignness. 3. The tongue of a country. So the original of the term 'Vernacular' is always related to the native language of a specific country or region. Many writers have defined the term 'vernacular' differently. According to the design historian *Darron Dean*, the term 'vernacular' was first used in design by *George Gilbert Scott* in his book 'Domestic and Secular Architecture', published in London (1857). He observes that the first study on Vernacular Design were in the field of architecture. He mentions that the term 'popular' or 'classic' can be used to describe what we call 'vernacular'.

In some Latin countries the term 'vernacular' is used as a synonym of 'popular', while in some European countries it is linked with before industrialization production.

Rudofsky (1964) mentioned that the definition of the term 'vernacular' varies from culture to culture, and from country to country. Today, there are many targets which characterize the word 'vernacular': authentic, informal, spontaneous, non-academic ingenious, popular, rustic, genuine, artisanal, non-official, anonymous, and local.

The meaning of 'vernacular' varies according to the context of its use. It has been used by architects, historians, archaeologists, folklorists and others. Sriti (2013) stated in her study that the emergence of the term, 'vernacular' has played an increasing part in architectural design.

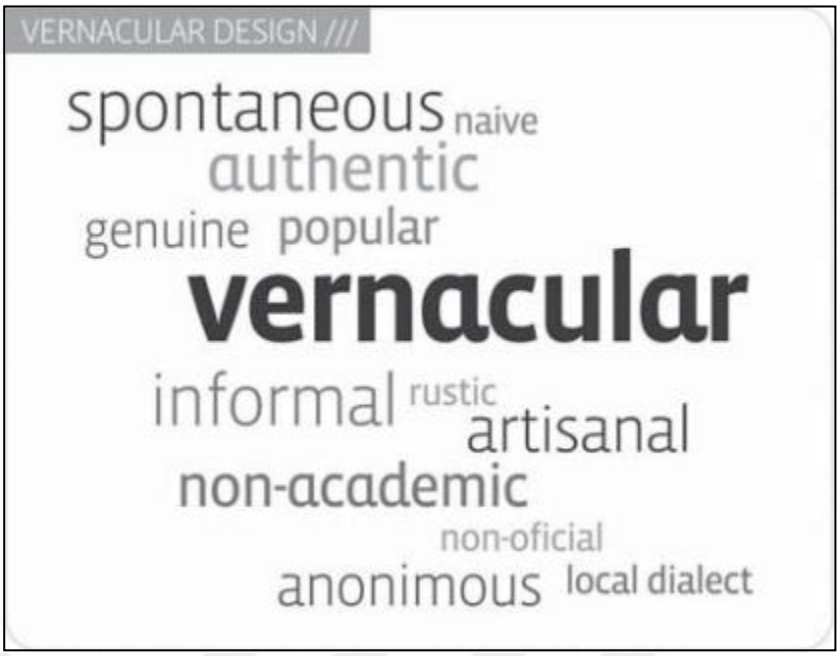


Figure 2.1: Words related to the term 'Vernacular Design' (Finizola et al., 2012).

When we say the word 'vernacular', we mean something specific, native, local and common, which depends on a specific country or a region, its people, its environment, its lifestyle and traditions, and its climate conditions.

2.2 Description of the term 'Vernacular Architecture'

According to the study of Halıcıoğlu (2012) vernacular buildings are human constructions that are the results of relationships among economical, ecological, material, and social aspects. Vernacular Architecture merges local climate conditions, available local materials, modest construction techniques and strategies, living styles, traditions, and socio-economic conditions of a specific region. Vernacular buildings and site planning depend on essential experience, surrounding conditions, and local materials.

Naciri (2007) in her analysis, defined vernacular architecture all as a rich and clever techniques early dwellers utilized to protect themselves from different weather conditions. The magnificent techniques of vernacular architecture can be an inspiration for the modern sustainable movement.

Vernacular architecture is generally characterized by a continuous process over time, as it has been growing in response to actual needs with the available means of every place. It is related to the environmental context and available resources, it is customarily owner or community built, utilizing traditional technologies and local materials (Philokyprou, 2014).

The study of Ozorhon (2014) defines vernacular architecture as the ways and the methods man used to survive, in the natural environment. People created this architecture according to local climate conditions: sun, wind and nature, and this vary according to an area's features, society's culture and social and economic data.

Sriti (2013) in her study defines vernacular architecture as sufficiency architecture because of the use of maximum exciting available means and local materials which nature supplies us. It needs less treatment, shipping, and environmentally and economically low cost.

Rupa et al., (2015) define vernacular architecture as a continuing dialogue between generations. It is the source of indications in the social, cultural and sustainable studies, with its territorial forms and materials at a particular place and time. Usually, it is a mixture of local materials, regional climatic conditions and local building traditions and techniques. It responds to many sides, like climates, places, culture, materials and local skills.

Vernacular architecture records subtly but insistently in the history of people. The shift from communal to individualistic enterprise, from self-sufficiency to dependence; the gain in control over nature, accompanied by a loss of personal involvement in creation; the gain of convenience, accompanied by the loss of pleasure in work; the gain in bodily comfort, accompanied by a loss of confidence in the social order. Vernacular architecture is a great resource for the scholar who wishes to write a more scientific and democratic history, and thus provide his readers with a means for understanding their present estate. At the same time, the study of vernacular architecture holds practical implications for the future (Glassie, 1990).

Valverde (2004) defines vernacular architecture as a kind of building tradition that has already existed and exceed over centuries. A kind of tradition which is recently recognized, it demands the adaptability of the built forms to the social, economical, ecological and climatic environment.

Atek (2012) in her study defined vernacular architecture as a traditional and natural way by which inhabitants create their houses. It is related to the economic, cultural and architectural normalization, and it answers the necessary demands of the human beings.

Bjornard (2010) stated that vernacular architecture is more than just a combination of different styles. But it is a formal method which guides us to more sustainable practices. It is a kind of design which aims to fulfill the most with the least.

Dabaieh (2011) demonstrated in her study that there are so many terms have been used to describe how people built their houses which are related to their needs and convert it to a form of habitations. They constructed it with respect to climate, environment, culture, traditions, beliefs and available local materials, it is architecture without architects: handmade, no engineers, self help, low tech and craftsmen. All these are some terms to describe this type of architecture.

Asimgil (2014) in her research stated that the term vernacular architecture' refers to traditional buildings that have been designed and built to match local climate and culture. Many researches have been done on vernacular architecture. But mostly from the perspective of humanities or social sciences, and very little from the view point of an environmental engineering.

Vernacular architecture refers to an architecture designed in harmony with its environment, in relation to the geographical area of its own, its people and their lifestyle. It performed with techniques and local means, which satisfy social, cultural, and economic needs. Note that the term vernacular architecture said: synonymous with architecture without architects, spontaneous, indigenous, rural, primitive, or anonymous.

2.3 The Value of Vernacular Architecture

Vernacular architecture gives simple solutions for sustainable issues because it has important positive impacts on the environment; these include low energy techniques for human comfort, strategies which are integral to form, orientation, and materials which are obtained from local resources (Halıcıoğlu, 2012).

Kazimee (2008) underlines that vernacular architecture is a learning method by which global challenges can be treated, as global warming, housing crises.

Joseph et al. (2009), present vernacular architecture as an effective solution for buildings in order to struggle with climatic conditions and topographic limitations.

Philokyprou (2014) demonstrated that vernacular architecture is built for specific needs. It shows the conditions and the history of each period in any area. According to the concept of sustainable development which is for integration of cultural heritage with social and economic strategy. The Vernacular architecture takes into consideration bioclimatic features in design, which gives a sustainable identity, by using traditional local materials and available resources.

Sriti (2013) stated in her research that the use of natural resources, and local materials as it was used in vernacular houses, is possible and reduces energy consumption in many different areas. This is because those materials do not need to be prepared or shipped to the location, which represents minimum economical and environmental harms.

Sun (2013) demonstrated that the use of natural materials minimizes processing infection of the carbon- dioxide, which has effects on human health. Vernacular architecture has different methods as related to the climatic factors: reaction with nature, designing with less need for energy resources, profiteering of

renewable energy resources, like wind and sun, low use of water and collecting precipitation.

Valverde (2004) in his study about vernacular architecture stated that it inherits traditional construction technology with the use of local materials, and linking both with natural environment.

Atek (2012) mentioned in her study that vernacular architecture optimizes the need for resources, and it uses available materials of a specific area which is free or costs less. It has a clear relation with its region.

According to Bjornard (2010), most of the materials used in vernacular buildings are naturally durable, like: stone, large timbers, ephemeral materials like: straw, thatch and wooden shingles. All are easy to repair and to replace. According to him, vernacular architecture is made for durability and longevity.

2.4 Examples of Vernacular Architecture around the World

Iranian traditional building techniques show an ingenious use of natural resources without the consumption of additional power (Kazemi & Shirvani, 2011). Soflaee & Shoukouhian (2005) in their study about vernacular architecture in Iran stated that the best example needs to be showed about vernacular architecture in Iran, is "wind tower" or "wind catcher". It is a ventilation technique for natural cooling of houses in hot arid and hot-humid climates; it is particular in the Middle East of Iran. Wind catchers consist of a tower and a head projecting above the roof of the house. However, two or four sides of the tower might be open to receive wind in all directions. The tower should be subdivided, respectively, into two or more groups of shafts, to allow the air to move up and down the tower, at the same time and provides more surface area in contact with the air.

The wind catcher operates according to the condition of the wind and sun radiation in the region. The inside and outside walls absorb a lot of temperature

during daytime. As a result they cause a balance of temperature at night and bestow the attracted warmth to the cold night air. The thickness of the wind catcher walls and the dimension of the holes inside it are designed in a manner to allow enough heat. The light warm air inside the wind catcher ascends and is sucked by upper elevations. As a result cool air flows from windows and doors into the house and continues all through the night (Eirajia & Namdar, 2011). (See Figure: 2.2 and 2.3).

Wind catcher system works by the wind power which comes through the holes designed on it. Air circulation at various points in the building is adjusted by opening or closing the various openers or ducts at the bottom of the wind catcher.

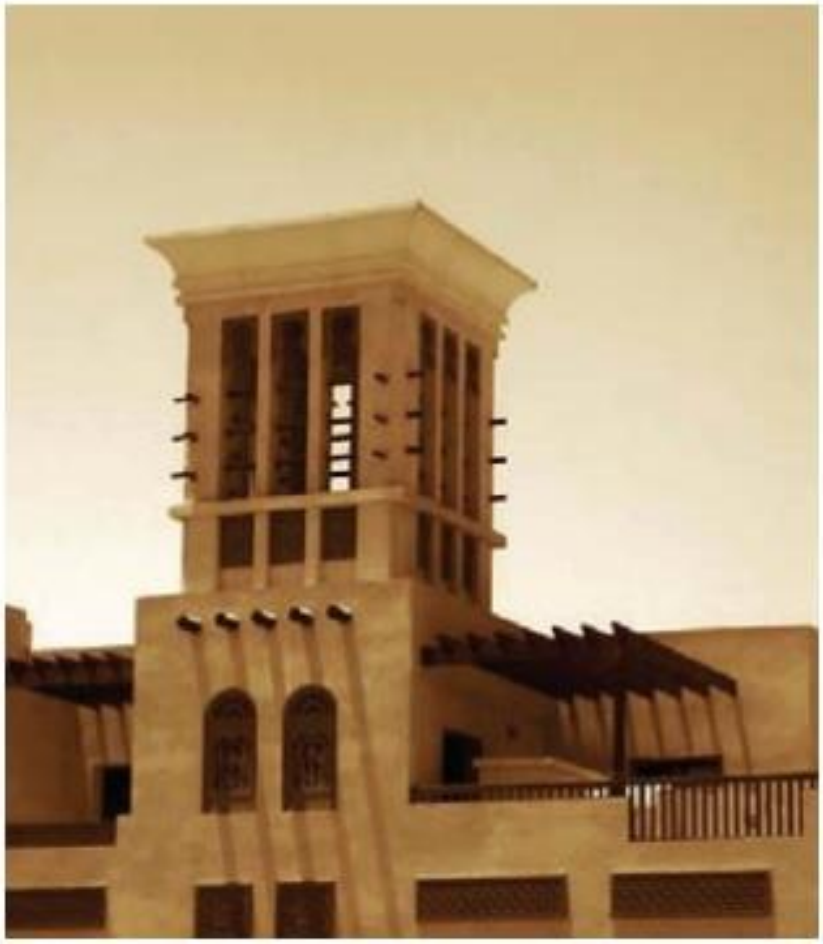


Figure 2.2: Wind Tower in Dry and Hot Region in Iran (Eirajia & Namdar, 2011).

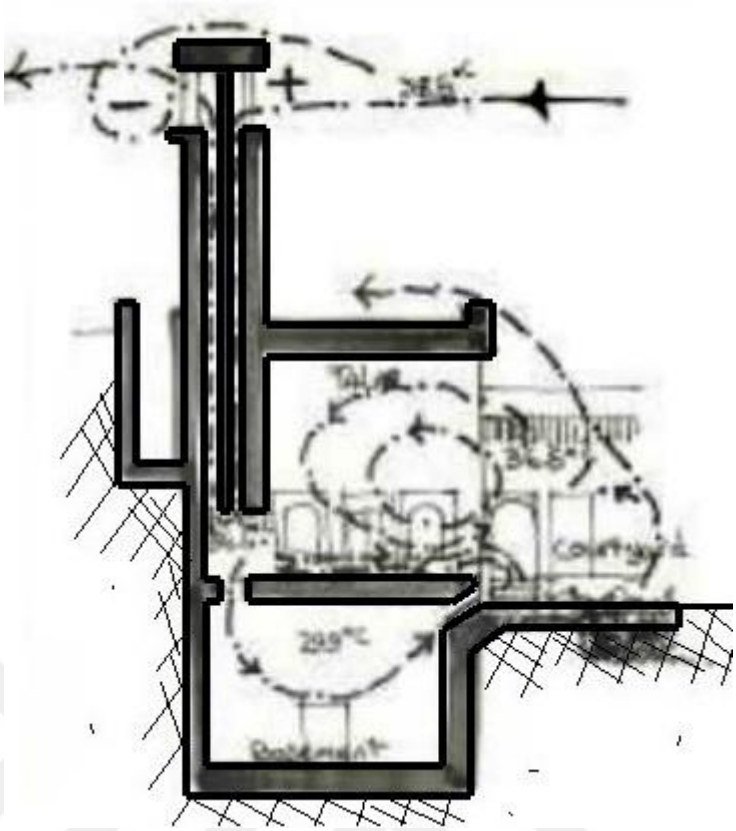


Figure 2.3: Wind Tower Air Circulation System (Keshtkaran, 2011).

Another country where interesting example of sustainable design is seen is India. It's called "step wells". Its original function is to collect and store water for the dry season. Some of them are old as 300 - 500 year old, and are still in good condition. Distinct relation between water and building typologies are a unique architectural contribution of Indian Water Architecture to the world. In India, at some places where rainfall is scarce we see unique architectonic built masterpieces due to varied climatic conditions and geographical terrain (Shubhangi & Shireesh, 2015).

Pathak & Kulkarni (2007) stated in their study that understanding the step well related to the environmental conditions of India, in the rainiest areas. Many of step wells were built on land under Islamic belief. Even under subjugation, the tradition of step well building of Hindu origin continued. (Figure: 2.4 and 2.5).

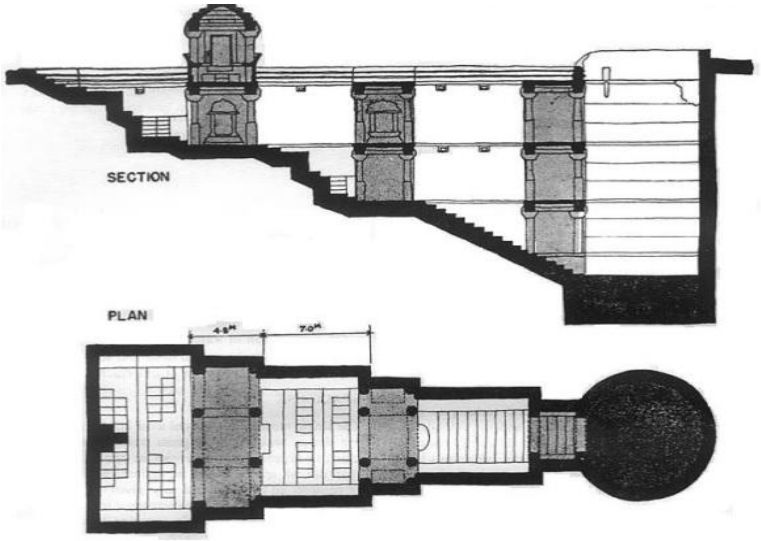


Figure 2.4: A Step Plan & Section Well in India (Gupta, 2013).

Figure 2.5: An Octagonal Step Well in India (Pathak & Kulkarni, 2007).

Turkey as well has several examples of vernacular architecture, Ozdeniz et al., (1998) studied one example. They are the Dome Houses in Harran, located in southern Turkey. Those houses have thermal performance with their interiors, being cool in summer and warm in winter due to the building material which is the adobe. Harran people built their houses with the materials they could find easily, like adobe, brick and a little bit of stone. Another characteristic of the Harran house is that it can be built very rapidly. The tops of the domes are left open as chimneys. (Figure: 2.6 and 2.8).

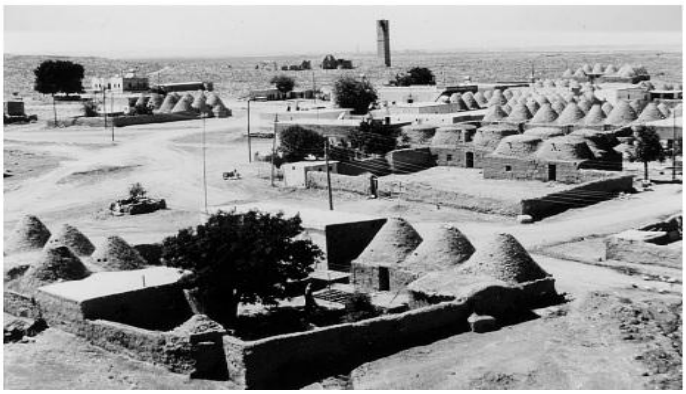


Figure 2.6: A General View of Harran (Ozdeniz et al., (1998).

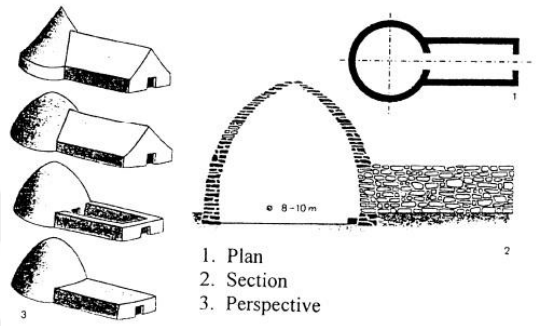


Figure 2.7: Domes Building Forms of Harran (Ozdeniz et al., (1998).

Figure 2.8: Interior View of Harran Dome (Ozdeniz et al., (1998).

Each Country or region has its vernacular architecture which synthesizes most of the specific elements that characterize it; its shape, its responses to the climate, topographical, socio-economic, technical and cultural aspects, as well as materialization linked to endogenous resources. This architecture allows a community to define itself in relation to its area, its tradition and past. Vernacular architecture is therefore an important element to identify a territory as well as its heritage.

3 BACKGROUND OF SUSTAINABLE ARCHITECTURE

3.1 Description of the Concept of Sustainable Architecture

Ozorhon (2014) identified sustainable architecture as all the activities for creating buildings that characterize by the usage of renewable energy resources; sensitive towards the environment, in using energy, water, materials and the space they are in; that which protects the inhabitants' health and comfort in any period or season; it's architecture which consumes less energy and utilizes passive systems. The properties of climate in sustainable architecture play the important rules in its design.

Atek (2012) demonstrated that sustainable architecture should be interested in the constructional and architectural strategies which do not have a negative impact on the environment; and that which ecological, bioclimatic and environmental architecture have the same meaning. It's an architecture which respects the environment and reduces pollution in energy consumption, reuses water, and ecological materials.

Stauskis (2013) stated that sustainable architecture is a tool for evaluating ecological, technical and social quality; in particular plays attention to energy efficiency, and environment friendliness.

Milo (2004) defines the term 'sustainability' as where people can survive without the contributions of the larger natural environment or ecological systems. 'Sustainable Architecture' for him expresses the architectural concept of the reduction of the consumption of natural resources and fuels. It's a kind of energy and ecologically conscious approach to the design of the built environment. It is also a creation of an environment for human occupation, performance and support for life to which sustenance or nourishment is continuously given.

Sustainable architecture is a kind of architecture which is functional, comfortable, which uses efficient raw materials and respectful of the environment. The design of this architecture also referred to bioclimatic aspect, it varies dramatically depending on terrain, climate, regional resources, and local culture. So, it is an architecture which respects the environment and does not have any negative impact on it. It aims to obtain pleasant living conditions in the most natural way possible, by using renewable energy.

3.2 The Importance of Sustainable Architecture

Sustainable architectural design significantly decreases side effects of people on the natural environment and increases the quality of life and economic welfare (Ozorhon, 2014).

In the study of Stauskis (2013) he states that sustainable architecture focuses on the environment, economic and human comfort, and that has three segments: (a) social aspect: by implementing design and construction innovations, user's awareness; (b) technical - economic aspect such as energy efficiency, building materials, communications and waste; (c) environmental aspects, site ecology, water use and pollution.

Barbara (2006) in her study mentions that using sustainable design has many positive effects on the environment by its methods: starting from the building form, material selection, heating, cooling, ventilation, day-lighting and water conservation. It has such benefits as energy, water and operational cost savings. Working with sustainable recycling materials programs which support cradle to cradle cycles, this approach creates products and systems that contribute to economic, social and environmental prosperity. Also, reducing consumption of potable water and protecting water quality are important to sustainability goals. With growing world population and water demands, the aquifers are being depleted faster than they are being replenished. Weather changes also affect water availability in many parts of the world; water conservation programs help water systems to reduce expensive infrastructure projects. Developing new water source

supplies, building new treatment plants to increase capacity, and to expand infrastructure are also important (Barbara, 2006).

According to Palich et al., (2013) sustainable design aims to: Move towards sweeping the use of non-renewable resources, of solid waste production, air, soil and water pollution, in creating healthy indoor environments, and protecting and enhancing natural ecological systems.

Grierson & Carolyn (2011) in his study, made a literature review of different books who wrote about sustainability, to compare how writers described the different sustainable principles. This is summarized in the following table:

Principles	Ecological Design	Green Architecture	One Planet	Adapting Buildings for Climate Change
Authors	S.Van der Ryn, S.Cowan	B.Vale , R.Vale	BR, WWF	S.Roaf
Environmental	-making nature visible	-holism	-natural habitats and wildlife	-not destroy fragile biodiversity and ecosystems
Environmental	-design with nature	-conserving energy -working with climate	-zero carbon	-use as little energy as possible through good design -provide that energy , where possible from clean, renewable sources that will not pollute nor run out
Environmental	-ecological accounting	-minimizing new resources	-local and sustainable materials -sustainable transport -sustainable water -zero waste	-reduce waste in construction, operation and demolition
Social	-everyone is a designer	-respect for users	-health and happiness	-promote the health of all -ensure that people are comfortable and can survive even in extreme weather within them -be built with goods and materials that produce minimal pollution
Economic	-solutions grow from place	-respect for site	-culture and heritage	
Economic			-equity and fairtrade	
Economic			-local and sustainable food	

Figure 3.1: Sustainable Principles Comparison (Grierson & Carolyn, 2011).

Form the figure we may understand that every writer mentioned about different sustainable methods. For the environmental aspect, S. Ven der and S. Cowan stated that making nature visible, design with nature, and making ecological accounting is important for environmental aspect. B. Vale and R. Vale focus on holism (everything connects to everything else), conserving energy, working with climate, and minimizing new resources. BR and WWF focus environmental on natural habitats and wildlife, zero carbon, local and sustainable materials, sustainable transport, sustainable water, and zero waste. According to S. Roaf, environmental principles should include: not destroy fragile biodiversity and ecosystems, use as little energy as possible through good design, and provide energy where possible from clean, renewable resources that neither will not pollute nor run out, reduce waste in construction operation and demolition. For social principle, the methods vary between: respect for users, providing health and happiness, ensure that people are comfortable, and build with materials that produce minimal pollution. For economic principle, some methods should be taken into consideration: respecting for site, cultural heritage.

3. 3 Architectural Sustainable Methods

Stauskis (2013) demonstrated that there are many different sustainable organizations methodologies and each has a different aspect: LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Methodology), BCA Green Mark (Building Construction Authority), DGNAB (German Sustainable Building Council), etc. Despite their different features they have a characteristic common; they all are clearly focused on the environment, economics and human comfort. The following figure explains each system methodology with its percentage in its focusing:

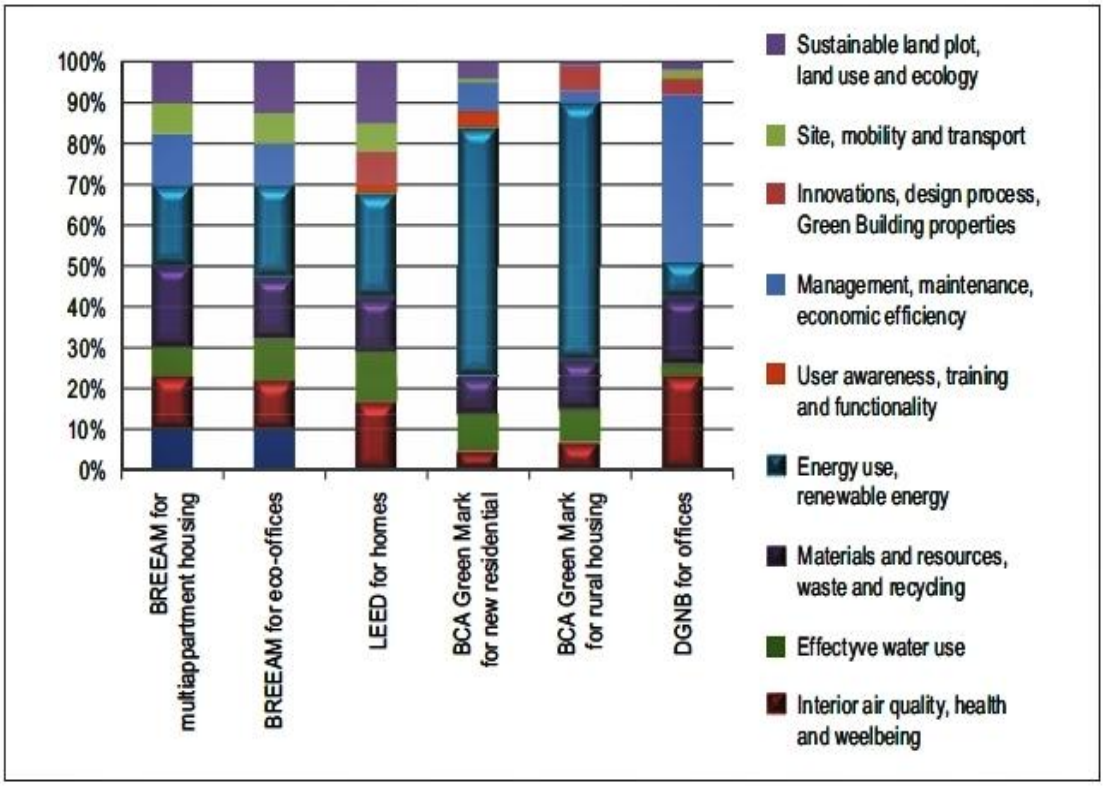


Figure 3.2: Comparative Analysis of Different Sustainability Methodologies (Stauskis, 2013).

From figure 3 we understand that each methodology has different focusing points in order to create a sustainable building. For example LEED for housing, focuses on energy use and renewable energy more than other strategies. The DGNB, for offices focuses on the interior air quality, health and wellbeing more than the other points. The BREEAM, for multi-apartment housing and eco-offices, focuses equally on all sustainability points (sustainable land plot, land use and ecology, site mobility and transport, innovations, design process, green building properties, management, maintenance, economic efficiency, user awareness, training and functionality, energy use, renewable energy, materials and resources, waste and recycling, effective water use, interior air quality, health and wellbeing).

Reducing consumption of potable water and protecting water quality are important for the goals at sustainability. With growing population and water demands, many aquifers are being depleted faster than they are being replenished.

Weather pattern changes also affect water availability in many parts of the U.S. Water conservation programs help water systems avoid or postpone expensive infrastructure projects, such as developing new water source supplies, building new treatment plants to handle increased capacity, and expanding infrastructure (Barbara, 2006). In her study she also mentioned about some current sustainable material methods like Solar Insulating Glass which has several advantages in reducing glare; increasing thermal control and environment comfort for building occupants; generating savings on heating, ventilation and air conditioning (HVAC), and long term annual operational costs. She also mentions the need of using recycling materials programs that support cradle-to cradle cycles, which are perpetually circulated in closed loops. This can maximize material value without damaging ecosystem like mineral fiber ceilings.

If we think globally the relationship between water and sustainability, we must act locally to reduce the harmful effects of the disturbances. Sustainability implies a quantitative and qualitative regulation of the use of water flow. The amount of water withdrawn for agriculture, industry and cities cannot increase indefinitely, as there is a limited resource. Also, collect, process, store, distribute, remove and clean the water has an energy, economic and social cost even more important that people are disadvantaged. Even in wealthy countries where tap water is of good quality, waters are bottled and transported with a significant impact in terms of environment. We should have to adapt to new uses of water, based on the refusal of the waste, the reprocessing and reuse. The rainwater harvesting, low-flow faucets and more sober lifestyles are all simple steps to preserve this valuable asset (Barbara, 2006).

Vandevyvere & Heynen (2014) stated that San Francisco's Orchard Garden Hotel will be California's first hotel to be LEED certified under the LEED-NC rating system (Leadership in Energy and Environmental Design of New Construction). The hotel has many sustainable features which include low flow water fixtures; low organic gas emissions (from paint, carpets, and varnishes), recycled interior finish products are healthier for guests, a guestroom key card system that controls each room's lighting, heating, ventilation, and air conditioning.

According to Milo (2004) there are two main factors to build a sustainable design, the natural factors and the human and cultural factors. In each there are some methods a designer needs to take in consideration:

Natural factors

Climate

- Use natural ventilation techniques to have the appropriate comfort for human activities.
- Use climatic components of temperature, sun, wind to improve the levels of interior comfort (Milo, 2004).

Temperature

In hot climate region:

- Maximize roof ventilation.
- Minimize internal heat gain and maximize exposure for ventilation.
- Maximize wall shading and induce ventilation.
- Isolate heat functions, as kitchens and laundries, from living areas.

In Cold Climate:

- Use powerful Insulation materials to minimize heat loss.
- Maximize openings which oriented toward the sun (Milo, 2004).

Sun

- Use it to provide passive heating.
- Use vegetation to provide shading to walls having eastern and western exposition.
- Orient wide building surfaces away from the hot sun orientation.
- Use light wall and roof colors to reflect solar radiation.
- Maximize building openings to the south.
- Use darker exterior building colors to absorb solar radiation, and to promote heat gain (Milo, 2004).

Wind

- Use it as natural ventilation.
- Maximize or minimize exposure to the wind, by the position of the walls, roof openings, and vegetation.
- Use wind turbines in order to get energy from natural resource (Milo, 2004).

Humidity

- Maximizing ventilation by letting air to flow around indoor environment in order to improve the human comfort.
- Provide fountains, pools, and plants for evaporative cooling (Milo, 2004).

Vegetation

- Minimize disruption of any kind of damage with other natural features by considering and the location and the size of any facility.
- Use natural vegetation in building plans to minimize visual impact of facilities (Milo, 2004).

Topography

- Reduce any kind of changes to the sites' figure, skyline, vegetation, hydrology and soils.
- Use suitable buildings order in order to reduce the visual impact (Milo, 2004).

Hydrology

- A suitable building location is necessary in order to minimize impacts on natural hydrological systems.
- The hydrological system should be protected from any kind of pollution (Milo, 2004).

Humane and cultural factors

- Preserve archeological features to provide previous responses to the environment, as in Vernacular Architecture. Local historic building systems and materials approaches.

- Use local building materials, construction techniques, craftsmen techniques in improving new facilities.
- Understand the local culture and people's needs in order to avert social undesirable practices.
- Provide opportunities for proofing local crafts (Milo, 2004).

In their detailed study about sustainable design Kim & Rigdon (1998), assumed that there are three principles of sustainability in architecture. The first is **Economy of Resources** which is concerned with the reduction, reuse and recycling the natural resources. The second is the **Life Cycle Design** which contains the methodology for analyzing the building process and its impact on the environment. The third principal is **Humane Design.** It focuses on the interactions between humans and the natural world.

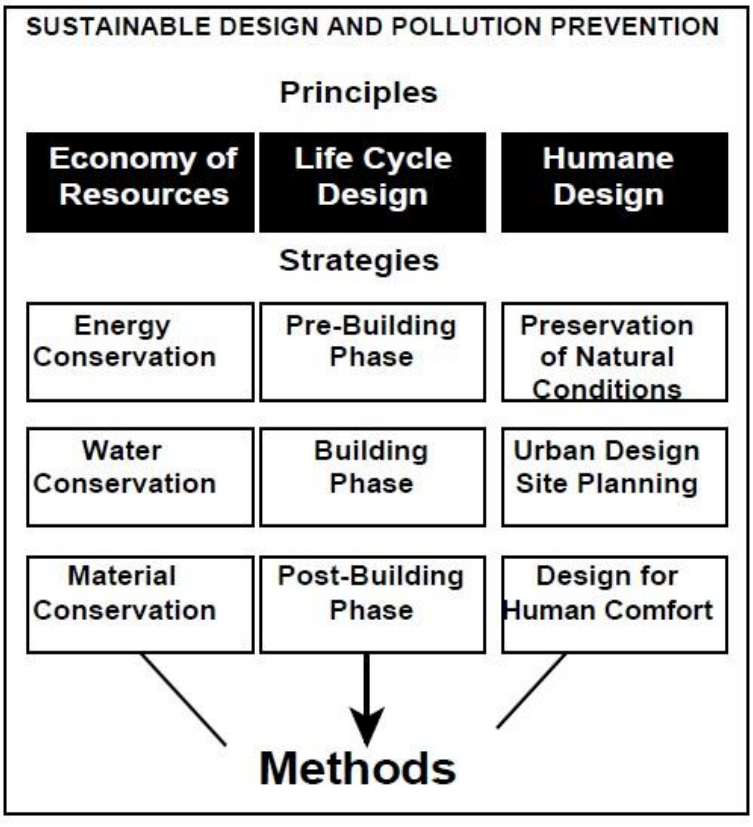


Figure 3.3: Conceptual Framework for Sustainable Design and Pollution Prevention in Architecture (Kim & Rigdon, 1998).

The three principles of sustainable design, economy of resources, life cycle design, and humane design provide a broad awareness of the environment and issues associated with architecture. There are methods in applying sustainable architectural design which are purposed to understand how a building must interacts with the internal, local and global environment.

Economy of Resources

To save resources, architects need to reduce the use of nonrenewable resources in the building constructions. There is a continuous stream of resources. It begins from production of building materials and continues throughout the building's life. The three parts for the economy of resources are: *energy conservation*, *water conservation*, and *material conservation.* Each focuses on a particular resource which is necessary for building construction. Conserving energy, water, and materials can also have some specific design methods that will improve sustainability in architecture (Kim & Rigdon, 1998).

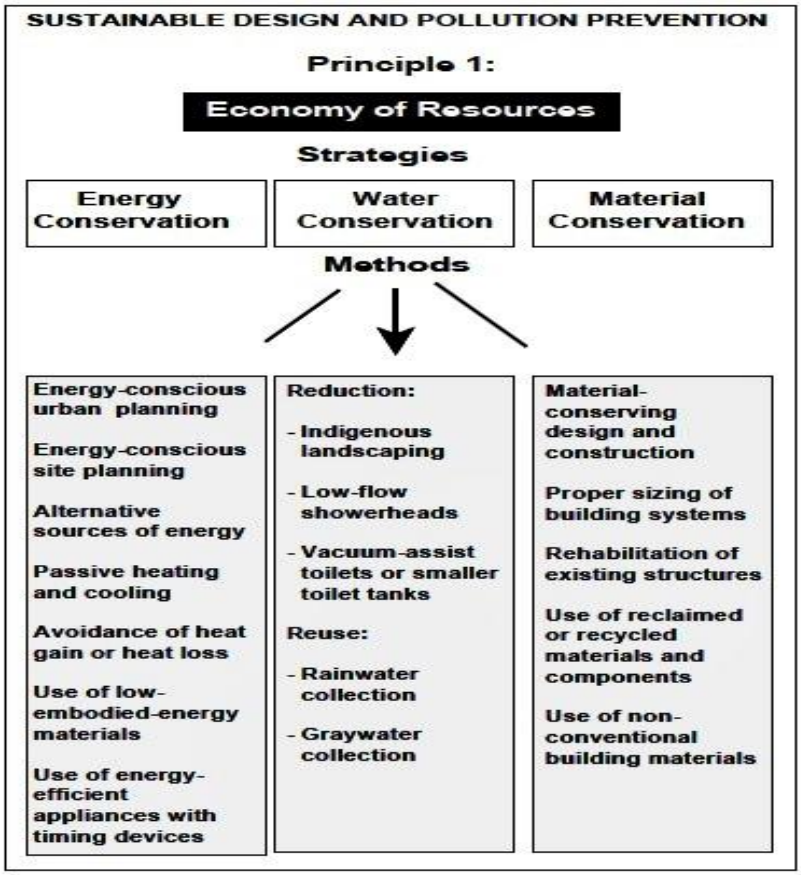


Figure 3.4: Economy of Resources Methods of Applications (Kim & Rigdon, 1998).

Energy Conservation

Building demands a flow of energy during its construction operations. The environmental impacts of energy consumption in buildings happen away from the building site, starting from harvesting energy sources. The energy consumed by a construction building process of heating, cooling, and lighting, cannot be recuperated. Energy conservation criteria are as following:

Energy-Conscious Urban Planning: The favorable city's zoning is by mixed use development; which is planned around public transportation, and pedestrian walkways. In order to allow inhabitants to live near their workplaces, without the need of using cars or buses which effect the environment (Kim & Rigdon, 1998).

Ouis (2012) mentions about the need of encouraging redevelopment of existing sites and the adaptive reuse of old buildings. In addition to this, climatic conditions determine orientation. For example, a very cold or very hot and dry climate requires buildings sharing walls, in order to reduce exposed surface area. A hot, humid climate requires widely spaced structures to maximize natural ventilation.

Kim & Rigdon (1998), the target of these criteria is the organization way of houses and buildings with each other, in order to have a suitable urban planning and arrangement.

Energy-Conscious Site Planning: Designers should know how to maximize the use of natural resources on site. For example, in mild climates, open southern exposure will encourage passive solar heating. Trees and vegetation may provide shade in summer and solar heat gain in winter. Evergreen plants protect it from winter winds, which improve its energy efficiency. Buildings can be located close to water onsite in order to provide natural cooling in summer (Kim & Rigdon, 1998).

In this principle, natural site aspect should be taken in consideration, in order to have a well building arrangement and orientation according to the site environment, and the climatic conditions.

Passive Heating and Cooling: Passive solar methods are offered to control solar radiation. Shading in summer by plants prevents summer heat gain, as well as air-conditioning costs. The wind provides two major benefits: cooling and hygienic effects. Improving the indoor thermal comfort by maximizing the use of natural heating and cooling, reduces energy consumption (Kim & Rigdon, 1998).

Insulation: Heat gain and loss can be prevented by windows and walls. Reducing this creates more comfortable thermal environments. The building insulation aspect is affected by materials properties, the surface of windows and walls (Kim & Rigdon, 1998). The selection of building materials should be thoughtful, in order to have enough and suitable thermal and acoustic insulation.

Alternative Sources of Energy: Solar, wind, and water, can be used to reduce and eliminate the need for external energy sources. Electrical and heating energy requirements can be done by these natural systems (Kim & Rigdon, 1998).

Day lighting: Building and window design that utilizes natural light will lead to conserve electrical lighting energy and reducing cooling energy consumptions (Kim & Rigdon, 1998).

Choose Materials with Low Embodied Energy: Embodied energy of a material attempts to measure the energy goes into its entire life cycle. For example, aluminum has very high embodied energy because of the large amount of electricity that must be used for its manufacturing process. In the other hand, recycled aluminum requires less energy to prefabricate. Choosing materials with low embodied energy reduce the environmental impact. As well as using local materials will save transportation energy (Kim & Rigdon, 1998).

Sassi (2006) stated in her study that buildings consume energy not only in their operation. For heating, lighting and cooling, but also in their construction. The materials used must be harvested, processed, and transported to the building site. Also, construction process requires large amounts of energy. The main goal of energy conservation is to reduce consumption of fossil fuels (a natural fuel such as coal or gas, formed in the geological past from the remains of living organisms) (Sassi, 2006).

Water Conservation

A building requires a huge quantity of water for different purposes: drinking, cooking, washing, cleaning, irrigating plants, etc. All this water should be treated by using lot of energy. A reduction in water use produces a reduction in water waste (Kim & Rigdon, 1998).

Reduce Consumption: Using water on site also eliminates the need for energy-intensive municipal treatment. Using native plants to the local ecosystem which are adapted to the local rainfall condition reduces water consumption and eliminate the need for additional watering (Kim & Rigdon, 1998).

Material Conservation

The waste generated by the construction and installation process of the building is so significant; the output materials should be recycled.

Adapt Existing Buildings to New Uses: Reusing resources that already exist in existing buildings is one of the most effective methods to conserve materials. Another way is to convert these buildings to new uses (Kim & Rigdon, 1998).

Incorporate Reclaimed or Recycled Material: Demolishing a building might be a resource for new buildings. Some building materials, as wood, steel, and glass, can easily be recycled into new materials. Brick or windows can be

used in new structure. Furnishings can easily move from one location to another (Kim & Rigdon, 1998).

Use Materials That Can Be Recycled: Using materials that can be recycled in the process of designing building and selecting building materials preserves the energy embodied in their manufacture (Kim & Rigdon, 1998).

Size Buildings and Systems Properly: If a building is too large or small for the number of people who live in it, its heating, cooling, and ventilation systems, will be inappropriate. Programming issue has to be well thoughtful. Interior spaces must be carefully studied in order to ensure having a building which is sized correctly (Kim & Rigdon, 1998).

Reuse Non-Conventional Products as Building Materials: Building materials from unusual sources like recycled tires, pop bottles, and agricultural waste, reduce the need for new landfills.

Life Cycle Design

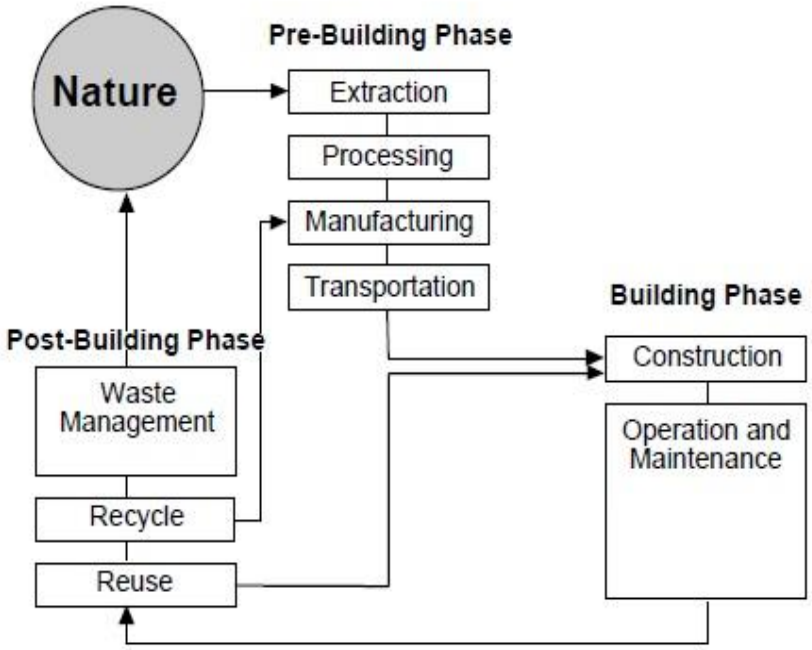


Figure 3.5: Sustainable Building Life Cycle (Kim & Rigdon, 1998).

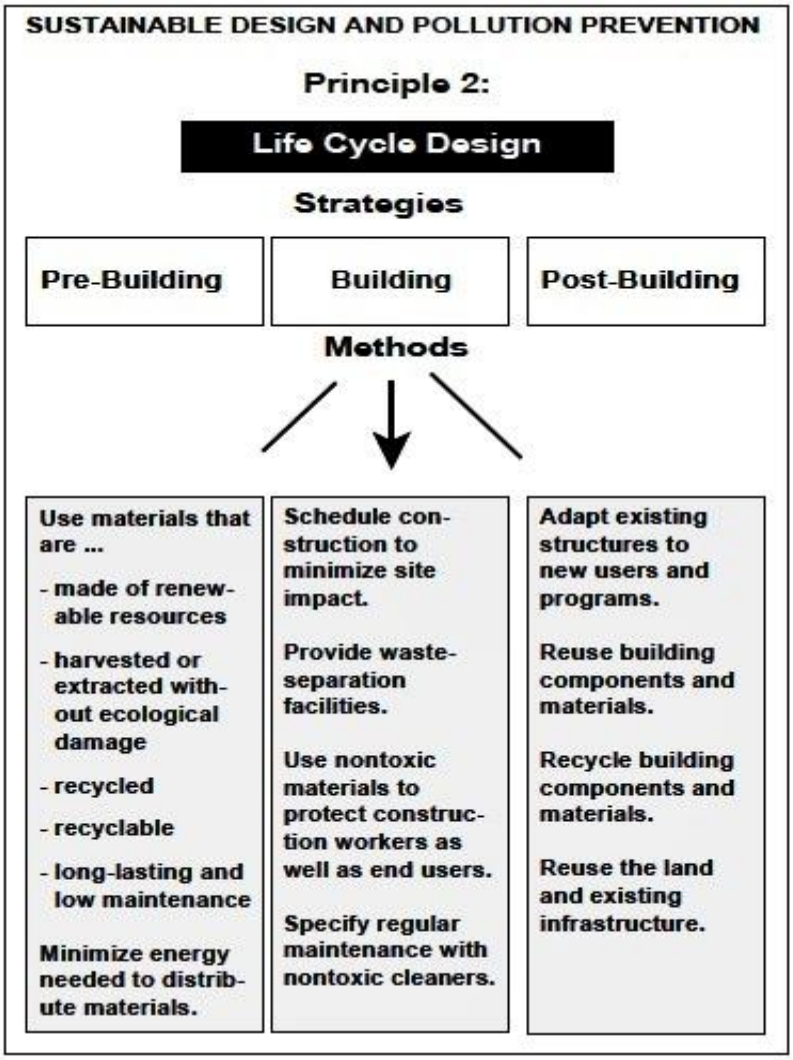


Figure 3.6: Life Cycle Design, Methods of Applications (Kim & Rigdon, 1998).

LCD (Life Cycle Design) is based on the notion that a material passes into a different body after death, from a useful life to another, with no end to its usefulness. This principle can be categorized in three phases: pre-building, building, and post-building (Kim & Rigdon, 1998). The method of this principle focuses mainly on reducing the inputs of the building. These materials reduce the environmental impact of the manufacturing process.

Pre-Building phase

Site selection, design, and the building process, include in this phase. The designer should examine the environmental consequences, the impact on the landscape and materials used. Depending on their weight and distance from the site, the transportation of these materials can be a highly polluting activity. For this phase we need to:

Use Materials Made From Renewable Resources: Renewable resources are those that can be grown or gain at a rate that exceeds the rate of human consumption. Nonrenewable materials like petroleum, metals, etc, are not sustainable. The use of renewable materials reduces the need for nonrenewable materials (Kim & Rigdon, 1998).

Use Materials Harvested or Extracted Without Causing Ecological Damage: The architect or the designer should be aware of how different raw materials are harvested and understand their local and global impacts, because some renewable materials cannot be obtained without significant environmental effects (Kim & Rigdon, 1998).

Use Recycled Materials: Using recycled reduces the consumption of materials made from virgin natural resources and reduce waste as well. For example: steel, is easily recycled, this means eliminating the need for more operations which need energy (Kim & Rigdon, 1998).

Use Materials with Long Life and Low Maintenance: To reduce the consumption of raw materials, using durable materials which last longer and require less maintenance is a sustainable way to achieve this aim (Kim & Rigdon, 1998). The manufacturing of building products requires energy and creates environmental pollution. For example, a high level of energy is required to manufacture steel or aluminum products. The designer or the architect chooses which materials will be used for the building. The selection of materials is particularly important; the impact of materials processing can be global and have long-term consequences (Joseph et al., 2009).

Building phase

This phase refers to the stage when a building is physically being constructed. A building should be examined to reduce its environmental impact on resource consumption. Also it should consider the long-term health effects of the building environment on its occupants (Kim & Rigdon, 1998). This phase is concerned with the environmental impact of actual construction and operation processes.

Minimize Site Impact: Careful planning can reduce damage on the ecosystem on the site. Trees and vegetation should only be removed when absolutely necessary for access. Finished structures should respect site topology and existing drainage. Excavations should not alter the flow of groundwater through the site (Kim & Rigdon, 1998).

Post-Building phase

This phase begins when the useful life of a building ends. In this stage, by recycling and reusing building materials, it becomes a resource for other buildings. Reusing or recycling allows a building to become a resource for new buildings (Kim & Rigdon, 1998).

Reuse the Building: Energy will be conserved if a building can be adapted to new use. If this is not possible, individual components can be selected for reuse: doors, windows bricks, etc (Kim & Rigdon, 1998).

Recycle Materials: For example steel, which can easily be easily separated. And concrete, can be used as aggregate in new buildings (Kim & Rigdon, 1998).

Humane Design

The methods on this phase focus on improving the quality of life for humans and other species.

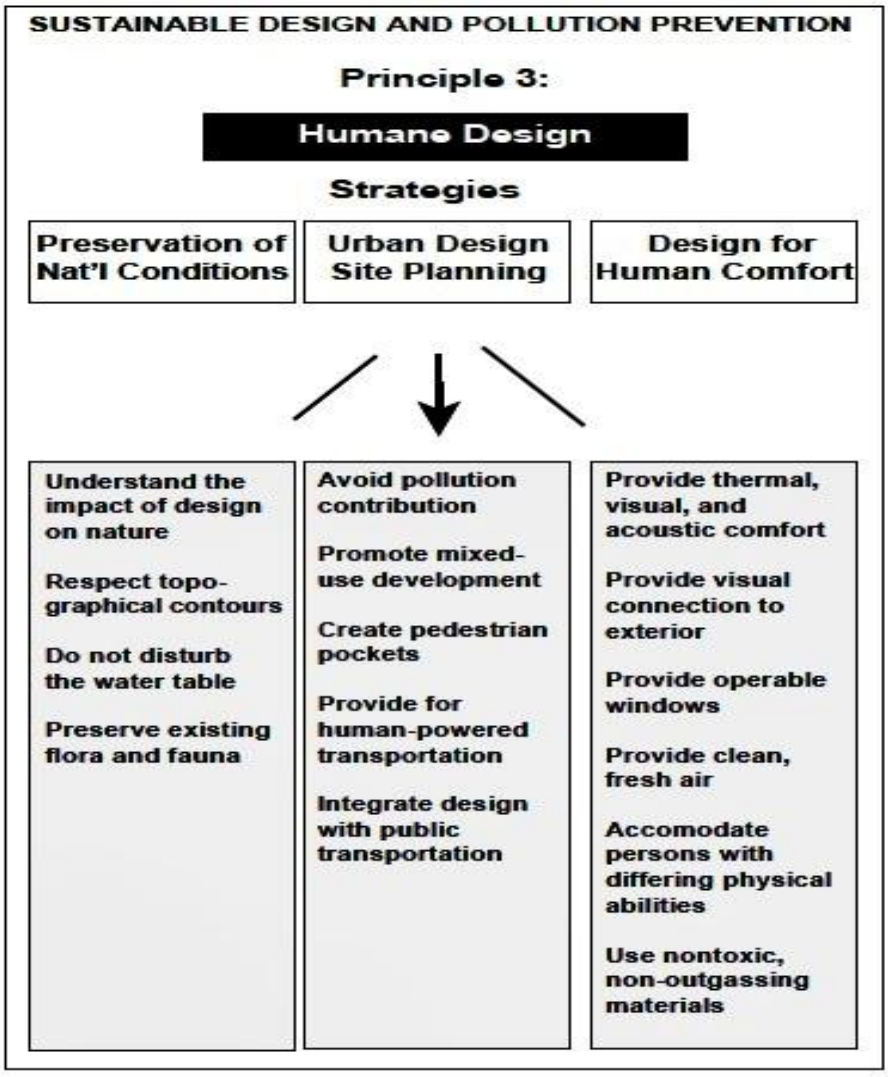


Figure 3.7: Humane Design, Methods of Applications (Kim & Rigdon, 1998).

Preservation of Natural Conditions

Respect Topographical Contours: Designers should respect the existing contours of the building site. Modification on site contours will affect how wind moves and water drains through a site.

- Natural hydraulic process will be disturbed if a large obstruction is placed into a water table. Sites should not require an excavation below the local water table.

- As a part of a building site, Local wildlife and vegetation should be recognized. The building might be more enjoyable space for human habitation if native plants and animals are surrounded with the building (Kim & Rigdon, 1998).

Urban Design and Site Planning

Integrate Design with Public Transportation: To promote public transportation, sustainable architecture on an urban scale must be designed. Vehicles moving in and out of the area with the daily congested traffic, parking spaces, should be taken into consideration (Kim & Rigdon, 1998).

Promote Mixed Use Development: If people have the option of living near where they work and shop. This will provide a greater sense of community. Sustainable development encourages the mixing of residential; where different needed facilities are surrounded with inhabitants living places (Kim & Rigdon, 1998).

Design for Human Comfort

Provide Thermal, Visual, and Acoustic Comfort: Proper lighting, acoustic and visual privacy need to be considered in any kind of building, because users do not feel well in spaces that are too hot or too cold for them (Kim & Rigdon, 1998).

Provide Visual Connection to Exterior: From a psychological and physiological estimation, windows which open to the outside are essential in order to keep the body to work properly (Kim & Rigdon, 1998).

Provide Operable Windows: Building occupants may control the indoor temperature and ventilation of their inner spaces, by a suitable size and practical windows (Kim & Rigdon, 1998).

Provide Fresh Clean Air: Fresh air is necessary for the well-being of a building's occupants. Opening orientation and location should be considerable in any building (Kim & Rigdon, 1998).

Accommodate Persons with different Physical Abilities: Buildings that are durable and adaptable are more sustainable than those which are not. This adaptability includes welcoming people of different ages, physical conditions and genders. The more people that can use a building, the longer will be a building's useful life (Kim & Rigdon, 1998).

Palich et al., (2013) in their study on sustainable design strategies defined it as an approach to building procurement and other urban development which works towards achieving zero net environmental this was to include the following points:

- Eliminating the use of non-renewable resources.
- Eliminating air, soil and water pollution.
- Creating healthy and accessible indoor and urban environments.
- Protecting and enhancing natural ecosystems and cycles.
- Supporting the conversion of waste into useful resources.
- Creating a built environment that is resilient, flexible and adaptive to climate change.
- Supporting decentralized electricity and water systems.
- Supporting a move towards understanding and implementing positive development.
- Supporting sustainable modes of travel, and
- Harvesting rainwater for reuse (Palich et al., 2013).

According to Palich (2013), there are some key Sustainable Design Categories:

Indoor Environment Quality: For a healthy indoor environment quality for the wellbeing of a building's occupants by providing:
- Daylight.

-Thermal comfort.
- Natural ventilation.

Energy Efficiency: To reduce energy demand, to reduce total operating greenhouse emissions, and to ensure the efficient use of energy, one takes into account:
. Efficient shading, and
. Efficient heating and cooling (Palich et al., 2013).

Water Efficiency: To reduce total operating potable water use, to encourage the appropriate use of alternative water sources, and to ensure the efficient use of water, these should be done:
- Avoid the use of mains water for landscape irrigation.
- Reuse water (Palich et al., 2013).

Building Materials: By encouraging the use of materials with a favorable lifecycle valuation, this provides a minimizing environmental impact of materials used, these should be taken into account:
- Embodied energy of materials.
- Use of materials with recycled content.
- Future recyclability of materials (Palich et al., 2013).

Waste Management: To ensure waste evasion, and reuse and recycling during the construction and operation stages, pay attention to:
- Preparation of a construction Waste Management Plan.
- Adoption of a demolition and construction material recycling target.
- Preparation of an operation Waste Management Plan (Palich et al., 2013).

According to RAIA (2001); the Royal Australian Institute of Architect Environment Policy states an objective to perform sustainable design practices. In order for architects to meet the objectives they should consider at all stages of a building's life:
- Bio-diversity: protect and restore ecological variety, health and functionality.

- Resources: optimize non-renewable resources.
- Pollution: minimize pollution of soil, air and water.
- Quality of life: improve health, safety and comfort of the building users.

To make appropriate sustainable design decisions, the following specific design strategies and actions are recommended according to RAIA. In the context of these strategies, sustainability always refers to the environmental approach. There are three criteria which RAIA explored: approaches which need to be considered in the Pre-design phase which cares about the site, and the environmental impact. Second criteria is Sitting and planning issues, which cares about preservation the vegetation of the site, rehabilitation and restoration, the appropriate interior spaces of a building, the position of the building for passive design opportunities, protecting the lifestyle, avoiding any kind of pollution, the use of local community to minimize the need of motorized transport. The third criteria is Concept design, it focuses on the climate, building orientation, minimizing sun penetration in summer and maximize it in winter, and recycling waste.

1. Pre-design

Design strategies		Actions/examples	
1.1	Brief client on potential of ESD opportunities.	1.1.1	*Ensure client is appraised of all ESD opportunities, and the broader benefits of taking such actions.*
		1.1.2	*Actively participate in client briefing to ensure space and services in buildings will efficiently provided for the foreseen end use.*
1.2	Evaluate appropriateness of building project and site.	1.2.1	*Use instruments such as Environmental Impact Statements.*
		1.2.2	*Check availability of public transport.*
		1.2.3	*Negotiate with local government authorities to improve sustainable opportunities and outcomes.*
		1.2.4	*Evaluate 'no-build' or 'non-structural' options, or re-use of existing facilities.*
		1.2.5	*Consider the nature of subdivisions, which can greatly effect sustainable design options for individual sites or buildings.*
1.3	Adopt an inter-disciplinary integrated approach to design.	1.3.1	*Ensure selection of consultants with sustainable design credentials.*
		1.3.2	*Encourage a suitable fee structure.*

Figure 3.8: Pre-design Sustainable Strategies (RAIA, 2001).

*Environmental Design Guide [EDG]

In Pre-design principles, communication with client is important to ensure that what will be built, in order to make a suitable building for the users; otherwise it will not be useful and durable. Also, evaluating appropriateness of building project and site by checking the availability of public transport, improving sustainable opportunities and outcomes by negotiating with local authorities, are also necessary in this phase.

2. Sitting and Planning Issues

Design strategies		Actions/examples	
2.1	Evaluate site and local ecosystems to ensure they are maintained and enhanced.	2.1.1	*Preserve vegetation and topsoil as much as possible*
		2.1.2	*Rehabilitate and restore habitat corridors.*
		2.1.3	*Minimise construction practices which encourage erosion.*
2.2	Maximise re-cycling of existing building stock.	2.2.1	*Evaluate opportunities to adapt and/or utilise existing buildings, facilities, infrastructure, etc.*
2.3	Appropriately site with regard to microclimate.	2.3.1	*Position buildings on site to allow for optimum passive design opportunities - consider prevailing winds, solar access, water supply, etc.*
2.4	Appropriately site and design with regard to effects on natural and built surroundings.	2.4.1	*Consider effects on adjacent natural features such as bushland and watercourses.*
		2.4.2	*Maintain or provide solar access to adjacent sites.*
		2.4.3	*Maintain and protect lifestyle and amenities of neighbours.*
		2.4.4	*Avoid visual and noise pollution for neighbours.*
2.5	Facilitate pedestrian and non-motorised forms of transport.	2.5.1	*Consider proximity to public transport and people as part of site selection.*
		2.5.2	*Design in pathways and cycle-ways.*
		2.5.3	*Ensure secure storage facilities for transport other than cars.*
		2.5.4	*Provide shower and change facilities.*
		2.5.5	*Design to allow for future changes to cars fuelling – e.g. electric re-charging.*
2.6	Recognise, respond and design to support the local social context.	2.6.1	*Provide or utilise local community and business facilities which minimise the need to use motorised transport.*

Figure 3.9: Sitting and Planning Sustainable Strategies (RAIA, 2001).

In sitting and planning phase, maximizing recycling of existing buildings is important. Also, facilitating pedestrian motorized forms of transport and supporting the local social context, all those design strategies have to be thoughtful.

3. Concept Design

Design strategies		Actions/examples	
3.1	Design to maximise building and siting orientation opportunities.	3.1.1	*Consider appropriate building orientation with regard to micro- climate.*
		3.1.2	*Consider appropriate orientation for different zones of the building.*
		3.1.3	*Consider appropriate orientation for external areas.*
3.2	Design for appropriate solar access through all seasons and for specific climate and location; maximise passive solar design strategies.	3.2.1	*Consider how the form of the building will effect the solar access for internal and external areas.*
		3.2.2	*Design to maximise sun penetration and minimise sun shading in winter (except in tropical climates).*
		3.2.3	*Design to minimise sun penetration and maximise sun shading in summer.*
		3.2.4	*Design to allow for flexibility during intermediate seasons and unseasonal weather.*
3.3	Determine appropriate building form to maximise natural lighting and ventilation for specific climate and location.	3.3.1	*Consider window sizes, spacing, details such as light shelves and devices such as atria and courtyards to optimise natural lighting.*
		3.3.2	*Consider building depth and location, operation of openings in external walls to optimise natural ventilation.*
		3.3.3	*Consider building form and amounts of external wall area to optimise thermal performance of the building envelope.*
3.4	Consider integrated sustainable systems at concept stage rather than during detailed design.	3.4.1	*Design for integrated energy, water and waste systems.*
3.5	Ensure building design supports and encourages ecologically sustainable lifestyles.	3.5.1	*Connect users to external environment in a meaningful and educative manner.*
		3.5.2	*Ensure building systems are easy to understand and operate.*
		3.5.3	*Design for ease of recycling of all wastes by users during occupation.*

Figure 3.10: Concept Design Sustainable Strategies (RAIA, 2001).

For concept design, it is important to maximize building and sitting orientation opportunities, by designing for appropriate solar access through all seasons and specific climate and location by maximizing passive solar design strategies.

The arriving analysis and evaluation of the two case studies are according to the study of Kim & Rigdon (1998), because their results comprise and include all sustainable principles which other literature reviews include.

4 ALGERIAN VERNACULAR ARCHITECTURE: TWO CASE STUDIES (CASBAH, M'ZAB)

4.1 Geography of Algeria

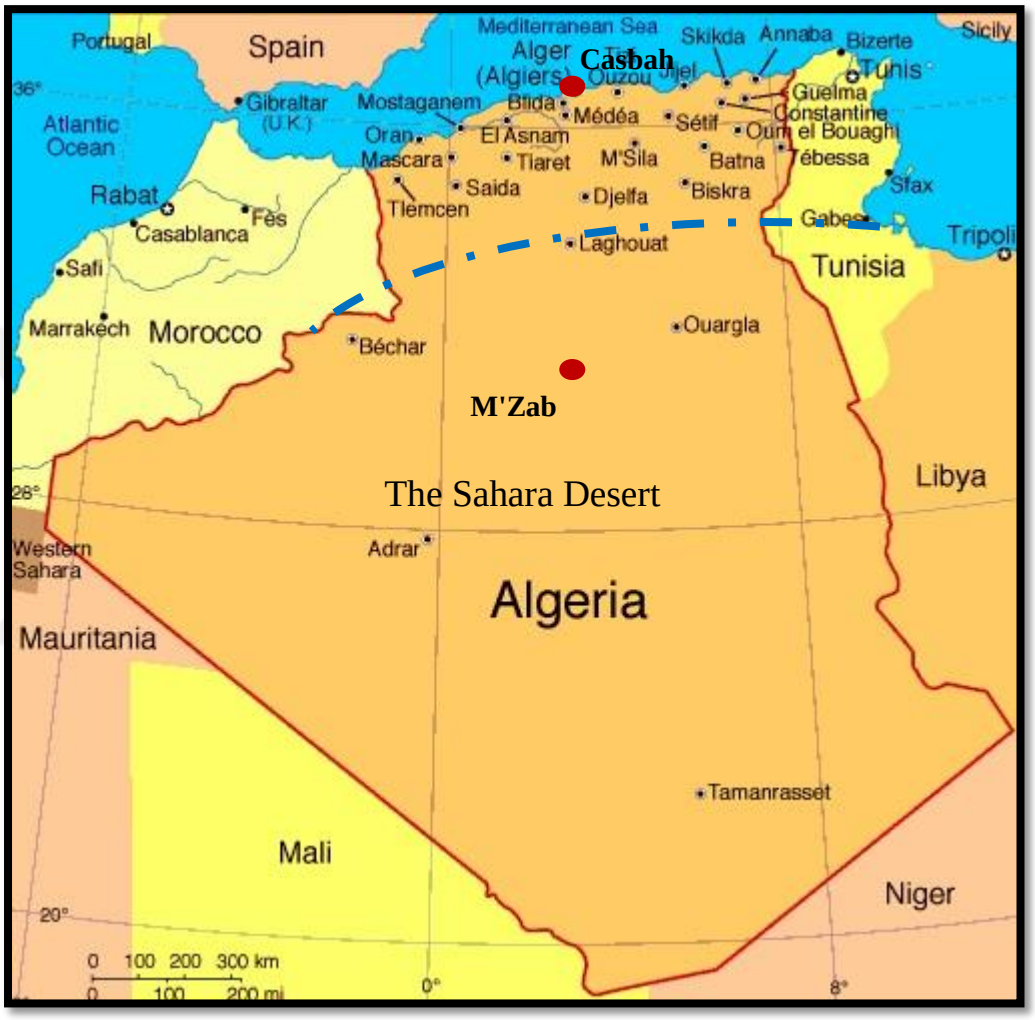


Figure 4.1: Location of Algeria (Country Profile, 2007).

Algeria is located in northwest Africa and limited by the Mediterranean Sea from the North. It has a surface area of nearly 2.4 million km², which makes it the second largest country on the continent after Sudan. It has an average altitude about 800 m. The Sahara occupies more than 2 million km², or 84% of its total surface area (www.al-djazair.com).

Algeria's population was approximately 32.3 million people in 2004, including 41% in rural areas. The population is heavily concentrated in the coastal area which includes the most fertile farmland rich in natural resources, as well as in major cities and areas of economic activity of the country. The North has 215 inhabitant/km² in 2000, compared to 38 inhabitants/km² in the highlands and 7 inhabitants/km2 in the south (Country Profile, 2007).

4.2 Historical Background of Algeria

Metz & Chapin (1991) stated that Algeria has a long history in different periods, starting from Phoenicians, Greek, Roman, Arab, Ottoman and French. All those periods had a powerful impact on urban changes and transformation was everlasting.

Phoenicians and Romans: Phoenicians arrived on the North of African coast around 900 B.C and established Tunisia on 800 B.C. By the sixth century B.C, they started to establish Algeria from the East to the West coast. But there were also the Berbers (the native people of Algeria). Many wars took place between them and the Phoenicians until 146 B.C. The Berbers won this war. In the second century B.C, the Berber Kingdom has emerged and established the state. One of their many capitals like Numidia. When the Romans came to Algeria, this caused dislocations of the Berber society. They established a frontier in the East of Algeria. The influence of Romans did not extend after the second century; they created many settlements around Algeria like, Djemila in Setif, Timgad in Batna, etc (Metz & Chapin, 1991).

Vandals and Byzantines: More than 800.000 vandals crossed into Africa from Spain in 429. But there was Belisarius, a general of the Byzantine and Constantinople which landed in the North of Africa in 533. They destroyed the Vandal Kingdom (Metz & Chapin, 1991).

Islam and the Arabs : The first Arab military expeditions into Algeria were between 642 and 669 and this resulted in the spread of Islam. Between 642 to 1830, there were so many successive decades of several empires, starting from; the Fatimids (909 - 1048), Almoravids (1048 - 1125), Almohads (1125 - 1271), The Zayanids (1250 -1420), the Marabouts (1430 - 1492), the European offensive (1492 - 1516), and the Ottomans (1516 - 1830). The coming of Islam which was spread by Arabs had many effects and transformations took place in the Algerian territory (Metz & Chapin, 1991).

French Colonial : After the dey Hussain hit the French counsel Pierre Deval in April and insulted him, because of some debt problems, France attempted to invade Algeria. There were battles in 1849, 1851, 1852, 1853, 1857, 1864, 1870, and 1871 and again in 1881. This happened despite agreements and treaties signed by both sides. It was not until November 1, 1954 that Algerian nationalists launched a series of planned attacks on colonial targets. In the ensuing seven-year war more than a million people lost their lives. Independence was announced on 5 of July, 1962 (Metz & Chapin, 1993)

4.3 Algerian Climate:

The territory of Algeria is characterized by three different regions: Mediterranean, Semi-arid, and Arid climate.

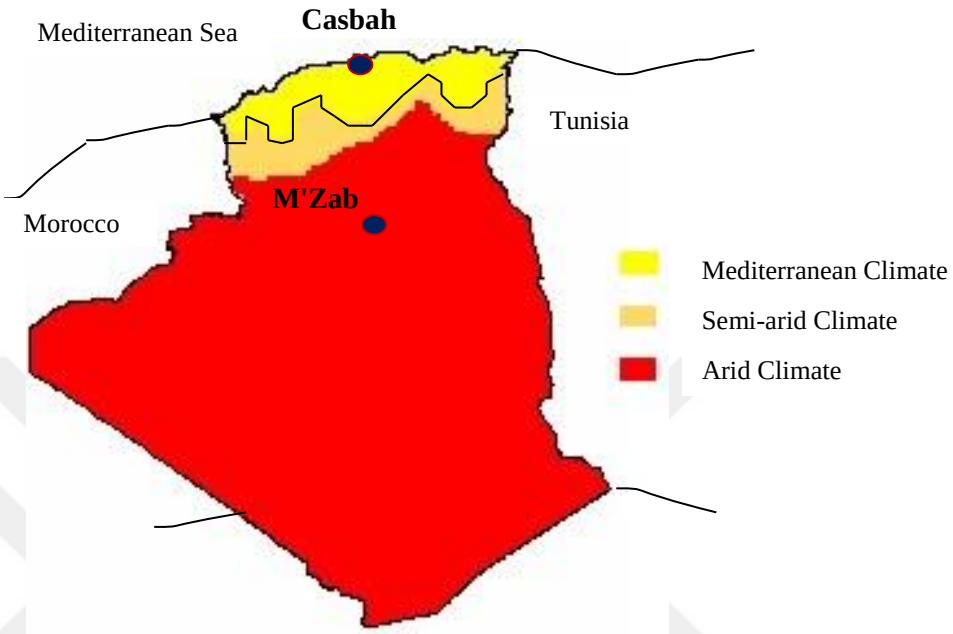


Figure 4.2: The Three Climate Regions (National Office of Air Monitoring, 2015).

The coastline and mountains occupy 4% of the total area. 2.5 million hectares are farmlands, rich in resources but very much threatened by excessive concentration of population and economic activities. The climate is Mediterranean, with very violent rains in the winter causing acute erosion. Summers are characterized by very high heat and extremely rare rainfall. In mountainous areas rainfall is up to 1,600 mm/year. But rains vary from one year to another, and are unevenly distributed (Sández et at., 2015)

Climate	Temperature (°C)	Rainfall (mm)	Length of dry period
Humid	Min 0-9; Max 28-31	900–1 200	3-4 months
Semi-arid	Min–2-4; Max 33-38	300–600	5-6 months

Table 4.1: Weather Conditions in Mediterranean and Semi-arid parts of Algeria (Sández et at., 2015).

Highlands, which make up 9% of the total area (including 5 million ha of farmland), are characterized by a semi-arid climate (rainfall between 100 and 400 mm/year). The lands of this region have a high salt content. The desertification process is important because of the drought. Bear soils is subject to wind erosion and low water (Sández et at., 2015)

Bioclimatic zone	Annual precipitation mm	Area, ha	Percent of total area
Per humid	1 200 – 1 800	185 275	0.08
Humid	900 – 1 200	773 433	0.32
Sub humid	800 – 900	3 401 128	1.42
Semi-arid	600 – 300	9 814 985	4.12
Arid	300 – 100	11 232 270	4.78
Saharan	< 100	212 766 944	89.5

Table 4.2: Bioclimatic Zones of Algeria (Nedjraoui, 2006).

The Sahara, Arid desert (average rainfall of less than 100 mm/year), covers 87% of the territory and the land used for agricultural purposes is estimated at 100,000 ha. It is characterized by poor lands, extreme weather conditions and high thermal amplitudes.

4. 4 Mediterranean Algerian Vernacular Architecture:

Case study: *Casbah*

4.4.1 Situation & Description

Figure 4.3: Location of Algiers City, (Country Profile, 2007)

Figure: 4.4: *Casbah*'s Location, (Country Profile, 2007)

Figure 4.5: *Casbah*'s Situation (Google Earth).

According to Hadjri (1993), '*Casbah'* is the oldest part in the city of Algiers. It was built in 1516 by the Ottomans, to be used as a military base. Its mission was to defend the country of Algeria. In the center of Algeria and overlooking to the Mediterranean Sea a military base was formed to defend the country. Casbah has been classified as World Heritage in 1992. It is a symbol of Algerian culture. It is based on the Turkish Islamic Ottoman-style. The *Casbah* preserves important examples of Arab-Mediterranean traditional houses that reflect a fusion of ancestral Arab lifestyle, Muslim customs and different architectural traditions. The city combined the science of Turkish military architecture with the Arab-Mediterranean architectural tradition. The exceptional natural position of site explains its winding streets, meandering in the urban texture of the ancient city. The urban complex that constitutes the Casbah still

retains its integrity, overall aesthetic features of Islamic art and original materials have been preserved. At present, it is threatened by lack of maintenance, lack of interest by its inhabitants and the administration. Despite its classification by UNESCO Local actors are struggling to sustain its tangible and intangible heritage. However, it still presents the features of traditional urban design and architecture of North Algeria (Hadjri, 1993).

Physical characteristics of the site of *Casbah* have influenced its built form; its steep slope forced its builders to rely on stairs and narrow, winding streets. Only pedestrians are able to enter the area (except that when the streets are flat, but animals may be used for transport action). The *Casbah* of Algiers is characterized primarily by the absence of squares and large streets. Only a number of narrow streets connect the inner alleys to houses, public baths, mosques and fountains. Now, *Casbah* is under serious threat due to physical decay and lack of maintenance. These conditions became so dramatic that UNESCO was called in to help the Algerian government in restoring this valuable urban heritage. However, it seems that the government intends to move inhabitants out from some parts of *Casbah*. These parts will be considered as protected cultural heritage and will be renovated as new tourist attractions (Hadjri, 1993).

4.4.2 **Sustainable Design Principles in *Casbah***

In this part of the chapter, the study of Kim & Rigdon (1998) will be used as the standard in evaluating different sustainable methods in the two cases studies (Casbah, Mzab). Their methods detailed and includes all previous principles of sustainability which literature reviews include.

4.4.2.1 **Economy of Resources**

4.4.2.1.1 **Energy Conservation**

Energy-Conscious Urban Planning: *Casbah* houses belong to Mediterranean architecture which is characterized by its exteriorization toward the sea and the sun. On the other hand, and it has an interiorization formed with courtyards. It was the "Oriental mystique" that had refined the interiorized qualities of Mediterranean architecture. There were some regulations concerning the fact that every house should face the sea and have an accessible roof in order to have clean and fresh air for its interior ventilation (Ali, 2007). In order to have a suitable urban planning, *Casbah* houses are organized in an open/ closed urban way; houses are close, and connected to each other by narrow streets for security reasons, and open to the outside in the same time by their orientation toward the sea, in order to benefit from the natural environment of the site. (Figure: 4.6).

Energy - Conscious Site Planning: The situation of *Casbah* which is so close to the Sea, provides natural cooling in the summer, especially because all the houses face this direction, this orientation provides buildings with natural ventilation (Frank, 2001). (Figure: 4.5). *Casbah* houses were built on a slope. The upper section of the slope is oriented to the South and protects houses from the winter winds. This orientation gives houses an open southern exposure which encourages passive solar heating and solar heat gain in winter (Ali, 2007). For the houses arrangement has been done according to the surrounded existing natural site, the houses were built on the slop in a way to be protected from the northern cold winds, the southern exposure provides the houses a natural ventilation, and sun exposure. (Figure: 4.7).

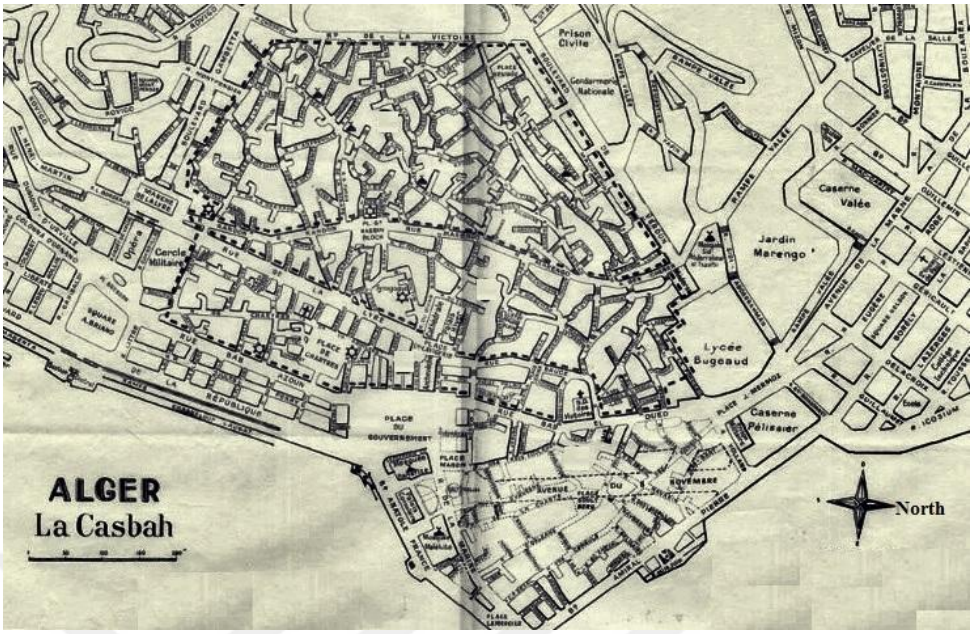


Figure 4.6: *Casbah*'s Map (http://alger-roi.fr/, 2002)

Passive Heating and Cooling: All Casbah houses have a courtyard, *wast eddar* (an opening and uncovered space, which located in the centre of the house, and surrounded with the other interior spaces of the house), or patio, usually surrounded by a covered gallery giving access to rooms, this patio in hot climates improves thermal comfort inside the house. It is a source of daylight, and fresh air. Since the rooms are surrounded by this patio; during the summer the rooms always left open to it in order to catch natural breezes (Ouahrani, 1993). (Figure: 4.7 and 4.19)

Çelik (2011) mentioned in her study that the courtyard of *Casbah* houses gives each space its own square of the sky, of sunlight, of fresh air, and of exterior connection.

Ouahrani (1993) stated that Le Corbusier argued that *wast eddar* which is like a patio absorbs light in great quantities and air from the exterior. It is a good solution which can improve greatly on current apartment units, reaching the feeling of freedom, and bringing in the charm of the Arab house as well. (Figure: 4.8).

The concept of *wast eddar* provides each house natural sunlight, and air, due to the interior spaces organization where all rooms are surrounded by it, so once it is opened it will be exposed and provided with a passive cooling or heating.

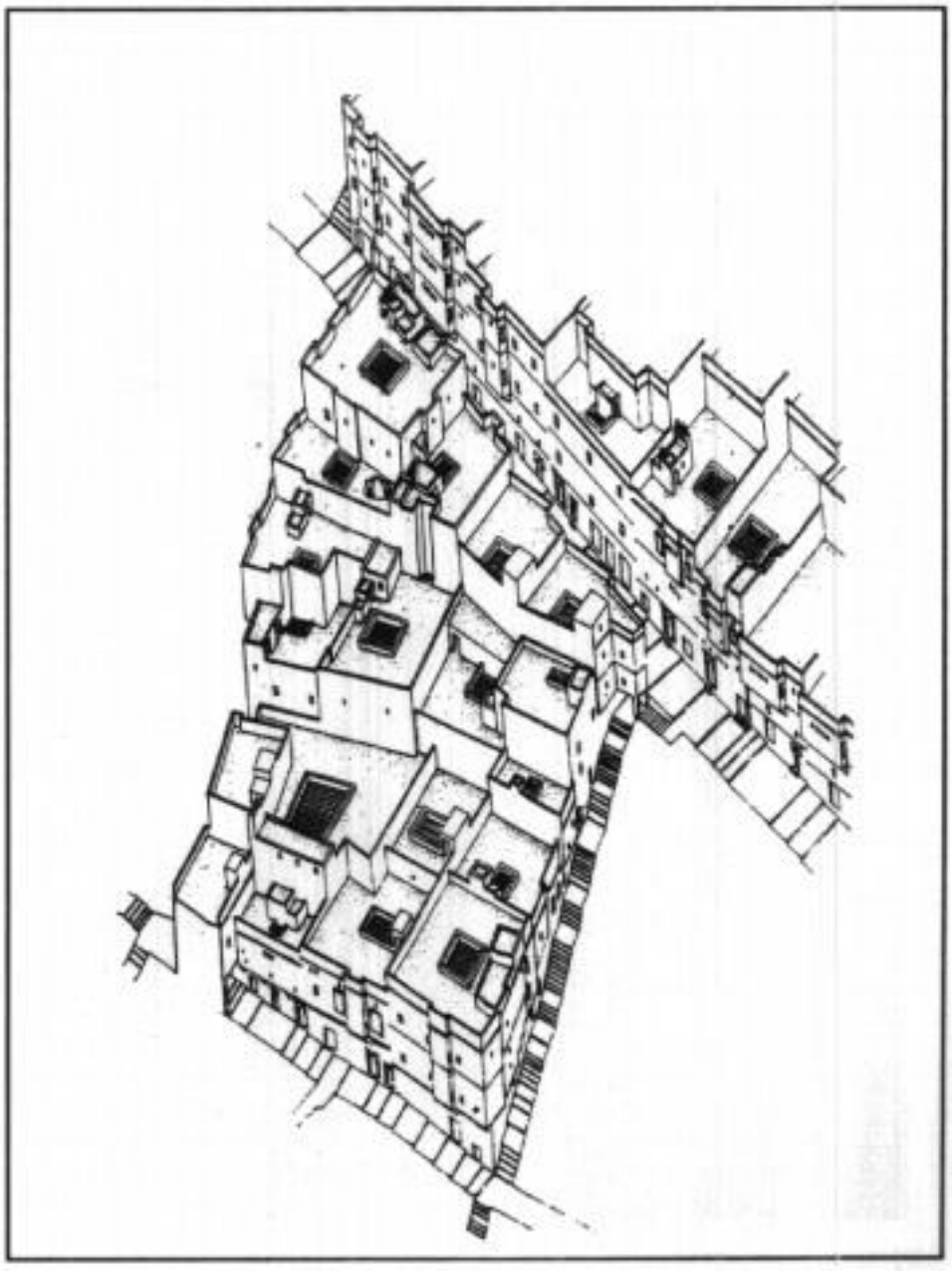


Figure 4.7: Perspective View on *Casbah* (Giovanetti, 1992).

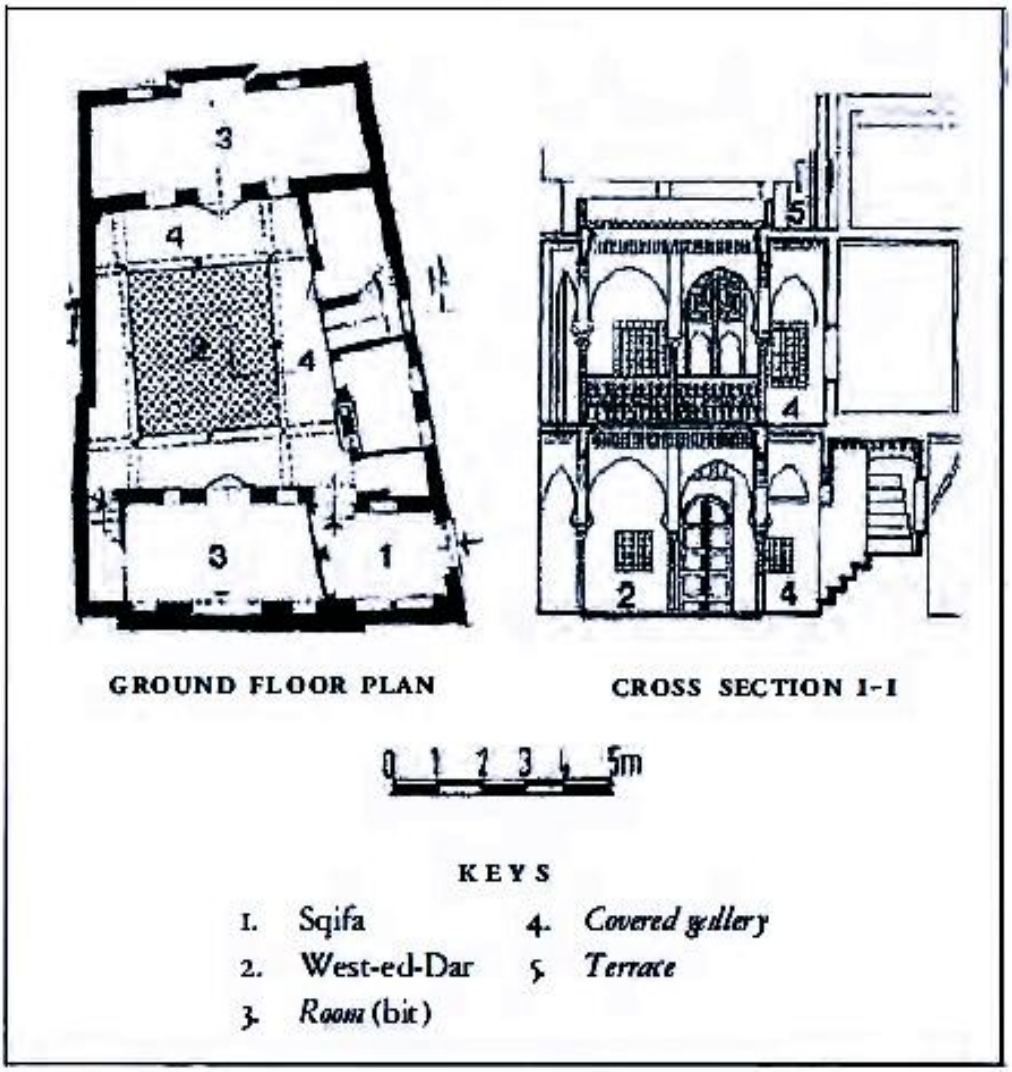


Figure 4.8: Ground Floor Plan and a Cross Section on *Casbah*'s House (Hadjri, 1993).

Insulation: The exterior walls of *Casbah* houses were built with stones. Mud bricks are made in partitions walls, crushed ballasts and stones used to assure thermal insulation both in winter and summer. In winter rooms keep the heat inside, and in the summer it keeps the fresh air, this means, that rooms cannot get cold easily in winter and hot in summer. A well-built mud brick wall has very good sound insulation properties. Some modern mud brick homes use mud brick for external walls and high partition walls internally. It is effective for thermal and acoustic reasons. The slabs are made by debarked cedar logs, to ensure thermal and acoustic insulation (Hadjri, 1993). For the insulation aspect, rooms of *Casbah* houses rarely have openings to the outside. Some houses have just one or two small windows, because *wast eddar* provides both sunlight and ventilation. The

materials used are characterized by a high thermal and acoustic insulation, this prevents heat gain and loss.

Day Lighting: All buildings are inside looking into courtyards (*wast eddar*) which provides good access to natural light during the day in order to provide natural light into the rooms (Hadjri, 1993).

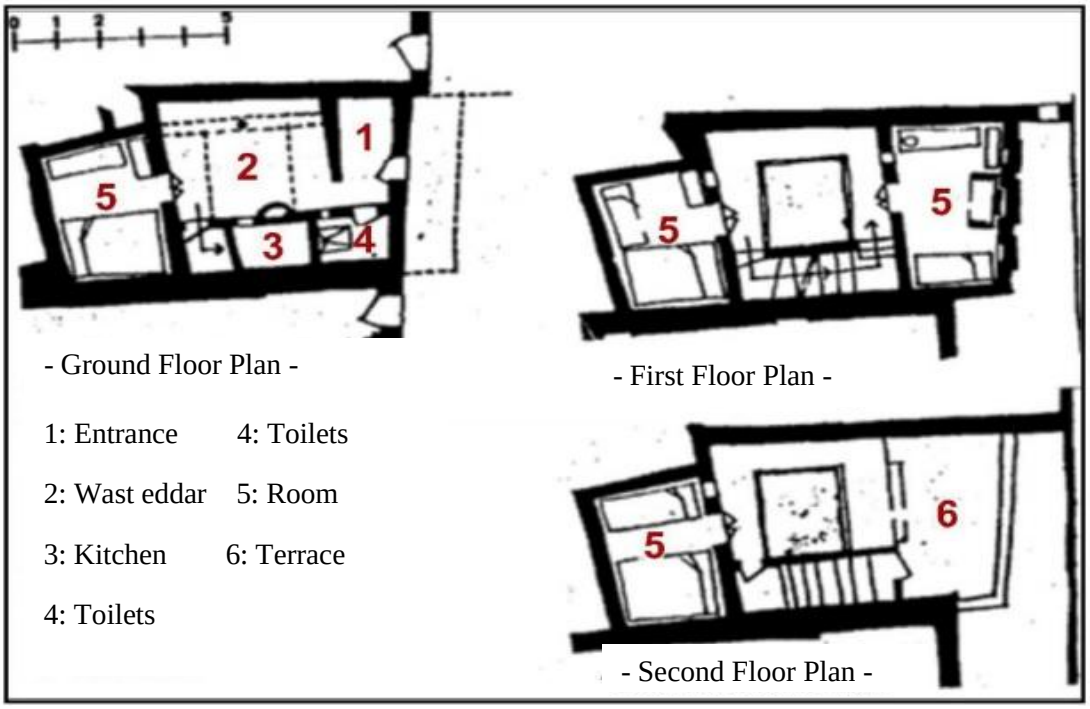


Figure 4.9: *Casbah* House's Plans (Didi, 2013).

The number of exterior windows is so limited in Casbah houses, because of the existing patio which provides the day lighting needed for the surrounded spaces.

Choose Materials with Low Embodied Energy: Hadjri (1993) in his study explored that the materials used in *Casbah* houses are elementary, local and easy to get from the site itself, without the need of energy for processing and transportation. This reduces ecological damage and energy consumption. Stones, mud brick, wood, and marl soil, are all sustainable. They are highly durable; offer long term life performance; have low maintenance and energy efficient. They also

provide healthy and comfortable environments and they are recyclable: The masonry used can be in marl soil and debris, or in brick . The structure of the columns is of wood and rocks. Some houses have walls which are mixed between thin brick and red clay soil. The walls of the ground floor are mixed with stones and mud brick. The mortar used is composed of lime and sporadic sand.

According to Hadjri (1993), the mortar used in *Casbah*'s houses is different according to the aesthetics of space the builders used modest, natural, available materials. The following table explains the components of each mortar:

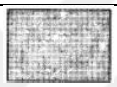
Form of the Mortar	components
	Grit - stone - Gypsum
	Gypsum - Organic substance,(hay, olive leaf)
	Red soil - Gypsum -
	Gypsum - Sand

Table 4.3: Mortar components Used in Casbah's House (Giovanetti, 1992).

4.4.2.1.2 **Water Conservation**

Reduce Consumption: To conserve water, each house in *Casbah* has *djeb* (well) in *wast eddar* (patio) this is a way to use the headwater grounds, which is a renewable water resource, tank is used to keep and collect rainwater for washing clothes, cleaning floors, etc. This helps reduce energy-intensive municipal treatment (Giovanetti, 1992). Having a second resource to have water rather than waiting municipal water is a beneficial way. A well in each house in *Casbah* is helpful to conserve natural water, and use it in the daily life.

4.4.2.1.3 **Material Conservation**

Use Materials that can be Recycled: All the different materials mentioned before (Stones, mud brick, wood, marl soil, the mortar components) are all sustainable, because they are highly durable, and they might be reused and recycled. This preserves the energy embodied in their manufacturing. (Figure 4.14).

Size Buildings and Systems Properly: There are three types of houses in Casbah. They are classified according to their size. Each suits different families according to the number of the family members; *Wast eddar* House (for big families), *Chebek* House (for medium size families), *Aloui* House (for small families). Each type has the same programming of design spaces. The difference is only in the size and number of the rooms. Also, each type of those houses has important interior spaces which any family needs: starting from, the rooms (for sleeping), the basement (for storage), the kitchen (for preparing food), the latrines, the laundry (for washing the clothes), space for a well and a tank, and a terrace. (Figure 4.10, 4.11, 4.12).

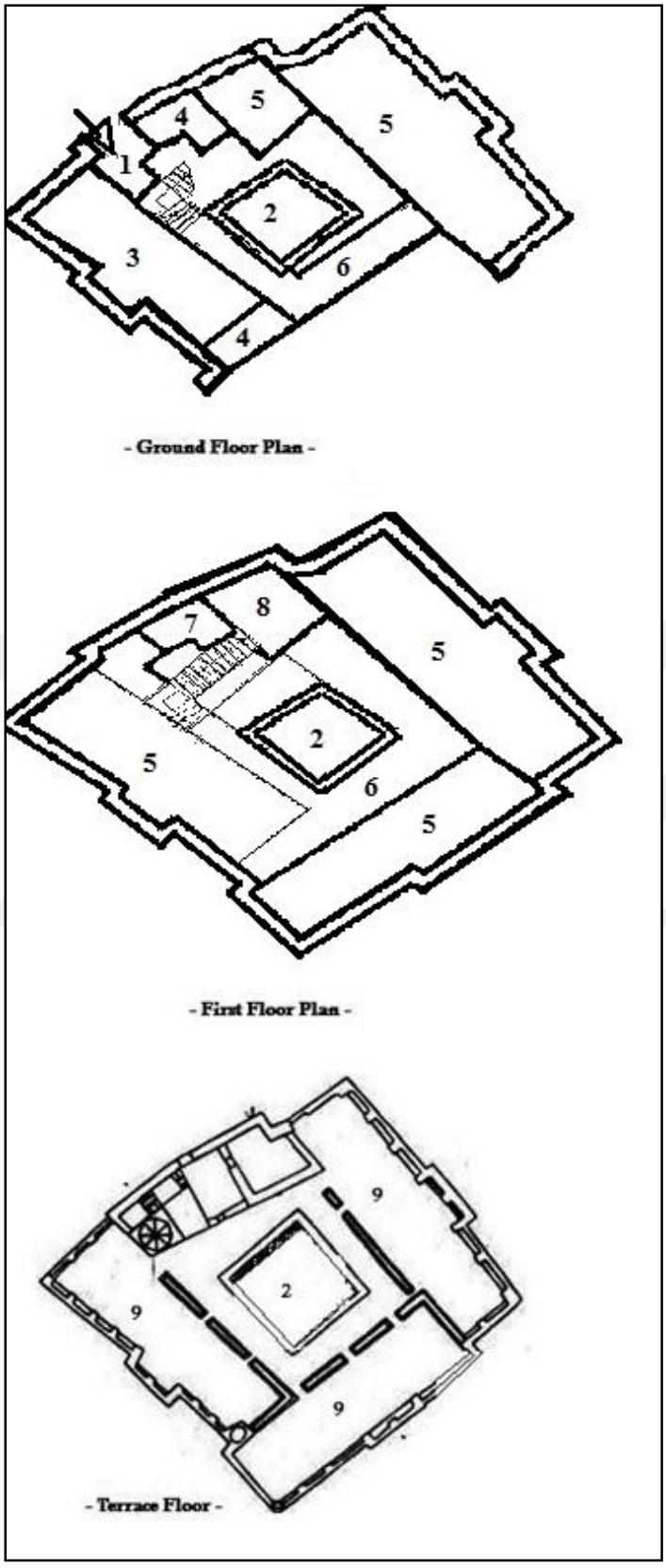


Figure 4.10: *Wast Eddar* House of *Casbah* (Çelik, 2011).

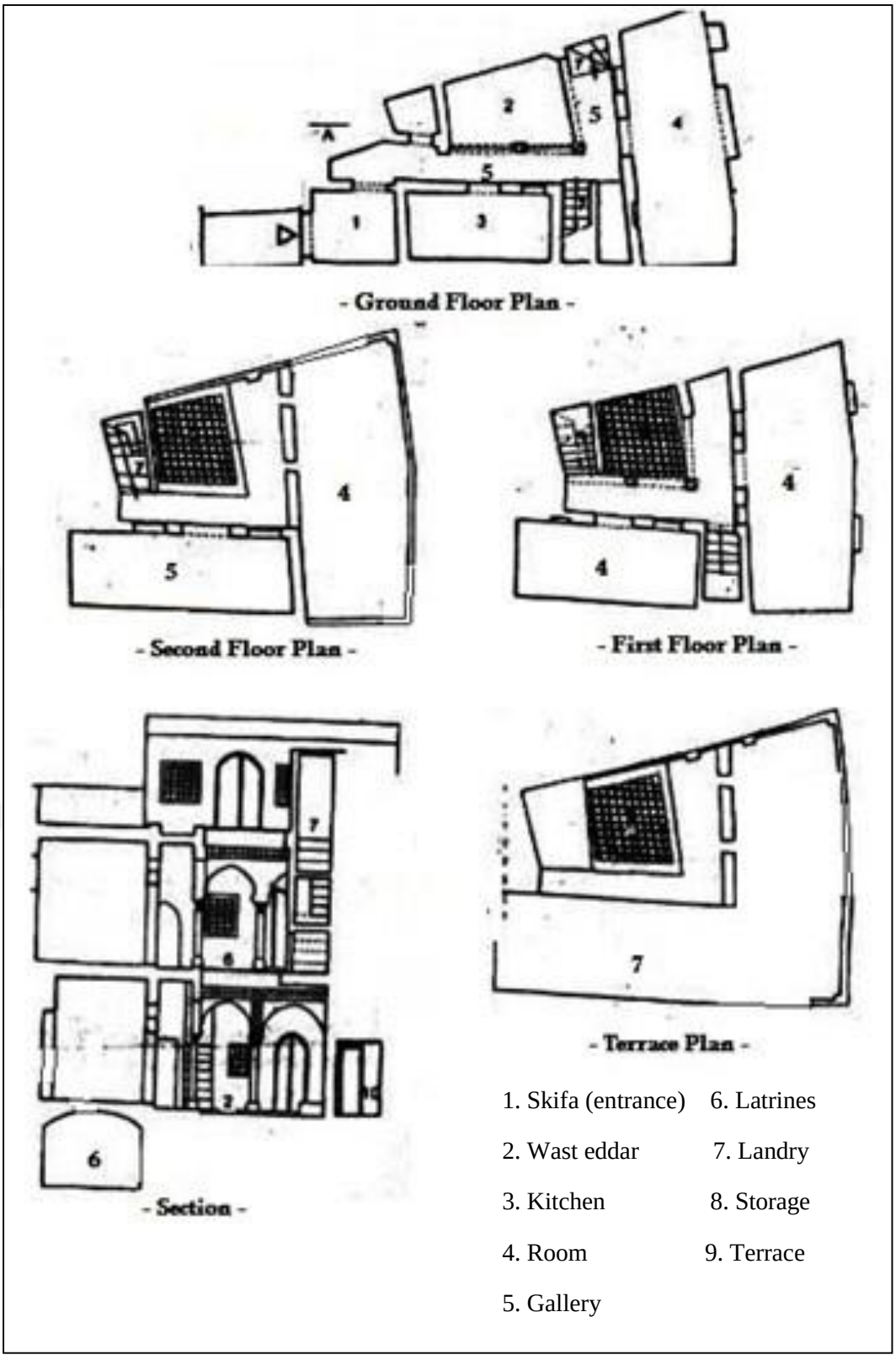


Figure 4.11: *Chebek*House of *Casbah* (Çelik, 2011).

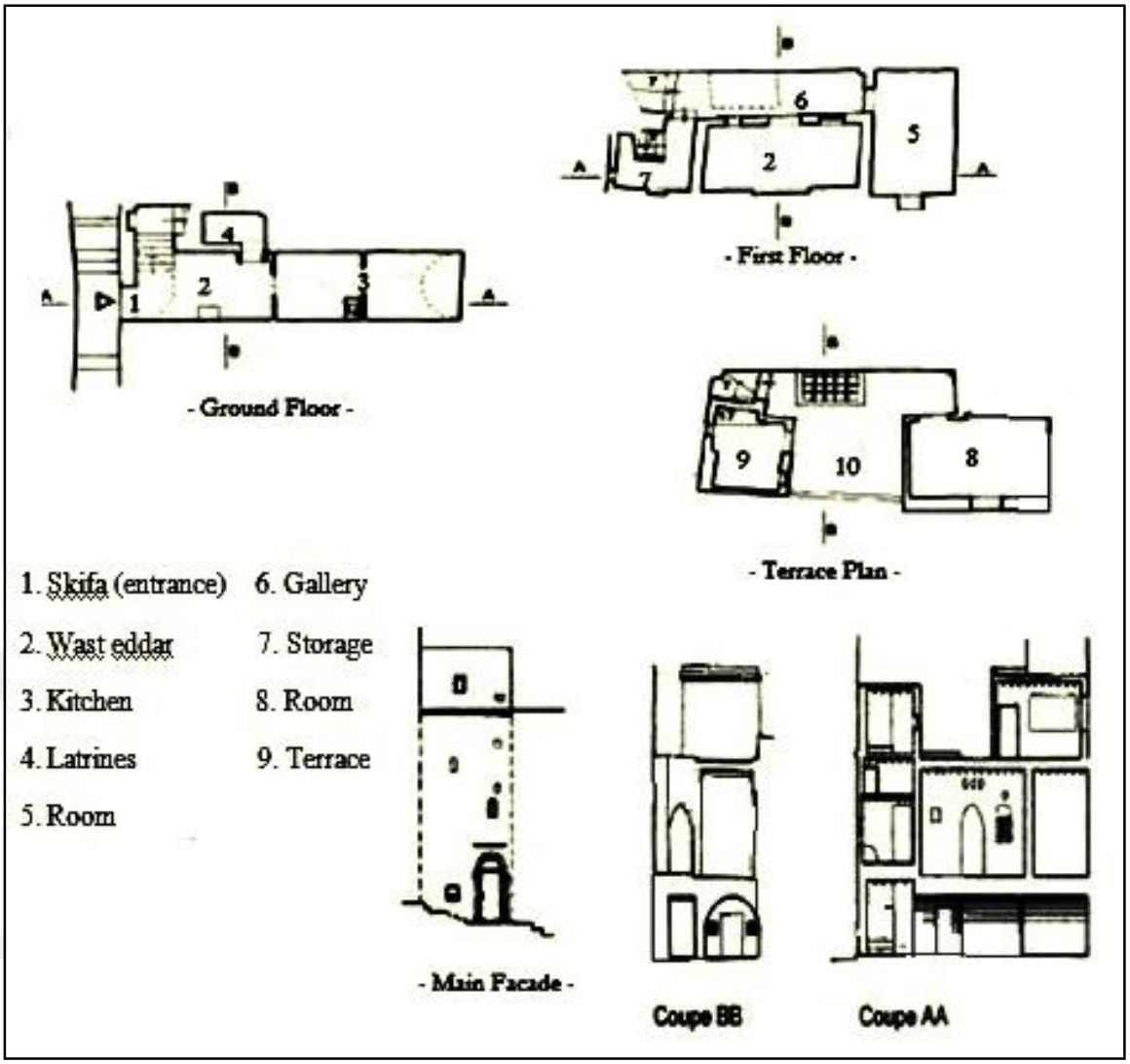


Figure 4.12: ***Aloui*** **House of** ***Casbah*** **(Çelik, 2011).**

4.4.2.2. **Life Cycle Design**

4.4.2.2.1 **Pre-Building Phase**

Use Materials Made From Renewable Resources: The Different Materials used in *Casbah* Houses are produced of renewable resources like; mud brick, wooden logs for the floors slabs, and debarked cedar logs which can be found easily from the local site. The use of those renewable materials reduces the need for non-renewable materials. (Figure 4.14).

Use Materials Harvested or Extracted Without Causing Ecological Damage: The majority of materials used in *Casbah* houses have been obtained from the site itself, without any significant environmental effects, the local stones, the earth, the wooden logs, the cedar logs, the mud brick, and all those materials can be harvested and extracted and get easily and without causing any ecological damage (Hadjri, 1993).

Use Materials With Long Life and Low Maintenance: The durable materials which are used in *Casbah*'s houses like stones, mud brick which are used for the structure and for the partition walls, have lasted for long time, those durable materials which are still used reduce the consumption of raw materials (Hadjri, 1993).

4.4.2.2.2 **Building Phase**

Minimize Site Impact: *Casbah* was built on a slope of a high hill. Houses were constructed on it without changing the form of the site and the builders respected site topology (Hadjri, 1993). The houses in *Casbah* were built on hill slop. The arrangement of the houses shows that old builders respected the topographical form of the site, without making any changes which might have a negative impact on it.

4.4.2.2.3 **Post-Building Phase**

Recycle Materials: Materials used in the houses of *Casbah* can be easily recycled. Like the stones and the mud brick, it's not hard to separate their different substances from one another. It can be crushed and reused as the aggregate of a new building.

Figure 4.13: Wall Masonry of *Casbah*'s House (Giovanetti, 1992).

4.4.2.3 **Humane Design**

4.4.2.3.1 **Preservation Natural Conditions**

Respect Topographical Contour: According to Hadjri (1993) in building houses of *Casbah*, the existing contours of this site were respected. There are no physical changes to the area or the surroundings. (Fifure: 4.7).

4.4.2.3.2 **Urban Design Site Planning**

Promote Mixed Use Development: There is variety of public spaces in *Casbah*: educational, religious and political, are located in specific areas. The need for family privacy and protection against strangers, a strict hierarchy of public and private spaces was mainly to protect the women. (Çelik, 2011). This extended from public space (the market), to main streets, alleyways and the entrance door of houses. Commercial activities can only be found in the main

streets. This is a way to mix residential and commercial spaces, which are not far from each other. There are easily accessible for buying food or clothes. This is a way to sense the community

4.4.2.3.3 **Design for Human Comfort**

Provide Visual Comfort: *Wast eddar* is the key space in *Casbah* Houses. It enclosed itself to the street and the external world by its blank, planar facades with minimal openings. Yet it opened to nature, to views by means of an ingenious use of roof terraces. These are considered one of their greatest assets." (Çelik, 2011). The *Sqifa* (a space which located directly after the entrance door, where male guests are received and wait without entering to the interior spaces of the house, it has a privacy aim) has a special strategy for the hierarchy of women. There are small openings in the two walls of *Sqifa*, and it's a way for woman to see who is inside without showing themselves. This provides visual privacy, and lead people of the house to feel well and comfortable. (Figure: 4.16).

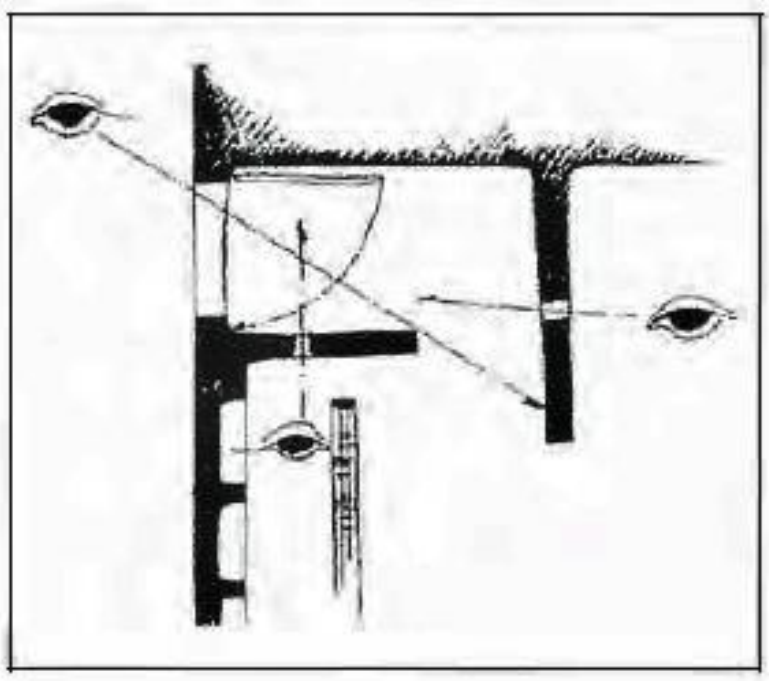


Figure 4.14: Principle of *Skifa* Entrance in the *Casbah* House (Hadjri, 1993).

Figure 4.15: Ground Floor Plan of a part from *Casbah* (Giovanetti, 1992).

Provide Visual Connection to Exterior: The roof terrace is largely used by women to dry clothes, look at the sea and the townscape, and meet with their neighbors. Women enjoy staying on roof terraces. Men can't see them and it's a place where they meet and enjoy the view into the sea side. It's also a place where they care about their own green roof. (Figure: 4.19).

Provide Operable Windows: The Windows in a *Casbah* house has a special design. Its height and width conforms to the human body. They are located in the wall where a woman can sit in the wall's thickness and see the outside easily. At the same time she cannot be seen from the outside even if she is standing. (Figure: 4.17).

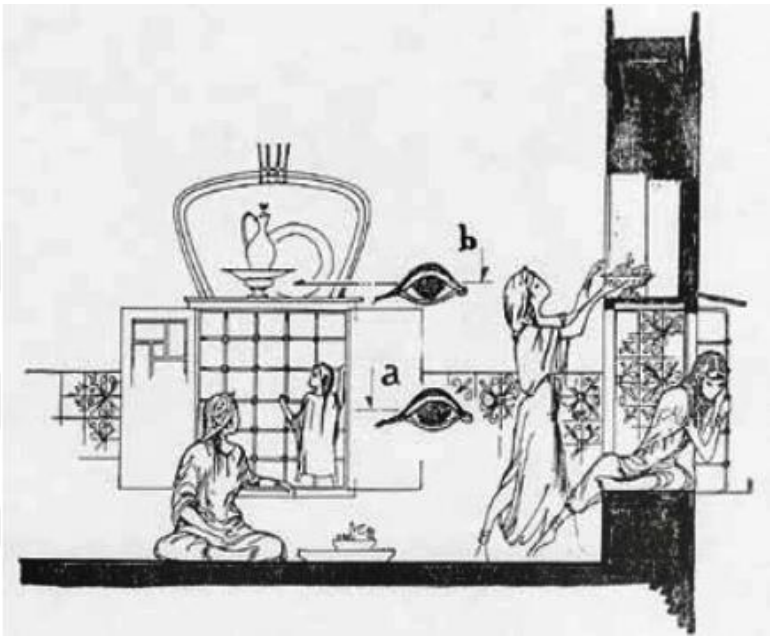


Figure 4.16: Window of *Casbah* Houses (Ravéreau, 2003)

Accommodate Persons with different Physical Abilities: *Casbah* houses are adaptable for men, women, children, and this makes it convenient and sustainable (Hadjri, 1993). The terrace is a totally opened space which overlooks the sea side of Algiers. It's designed as a female-only space. It allows women to make a discreet communication without going outside the house. In the Patio, men equally share the pleasure of socializing, eating, and even sleeping (in the hot season). Children play together. *Wast eddar* is the place where most family activities and wet domestic activities take place (Giovanetti, 1992). *Casbah* houses were designed to be used for the whole family members, men, women, and children. It has the necessary interior spaces and housing concept which any humane being needs. (Figure: 4.18).

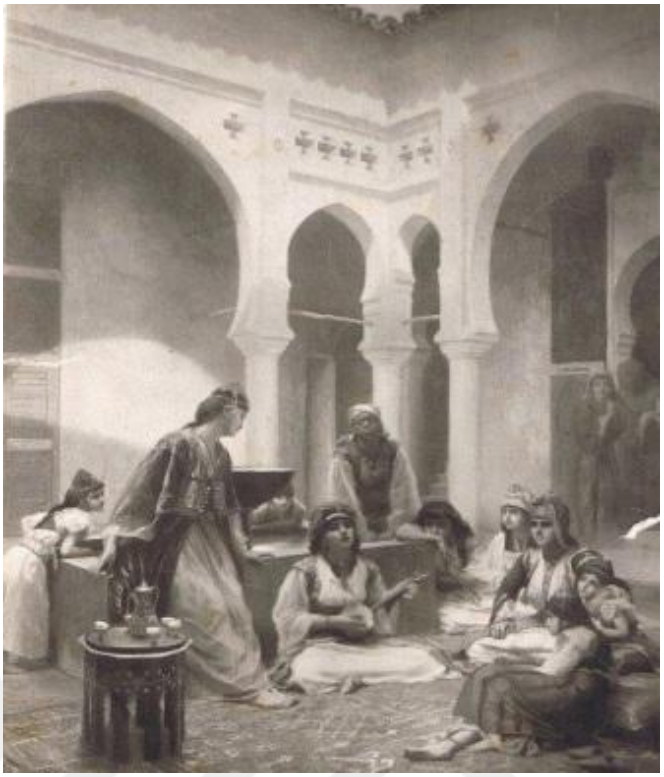


Figure 4.17: Scene of a Group of Women in *Casbah* house in the West Eddar (Didi, 2013).

Figure 4.18: Scene of a Group of Women in *Casbah* house in the Terrace (the-athenaeum.org)

2010).

4.5 Arid Algerian Vernacular Architecture

Case study: *M'zab* House

4.5.1 Situation & Description

Figure 4.19: *Guardaia* City Location, (Country Profile, 2007)

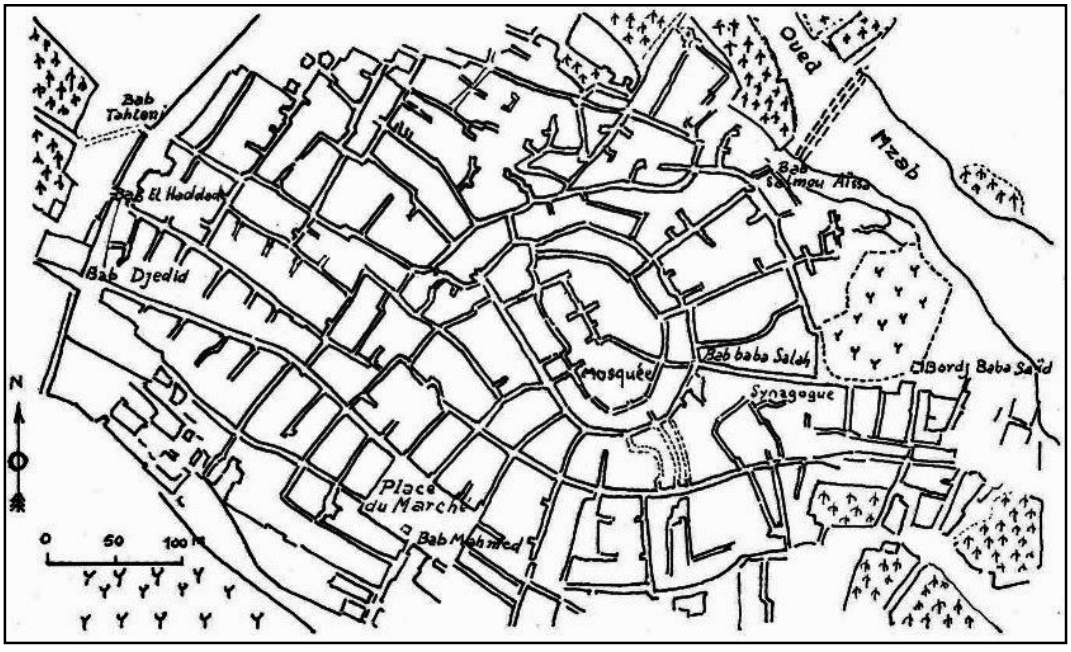


Figure 4.20: *M'zab* Plan, (http://encyclopedieberbere.revues.org, 2014)

Adad & Mazouz (2013) in their study stated that M'zab, with a length of 25 km is located in the city of *Ghardaia* in the heart of the Algerian Sahara. It is 600 km south of the Mediterranean Sea. People of *M'zab* belonged to Ibadit sect of Islam which appeared in the tenth century under the Caliph Ali. M'zab region takes pyramidal shape, where the mosque is in the center and on the top is a rocky terrain with a slope of 12 to 15%. A limestone plateau broken by valleys and entangled ravines, the architecture of this region has unique design features related to its environment. There is a clear ecological balance between the Saharans and the desert which enables them to live in such an environment. It has maintained its own unified system of traditions and social and religious organization for centuries. M'Zab way of planning has induced UNESCO to consider it an important monument for conservation and to inscribe it in The World Heritage List in 1982. *M'zab* architecture thus emerged from function, available local materials and building techniques, and a way of life which is dictated by the scarce resources of the desert. It struck a balance between heavy structure and sufficient stability that was able to endure for centuries. Town structure corresponded to social structure through a series of interconnected spaces with various functions. In this hierarchical system, every element fit into its place and assumed a role depending on its appurtenance and integration. It is a perfect adaptation to the environment and the simplicity of its forms provides an example and teaching for contemporary architecture and urbanism. *M'zab* houses followed a general Mediterranean scheme, but that they were adapted to the climatic conditions of the Sahara and to the strict religious and social convictions. The need to adapt to the harsh desert climate was particularly important, and this was evident in many other aspects of architectural and urban design in the town. (Adad & Mazouz, 2013).

4.5.2 **Sustainable Design Principles**

4.5.2.1 **Economy of Resources**

4.5.2.1.1 **Energy Conservation**

Energy Conscious Urban Planning: According to Adad & Mazouz (2013). Due to the climate conditions of *M'zab* valley region, which is very hot in the summer and cold in the winter, the houses are organized close to each other. This was needed in order to be protected from the sandstorms, to provide shadow in the narrow streets where people can walk easily and get to the place they want without any climatic difficulties. (Figure 4.22).

Orientation of *M'zab* houses was important. As a whole, the town is oriented to the southeast, and the blind facades of houses face the north to protect them from the sun's rays and from sandy winds (Adad & Mazouz, 2013).

"From the urban point of view, in *M'zab* region, sunlight and intimacy were considered inalienable features, and the owner of a building was prohibited from casting shade on neighboring houses by raising his walls too high." (Ouahrani, 2013). (Figure: 4.23).

In the study of Djamel (2013), the building's owner in *M'zab* was prohibited from violating his neighbors' privacy. So dwellings in M'zab never exceeded fourteen cubits (approximately seven meters) of height (Ouahrani, 2013).

M'zab houses are located and regrouped in a massive way. So close to each other, this is how the mass of houses were protected from the sandstorms and the hot sun in the summer. Houses were built one on top of another, in a way to create long surfaces of wall exposed to the sun and enabling streets and alleys to be continuously in the shade.

Figure 4.21: View in *M'zab* Street (Djeradi, 2012).

Energy Conscious Site Planning: The situation of *M'zab* Houses depends on the availability of water, the boundary of the valley defines the limits of the *M'zab* houses region. The valley provides and ensures the creation of palm groves around it. They are essential in creating microclimates needed by people. The height of each neighboring house is defined according to the sun in order to benefit from maximum of sunlight in the winter (Adad & Mazouz, 2013). (Figure: 4.34). *M'zab* house, its morphology fits perfectly to the hot and dry desert climate of the region. The region is located away from the water of the rocky peaks overhanging the valley. Houses at the grove may enjoy a cool air when the city is overheated (Didi, 2013).

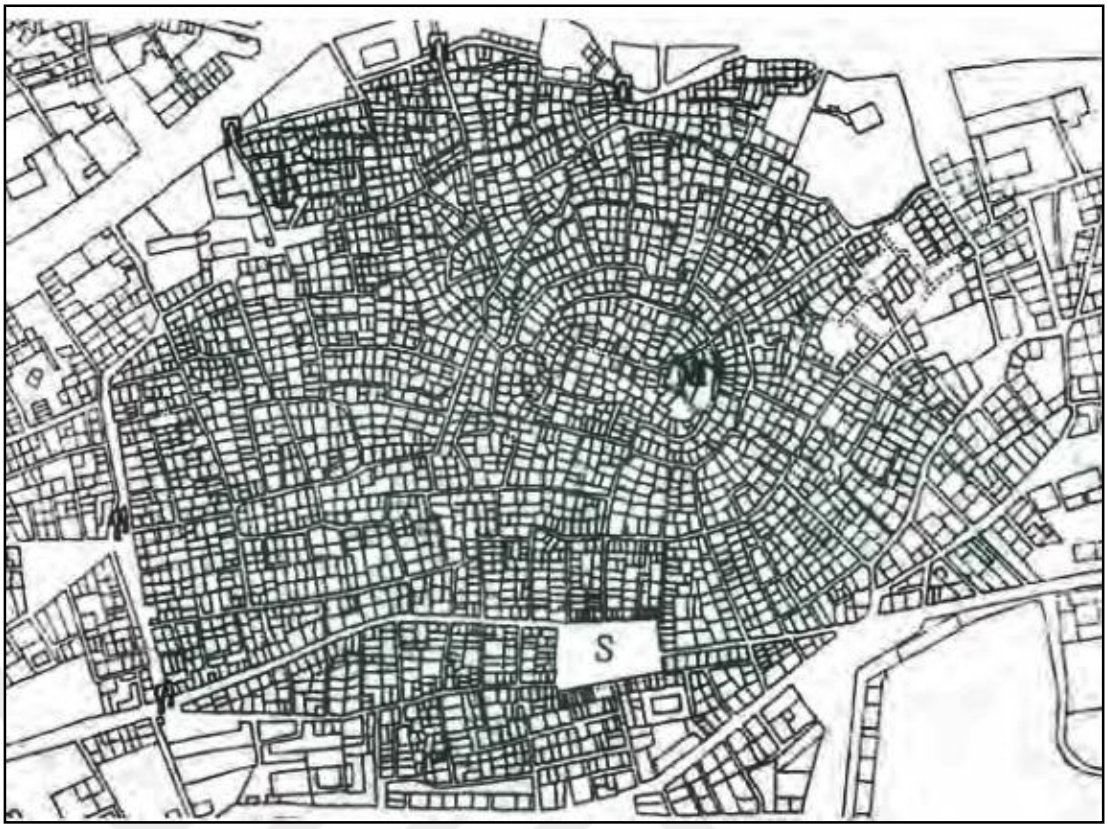


Figure 4.22: The Plan of *M'zab* Region (Golvin, 1989).

Passive Heating and Cooling: In *M'zab* houses, openings are reduced as far as possible to allow sufficient light but avert the intense heat of the sun (Rasid et at., 1996). The *chebbek* may be covered by a wooden board when it rains, or when there is a sandstorm or other undesirable conditions (Adad & Mazouz, 2013). (Figure: 4.24 and 4.25).

The *chebek* is located in the center of the ceiling, called *'ayn eddar'* (the eye of the house). Its shape is square and its size is determined by two main constraints: day lighting needed in the ground floor, and the shape of the open space located on the first floor (Adad & Mazouz, 2013).

In the study of Djeradi (2012), the horizontal position of the opening in the ceiling provides enough quantity of light, great in the morning than in the afternoon, due to the South-east orientation of the house. This quantity of light is more than enough for whatever activities are performed.

Among the inhabitants of *M'zab* houses, the entrance door should be kept open all day long in order to get sunlight. People think that an open door brings prosperity. A closed door means infertility: keeping the sun out, that bars the entrance of happiness and fertility. (Adad & Mazouz, 2013).

The house is lighted and ventilated by the door and the *chebek* (an opening located is in the roof of *the middle of the house -ikomar-).* This uncovered part of the ceiling allows light and air to come directly into the *ikomar* (a space where all domestic activities were transferred during hot periods, located in the center of the house).

Figure 4.23: View on the Chebek in the Terrace of an *M'zab* House, (Chabi & Dahli, 2008)

Figure 4.24: A View on the Eye of the House (*Chebek*) in *M'zab* House (Djeradi, 2012).

Insulation: For a comfortable interior environment; the stones which were used in Mzab houses, characterized by a high heat resistance capacity. Generally this is the building material of most houses. Stone had the advantage of capturing solar heat, collecting it and to later easily be evacuated at night by natural ventilation (Chabi & Dahli, 2008).

Didi (2013) stated in his study that since *M'zab* houses were built with thick stone walls, they are cool during the day and warm at night. This thermal phenomenon was enhanced by the use of light-colored plasters, which reflected light and heat. The use of heavy construction materials adapted well to the climate. Stone provides thermal comfort, as well as the light colour of gypsum exterior walls which reflects the strong sunlight.

Day lighting: To have natural light, the *chebbek* provides and distributes sunlight during the whole day to all different interior spaces of the house. The entrance door should always be kept opened during the day. This is another way to gain light for the surrounding interior spaces (Chabi & Dahli, 2008).

Figure 4.25: View on the Entrance Door in an *M'zab* House (Djeradi, 2012).

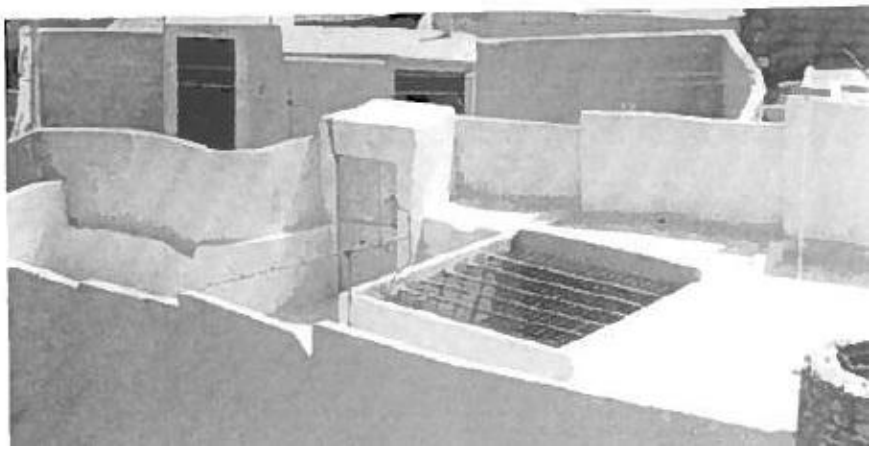


Figure 4.26: *Chebbek* Opening in the Ceiling of *M'zab* House (Ouahrani, 1993).

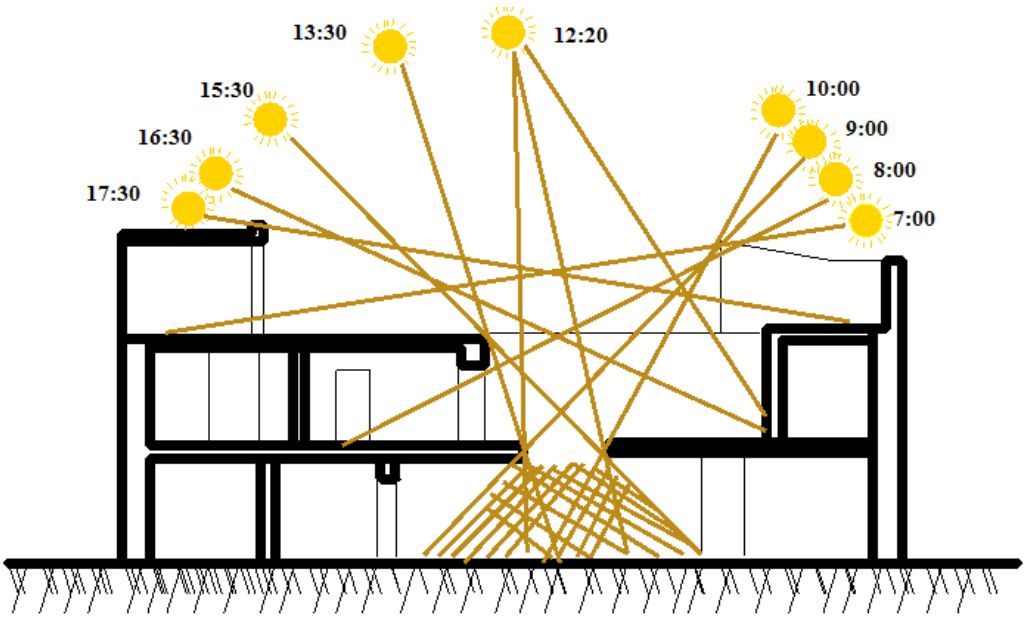


Figure 4.27: Day lighting System by the *Chebek* in *M'zab* House in Winter (Djeradi, 2012). Edited by the author

Choose Materials with Low Embodied Energy: Building materials used are those available locally (stone, gypsum, palm), which require no energy in their production, transportation and even implementation. Spending excessive energy generates pollution, is harmful to health and the environment. The wood of dead palms is used in making the roofs of houses. Trees are not cut as they are considered living beings which sustain the inhabitants (Chabi & Dahli, 2008).

Generally, the houses have structure bearing walls which are thick enough. The beams are made of palm trunks (*khashba*) and ceilings consist of a wattle fins (*jrid*). The terrace is made of earth mortar that combines clay and palm leaves. Tree trunks constitute the beams. For siding, lime mortar sand dunes are used. Or with a bunch of date leaves for shading and avoiding overheating of the wall (Djeradi, 2012).

The materials used are natural; Toub (it's a clay brick, manufactured very easily on the construction site, dried under the sun; it has an excellent isothermal quality), stone, *tchiment* (it's a kind of plaster which can be obtained after a few hours of local gypsum baking on fire; It serves to make the joints between bricks and stones), palm trees, with its wood, doors and windows were made. Dry dates

are used for the plaster of the interior and exterior walls; it has also a good isothermal characteristic. All those materials are locally obtained. These fit perfectly with the natural environment.

4.5.2.1.2 **Water Conservation**

There are irrigation systems in the *M'zab* valley to store rain, drain and divide the limited local water supply. Dikes, combs, hoppers and watersheds were used to exploit the rare and irregular spates. Over time the palm groves became luxuriant gardens (Chabi & Dahli, 2008).

The valley which is near the *M'zab* houses is the main source of water for the inhabitants. Also by underground sewage system was used to insure the well being of the *M'zab* people (Didi, 2013). (Figure: 4.34).

4.5.2.1.3 **Material Conservation**

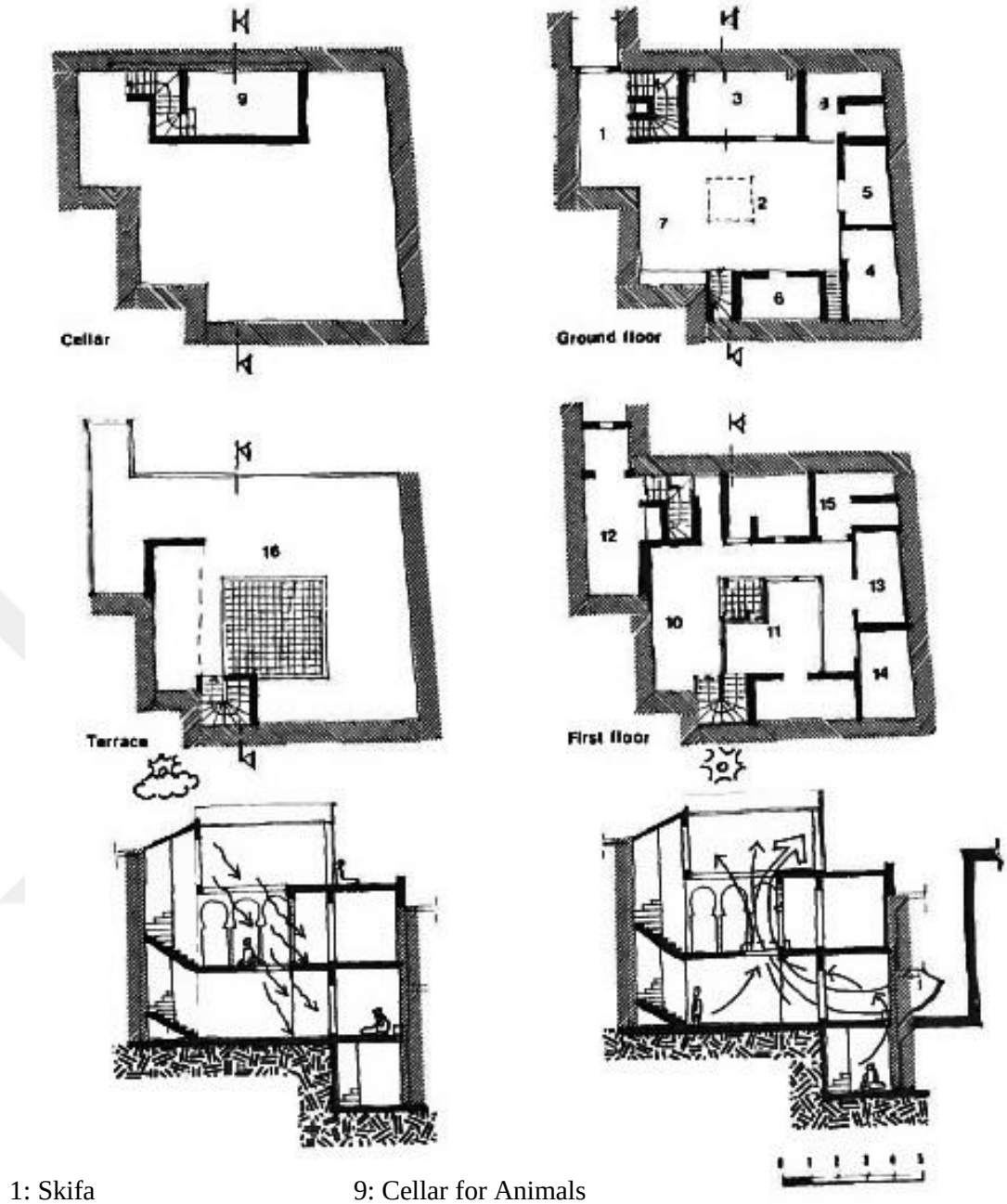
Use Materials That Can Be Recycled: The different materials used in *M'zab* houses which mentioned before, can easily be recycled: stones, wood, toub. They can be used in new structures.

Size Building and Systems Properly: The *M'zab* houses are constructed in way to show the local tradition by its different specific interior spaces. Each house contained a women's reception hall, called a *tizefti* (a place designed only for women, where they spend most daily time in making weaving). This space faced southeast to exploit the midday sun (Didi, 2013).

According to Chabi & Dahli, (2008), rooms which are facing onto the *amessent eddar* did not have fixed purposes. They could be used as storerooms or bedrooms. However, those used for bedrooms were always located in a sacred position to the right of the *tizefti*, a sign of intimacy. By contrast, as a sign of impurity, the water closet was situated in a corner of the central space to the left of the *tizefti*, The *houdjrate* (a reception room for men). This is a small room to the back of the central space. In order to preserve female intimacy, the *houdjrate* featured a separate entrance and was completely independent of the other rooms

of the house, for privacy reasons. The stairway led to a covered space, the *ikomar* (the only room which open to the terrace), which faced the southeast facing open air terrace.

In each *M'zab* house, we find the entrance called '*chicane' or 'skifa'*, designed as a closed area, where a guest can wait before entering the house or other private areas. Then we find the '*tizefti*' (space of women). This is a place where the women seat and talk and receive other women guests. In the middle there is *'wast eddar'*; which is the place designed for just cooking and eating. There is an opening in its roof which provides and distributes sunlight called *'Chebek'*. There is one room for just men, where they sit and talk. In the first floor, there is a *'tirrarghet'* which does not have a roof. It is a place to rest and sleep during the summer night time. There is also another room called *'ikomar'*. This is a room without a door, reserved for only women, to sleep during the summer in order to benefit from the fresh air at night. In the terrace level we find a 1.50m wall of height the inhabitants from other people eyes. (Figure 4.29 and 4.30).



1: Skifa
2: Wast eddar
3: Tisefri
4: Kitchen
5: Storage room
6, 8, 13, 14: room
7: Weaving area For Summer
9: Cellar for Animals
10: Weaving Area for winter
11: Open Space
12: Men's Reception Room
15: Toilets
16: Terrace

Figure 4.28: *M'zab* House's Plans and Sections (Ouahrani, 1993).

4.5.2.2 **Life Cycle Design**

4.5.2.2.1 **Pre-Building Phase**

Use Materials Made From Renewable Resources: Stones and toub for walls, palm trunks for columns and beam structures, palm leaves as a beams cover, sand dunes for the gypsum, lime mortar for siding. These are all materials from renewable resources which can be affordable without consumption any energy.

Use Materials Harvested or Extracted without Causing Ecological Damage: All the materials used in *M'zab* houses are local and obtained only from the site itself. They did not need any energy in manufacturing or in harvesting. This helped the environment to have less ecological damage.

Use Materials with Long Life and Low Maintenance: *M'zab* houses have been built since thousands of years. The same people still use the same materials today. This is a proof that all materials are durable and last for long time: the stone, toub, the palm wood (Chabi & Dahli, 2008).

4.5.2.2.2 **Building Phase**

Minimize Site Impact: According to Djeradi (2012), *M'zab* houses were built on a rocky hill, in a way which will not damage the original site. The valley is surrounded with different palm groves located around it.

4.5.2.2.3 **Post-Building Phase**

Recycle Materials: The materials of construction used in the *M'zab* houses might be easily separated from one another; the stone from wood and the toub from wood. Also they might be recycled for new use. Stones and the wood beams can be recycled or reused.

Figure 4.29: Wall Made by Local Stones in *M'zab* (Djeradi, 2012).

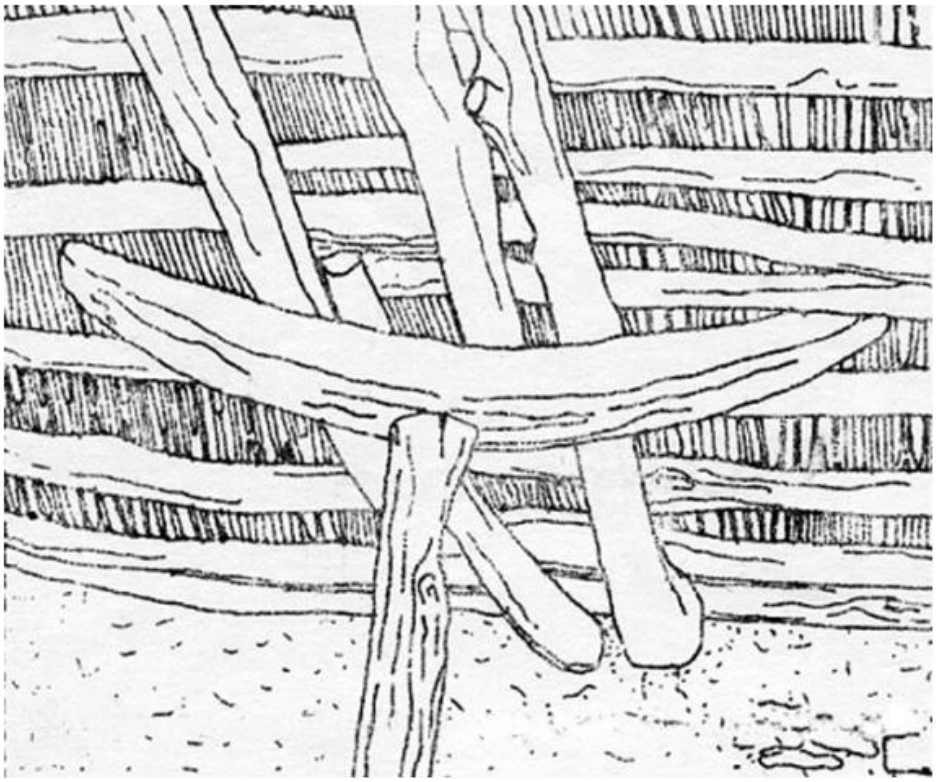


Figure 4.30: Structure Wood Palm System in *M'zab* house (Djeradi, 2012).

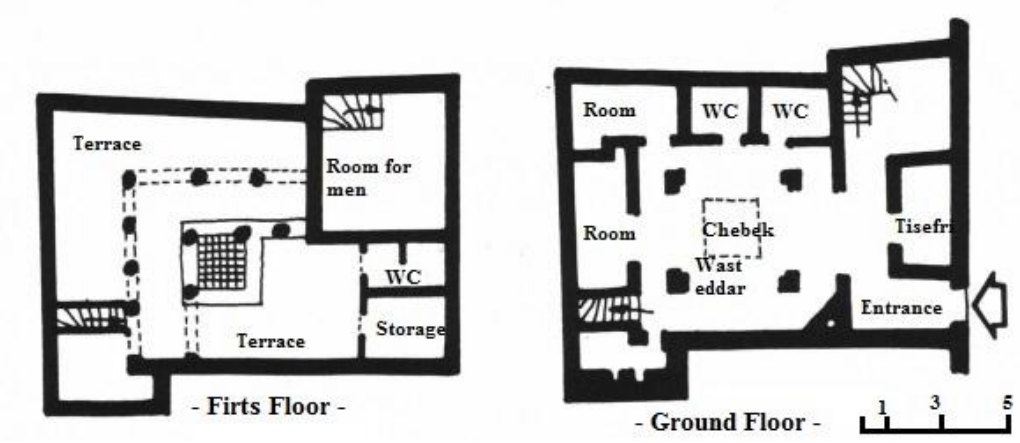


Figure 4.31: *M'zab* House Plans (Golvin, 1989).

Figure 4.32: The Palm Sheathes in Slab in *M'zab* House (Djeradi, 2012).

4.5.2.3 **Humane Design**

4.5.2.3.1 **Preservation Natural Conditions**

Respect Topographical Contour: The houses of the *M'zab* were designed and located in a way which does not disturb palm groves and the valley's lines. Each house respects the other, and is a part of a building site which makes it a more enjoyable space for human habitation (Chabi & Dahli, 2008).

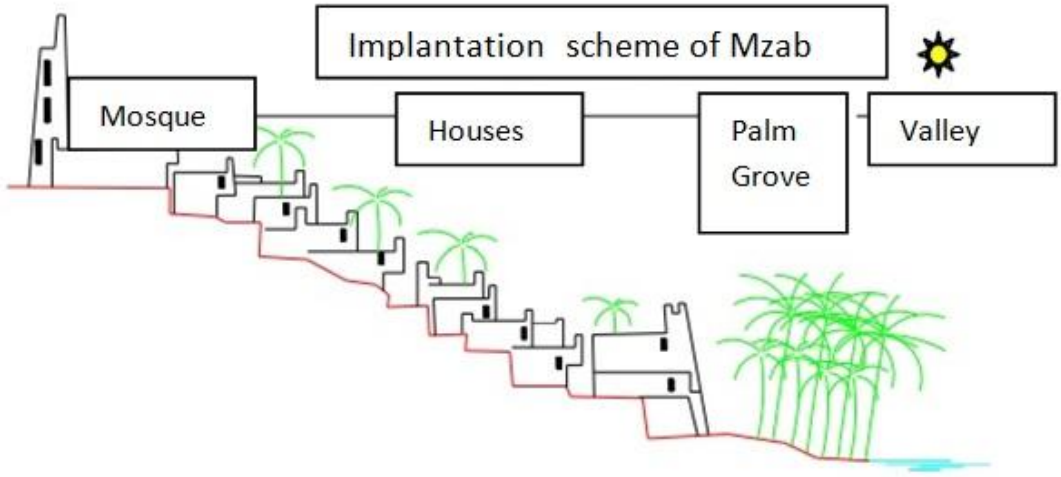


Figure 4.33: Implantation Diagram of *M'zab* Houses (Chabi & Dahli, 2008).

4.5.2.3.2 **Urban Design and Site Planning**

Promote Mixed Use Development: In the heart of the city there is the mosque which is the most prestigious building. In the district it unites all the families together. *M'zab*'s mosque is the key ordering and structuring element of the town. It is a place of worship, the seat of religious government, a meeting place, a school, and a fortress. Around the mosque, dwellings are laid out in a close set, orderly manner, and the existence of hierarchical alleys creates an urban form in the shape of a series of screens (Chabi & Dahli, 2008).

The entire town faces southeast: the direction of the *machriq* (rising), symbol of light and life, and the sacred direction of *Mecca*. Islam accompanied the Ibadites in all their activities, ruling their lives and guiding their gestures. Following the holy texts of the *Quran*, they developed a philosophy and a social, political and religious order that became the metaphorical foundation of their towns (Djeradi, 2012).

The ring of houses surrounding the mosque forms a real fortress, a place of religious intimacy. The souk (shopping area) provides *M'zab*'s trade center and meeting place. (Figure: 4.37).

Figure 4.34: Unified Image of *M'zab* Region (Golvin, 1989).

4.5.2.3.3 **Design for Humane Comfort**

Provide Visual Comfort: The outer walls, mostly blind to preserve the secrecy of family life, sometimes have narrow windows masked by wooden balconies. Houses also contained virtually no outside windows. The rare openings which existed were reduced in size. They were reminiscent of embrasures (Didi, 2013).

Chabi & Dahli, (2008), in their study stated that *M'zab* building owners were forbidden from adopting a style or any other building element that was different from other houses. All *M'zab* buildings, including places of worship, were unadorned both inside and out, and every architectural element was rationally and precisely used. The application of these strict rules, to all dwellings gave *M'zab* a simple and functional form that expressed the origins and principles of its residents (Chabi & Dahli, 2008). (Figure: 4.36).

'*Skifa'* or '*chicane'* was designed to preserve the interior from strange looks of the foreigner guests. Volumes and heights of the houses were regulated in detail to preserve the safety and intimacy of dwellings. This also led buildings to be sized according to humane proportions.

Figure 4.35: View on the *Skifa* in *M'zab* House (Djeradi, 2012).

Provide Visual Connection to Exterior: The palm grove which is located in the limits of the valley and close to the houses of M'Zab, provides beautiful green views for the inhabitants.

Accommodate Persons with Different Physical Abilities: Each dwelling, mirroring the organization of the town, featured an internal organization that both met the need for intimacy and allowed for sun and climate control. Since the outer part of the town was dominated and attended by men, house interiors expressed intimacy and were designed to protect the integrity of women. Despite the fact that they were indisputably the heads of families, men were largely left

out of this interior world. For them, the house was principally a place to join their wives and eat the food prepared by women (Chabi & Dahli, 2008).

Women are hardly allowed to go outside the house. They spend most of their time inside the house, the terrace, which is reserved for them, might be used at night to sleep.

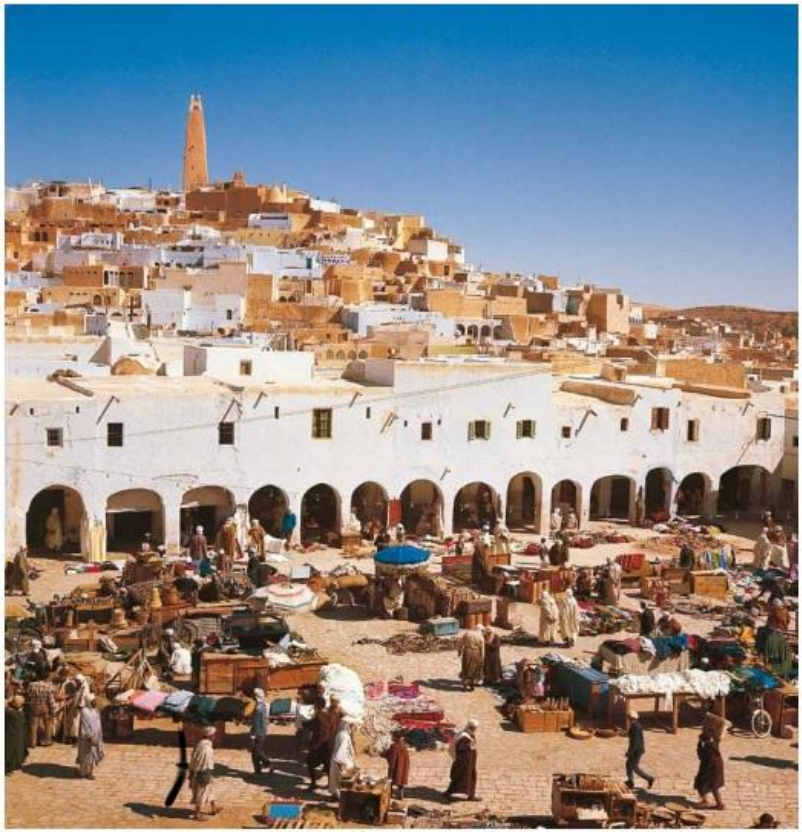


Figure 4.36: Exterior View on *Souk* of *M'zab* (Adad & Mazouz, 2013).

4. 6 Evaluation of the Vernacular Algerian Architecture in Casbah and M'Zab Case

The following table shows the evaluation of the two cases of studies *Casbah* and *M'zab* houses. Our evaluation depends on the sustainable strategies of the economy of resources, and life cycle design of the study of *Jong & Brenda* (1998) which were analyzed before. It shows which parts in both case studies are strong or weak. Depending on the sustainable methods which exist in each, in each criteria, the one who has more points means that sustainable methods are powerful and strong, the less means weak:

Sustainable Methods			*Casbah* /10	*M'Zab* /10
Economy of Resources	Energy Conservation	Energy-Conscious Urban Planning	5	10
		Energy-Conscious Site Planning	5	10
		Passive Heating and Cooling	10	10
		Insulation	10	10
		Day Lighting	5	5
		Choose Materials with Low Embodied Energy	10	10
	Water Conservation	Reduce Consumption	10	10
	Material Conservation	Use Materials that can be Recycled	10	10
		Size Building and Systems Properly	10	1
Life Cycle Design	Pre-building Phase	Use Materials Made From Renewable Resources	10	10
		Use Materials Harvested or Extracted Without Causing Ecological Damage	10	10
		Use Materials with Long Life and Low Maintenance	10	10
	Building Phase	Minimize Site Impact	10	10

Humane Design	Preservation of Natural Conditions	Respect for Topographical Conditions	10	10
	Urban Design Site Planning	Promote Mixed-use Development	5	5
	Design For Humane Comfort	Provide Thermal, Visual, and Acoustic Comfort	10	10
		Provide Visual Connection to Exterior	10	1
		Provide Operable Windows	10	10
		Provide Fresh Clean Air	10	5
		Accommodate Persons with Different Physical Abilities	10	5

Table 4.4: The Evaluation of Two Case Studies (Author).

10: Strong **5: Moderate** **1: weak**

4.6.1 Evaluation of *Casbah* Houses

According to the evaluation table above, *Casbah* has many powerful sustainable criteria. In economy of resources, starting from energy conservation in passive heating and cooling. The patio in the middle of the house provides: thermal comfort during summer and winter, ventilation during the whole day, and natural lighting. Small openings of the walls communicate with the street. All that reduces energy consumption. In the case of insulation: (a) the size and number of the windows (they are limited to prevent heat gain and loss), (b) the building materials used; (the mud brick of the walls), and (c) the debarked cedar logs of the slabs, need to be mentioned. All ensure acoustic and thermal insulation due to their characteristics. In water conservation, the use of wells and tanks are used as a renewable water resource collect rainwater. This also reduces energy consumption. In material conservation, using materials with low embodied energy, which are elementary, and easy to get from the locality without the need of energy for transportation. Those materials can be recycled. The building size and consumption systems properly were well studied. The interior spaces which

are needed for each humane being were optimum according to the number of family members. This is why one finds three types of houses in *Casbah*: each is different in size according to the size of the family.

In life cycle design, *Casbah* has a sturdy case in using materials which are made from renewable resources like stones, mud brick, cedar logs, and wood. Also, they are materials which can be harvested and extracted without causing an ecological damage to the environment. Moreover, those materials have a long life and demand low maintenance. In the building phase and in the preservation of natural conditions, *Casbah* has powerful augments in minimizing the site impact. Houses were built on a hills slope without making any changes. By respecting the topographical contour they do not disturb natural hydraulic process and everyone benefits from cooling winds blowing through the site.

Casbah is developed in humane design. In design for humane comfort, by providing thermal, visual and acoustic comfort. The *Casbah* provides visual connection to the exterior. It also provides fresh and clean air by its operable windows some of which face the sea. Also, in accommodating persons with different physical abilities, people of different ages and sexes may use the houses they are adaptable to different daily life conditions of citizens.

Casbah is moderate in both energy conscious urban and site planning. All houses should face the sea and have an accessible roof, to have clean and fresh air, and to benefit from the sun for day lighting, which is the only reason to organize the houses' location. As well as in promoting mixed use development where a mix of residential houses, commercial, educational, religious spaces provides people with a great sense of community. But still there is lack of other different facilities which should be needed in any living area, like parking spaces, green spaces, etc.

4.6.2 Evaluation of *M'zab* houses

According to the climatic analysis, *M'zab* houses are developed according to different criteria just as well as *Casbah*. In energy-conscious urban and site planning, due to the houses organisation and the protection offered to the

M'zab people because of this well urban organisation. In passive heating and cooling, it is powerful due to the only one central opening in the centre of the house for lighting, ventilation and for the thermal comfort of the inhabitants. Also, *M'zab* houses are strong in their insulation strategies, where thick stones, *toub*, are used for the walls of houses which characterize them by a high thermal comfort. This creates a good and well thermal environment. *M'zab* houses are powerful in choosing materials with low embodied energy. Stones, gypsum, sand, palms, *toub*, all are available locally and require no energy in production or transportation. All materials used in *M'zab* buildings can be recycled. Those materials are made from renewable resources and can be harvested and extracted without causing ecological damage; stones, *toub*, palm wood, brick, are also durable and require low maintenance. *M'zab* is sturdy in promoting mixed use development where different equipments surround the house units: educational, religious, commercial (souk), which *M'zab* people need in their daily life. And developed in providing an operable window, where the *chebek* has the main role in the house in providing light, ventilation and thermal comfort.

M'zab houses are moderate in providing clean air and in day lighting because there are only two sources of getting natural light from the *Chebek* and from the entrance door, not all the inside spaces can get enough light and fresh air.

The houses of *M'zab* region are weak in building size and system. This is because all houses have the same size for different kinds of families. This affects their daily life comfort, environment and activities. The same is valid in providing visual connection to the exterior, especially for women. It is too much closed for them, they have no contact with outside views, because of the strict rules they have in *M'zab* region. Because there is at maximum one small window which opens to the street. So people can only go to the terrace to have contact with the outside.

4.6.3 Implications for Algerian Architecture

Based on the findings and the conclusions, it is proposed the following recommendations for Algerian architects and designers, as well as for everyone in the field of architecture and urban design:

- The use of sustainable building methods should be taken into consideration in each building design process (starting from the pre-building phase until the post-building phase) using the three sustainable principles explored in this study. For the pre-building and post building phase of private buildings, it is much better to use natural stones which can be found from the near natural rock quarries near the site of the project, and to use it for exterior and interior walls. First, this is a renewable resource. Second, it is durable and long lasting. Thirdly, it can be reused as a component for another building in the post building phase.

- The use of local materials in each region is significant in reducing excessive energy consumption and any kind of environmental damage. Like in the arid region, the use of palm trunks for the columns and the beams, the sand for the mortar of walls siding, and palm leaves as beams cover. Those are examples of natural local materials which can be used in future building units in the desert region of Algeria. As well as in the Mediterranean side, stones or mud brick for the walls, wood for building structure, can be used anytime in housing projects.

- Climate conditions of each region has to be studied and used in designing a building in order to use the sun and wind at maximum level, and to reduce energy consumption in heating and cooling systems. As shown in the case of *Casbah* houses, all units face the sea in order to benefit from natural ventilation, to have fresh and clean air inside the house, and to enjoy the exterior views toward the sea.

- Algerian vernacular architecture is a heritage of the country. It should not be forgotten, its valuable architecture employs sustainable methods and approaches which can be used in the new buildings of Algeria. Current Algerian architecture, which is composed of a mass of concrete, seems to have forgotten the lifestyle of

the indigenous people. The two case studies have provided us with enough evidence about design methods which consider this issue. The designer or the architect should design a comfortable dwelling for the inhabitants, where they can have their whole privacy and comfort in accordance to their traditions and lifestyle. In the following figures, two proposals of housing units in both the Mediterranean region and the arid region have been shown. These provide vernacular design approaches like using *wast eddar* (court yard) in order to have natural ventilation and sulight, and the *skifa*, to create sufficient interior privacy as in *Casbah* houses. By using the *chebek* seen in *M'zab* houses, one can get natural coolness, and natural sunlight.

For the Mediterranean region, architects may use the concept of the court yard for their housing units. In order to benefit from natural ventilation for cooling, getting clean air, and for receiving the maximum sunlight needed the courtyard would be oriented to the south. This means that the house would be exposed to the sun during the whole day. This may not be suitable in summer. However it is great for the winter. Due to this, a line of trees can be placed in the south facade of the house in order to provide shadow during the summer. Fully grown trees, in winter let the sun rays pass and reach the inner spaces of the house. (Figure: 5.1, 5.2, 5.3)

For the Arid Region, creating two *chebeks* in the first slab of the house will provide sufficient ventilation, and sunlight for the whole of interior spaces. Each of these will be lit naturally during the whole day. (Figure 5.4, 5.5)

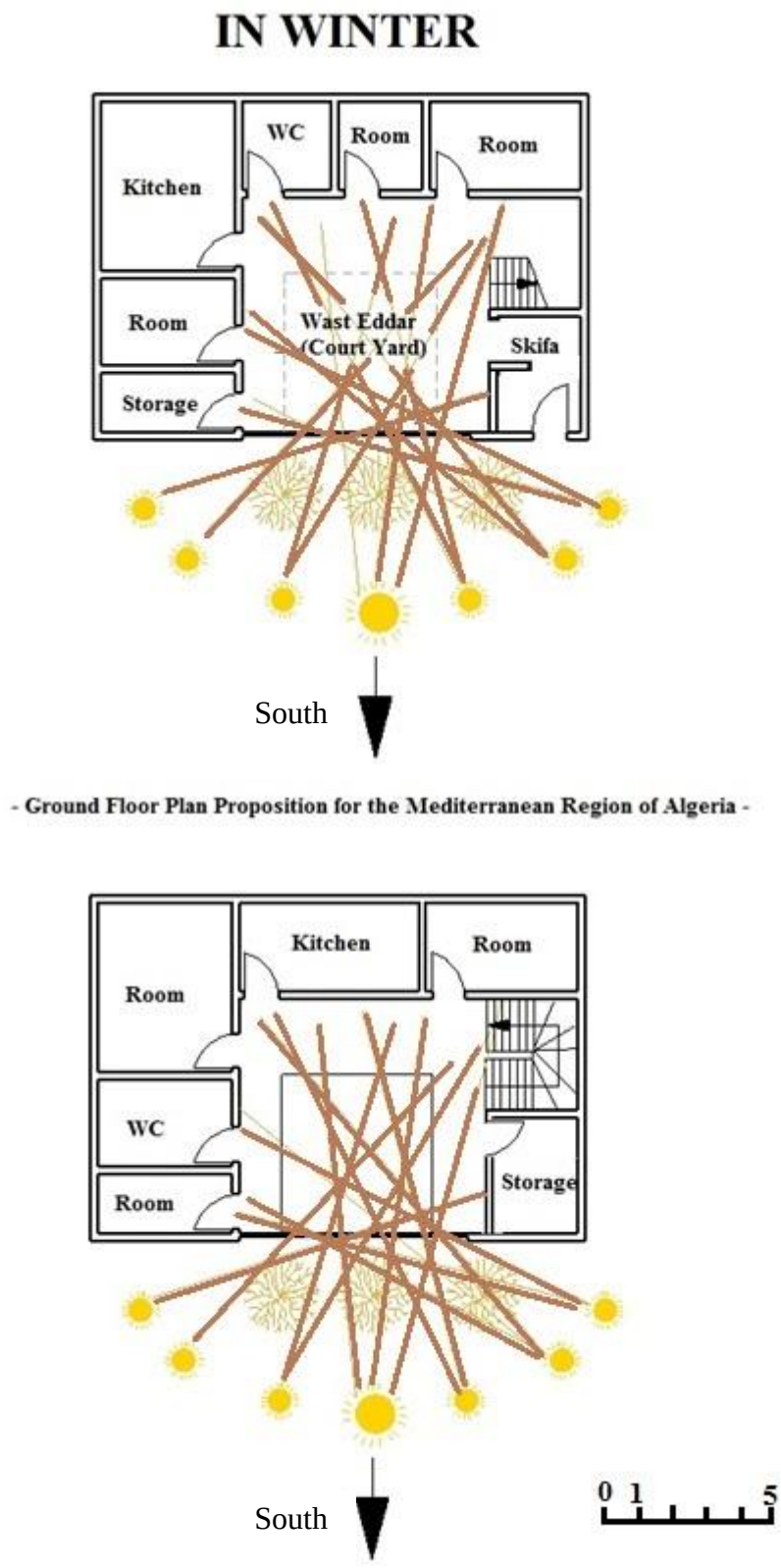
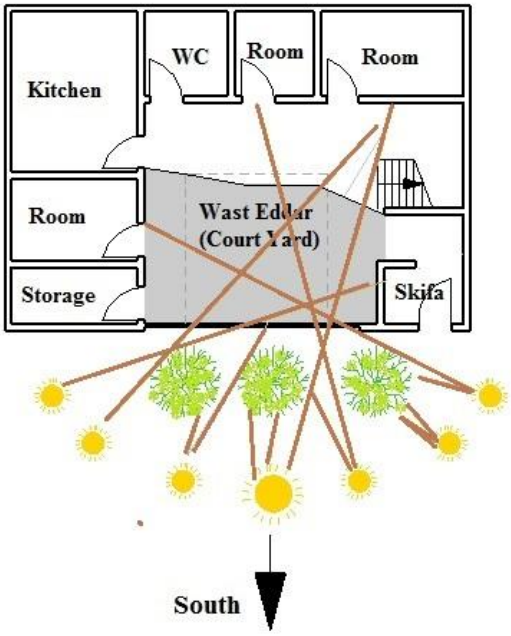
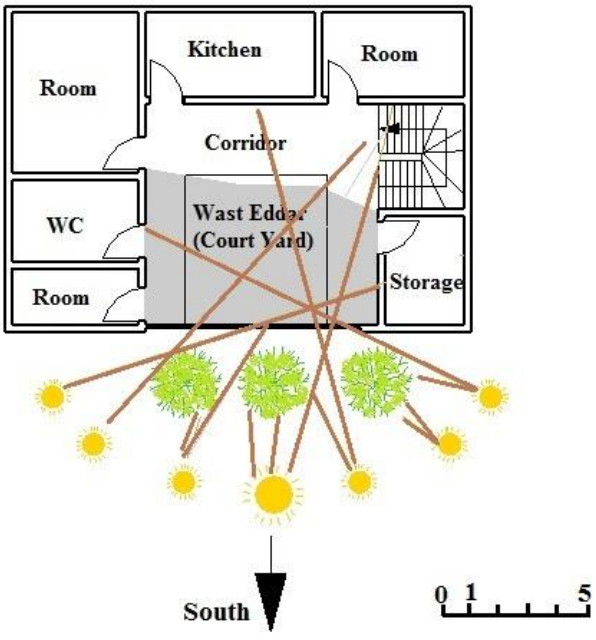


Figure 4. 37: Housing Unit Sketch Proposition in the Mediterranean Region / Winter (Author)

IN SUMMER

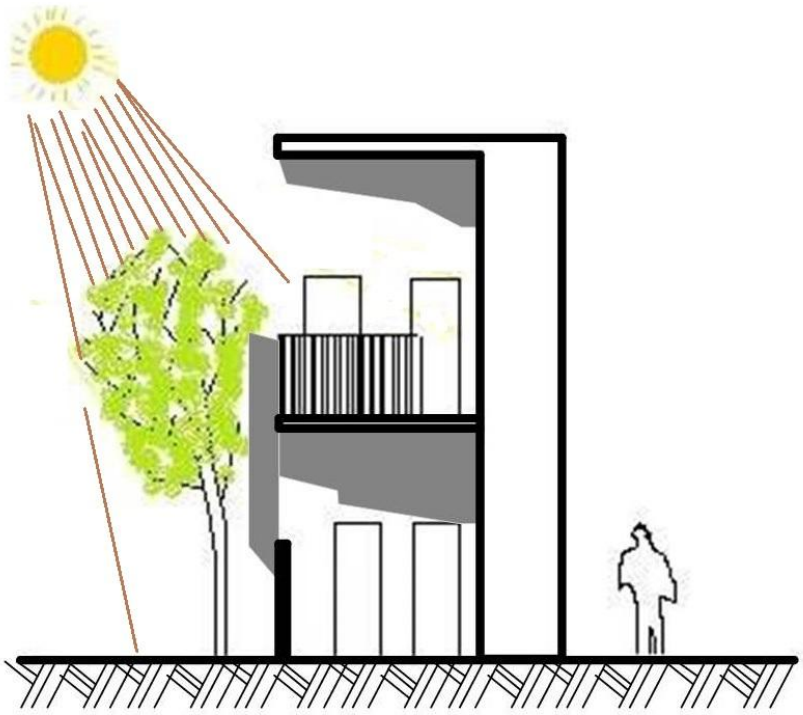


- Ground Floor Plan Proposition for the Mediterranean Region of Algeria -

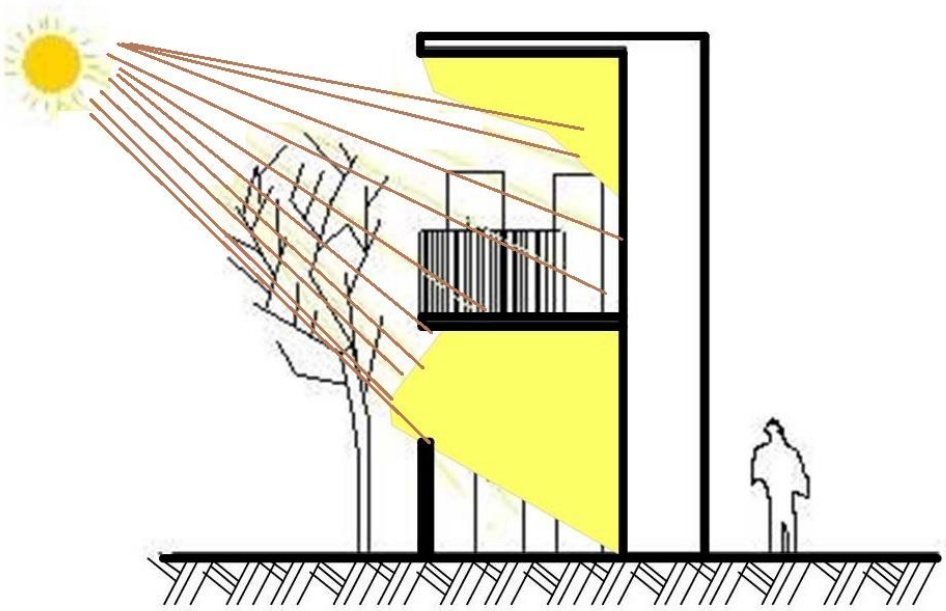


- First Floor Plan Proposition for the Mediterranean Region of Algeria -

Figure 4.38: Housing Unit Sketch Proposition in the Mediterranean Region/ Summer (Author)

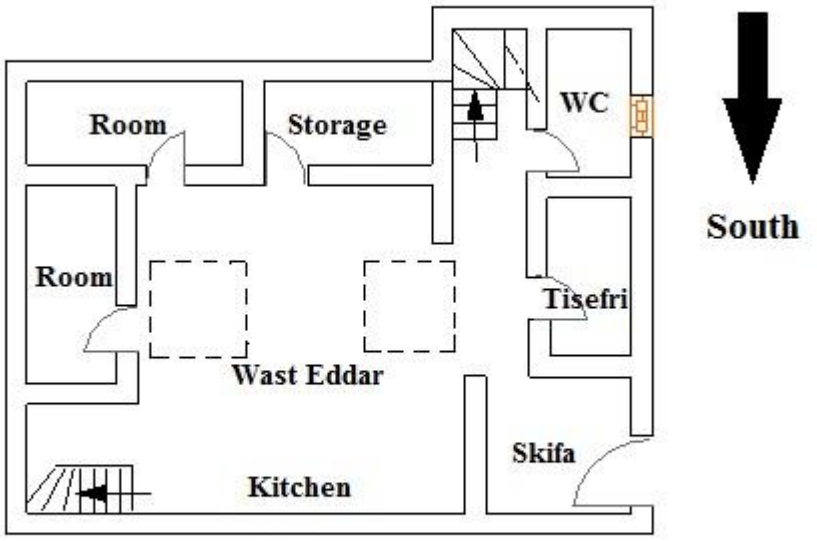


- Sunlight Path During Summer -

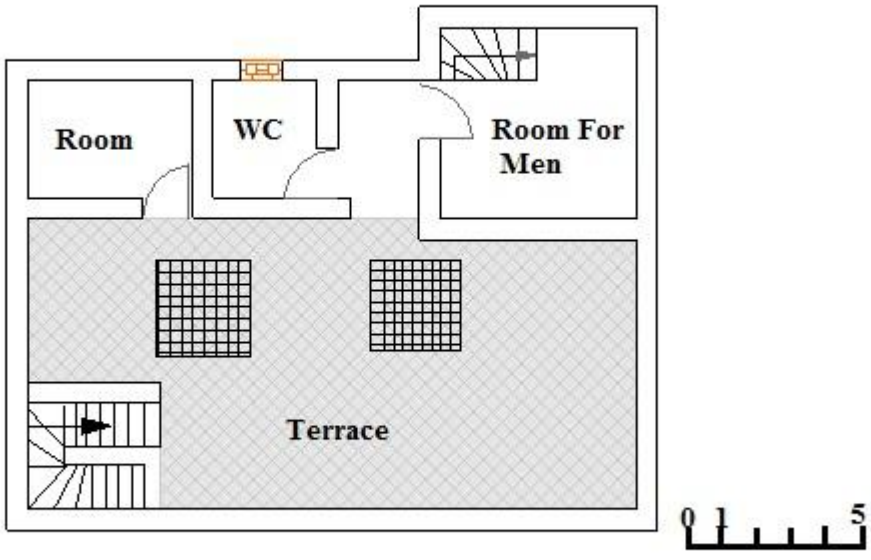


- Sunlight Path During Winter -

Figure 4.39: Sunlight Path during Winter & Summer in Mediterranean Region (Author)



- Sketch of Ground Floor Plan Proposal of Housing Unit for Arid Region -



- Sketch of Terrace Plan Proposal of Housing Unit for Arid Region -

Figure 4.40: Sketch Plans of Housing Unit Propositions for Arid Region (Author)

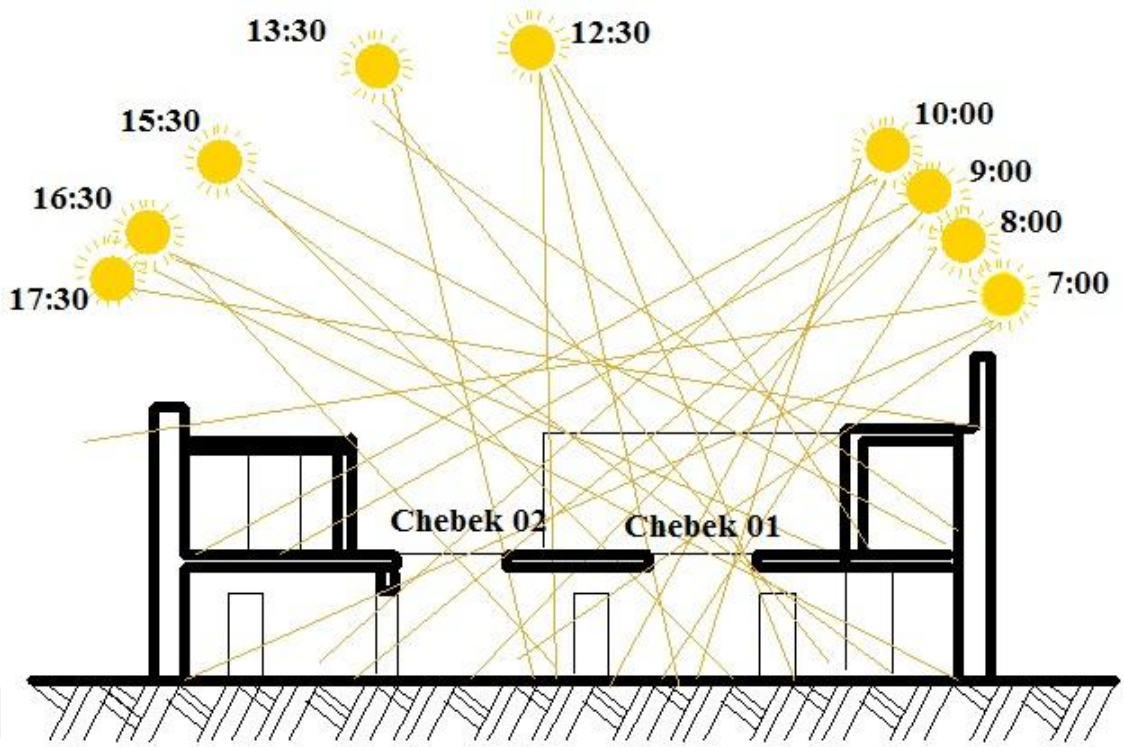


Figure 4.41: Sunlight Cross Section of a Housing Unit Proposal for the Arid Region (Author)

Both Propositions keep the same design approach, only some sustainable principles were added, like facing the courtyard to the south in order to get sufficient day lighting for all interior spaces. The line of the trees is for protecting the house from the undesirable sunlight in summer by providing shadow, and letting the rays of the sun get into the interior of the house in winter. In *M'zab* houses as well, the same design approach were saved, but in order to get sufficient natural lighting, another *chebek* were added next to the other one.

5 CONCLUSION

5. 1 General Conclusion

Economic environmental concerns for energy resources have been constantly increasing during the last three decades. As related to these issues "Sustainability" has come as major issues in order to use global resources intelligently to our surprise, we now see better how vernacular architecture has catered for sustainable use. We have started to see how intelligent our ancestors were.

This study combines the vernacular architecture with sustainability issues as regards architecture of *Algeria*. This is an issue which has not been dealt with in the past whereas traditional architecture possesses numerous features of wisely designed items. The analysis and the evaluation in the two case studies of this thesis follow the guidelines of sustainability. It is hoped that similar studies will be carried out in the future. It is also hoped that our present day architects will adopt the intelligent solutions discovered and implemented by our ancestors.

The preceding sections of this study explained the aim to be achieved: 'making an evaluation of two case studies of vernacular architecture in *Algeria*: *Casbah* (Mediterranean side), and M'zab (Arid region). This wanted in order to know the sustainable strategies which exist in such buildings. This aim required several stages of analysis, in order to be clear to the reader.

The description and the background about vernacular architecture has been written in order to explain that it does not mean poor or underdeveloped buildings, it is rather a clever and rich kind of architecture where early dwellers used modest techniques and local materials to create living spaces by simple methods to protect themselves and to adapt the house to be suitable for climatic conditions and to their lifestyles. It is now serious for us to be familiar with the importance of vernacular architecture. It contributes to culture and community, and allows a community to define itself in relation to its area, its traditions and its past. Vernacular architecture is therefore an important element to identify in

any territory, as well as its heritage. According to the literature review which was done in this part, most of writers stated that vernacular building techniques contribute of earnestly to sustainability. They used local available materials which lasted for long time. Paying attention to climatic conditions also makes the topic of vernacular architecture significant. This is exemplified by wind towers of houses in Iran. They are used for interior ventilation. The step wells of India conserve water and reduce energy consumption. The domed houses of Harran in Turkey were built from local modest materials (adobe), and the form of the houses is very suitable for the wind exposures.

Awareness of sustainability has increased significantly nowadays. The concept of sustainable design has come to the forefront in the last twenty years. Regardless of what it's called (sustainable design, sustainable development, design with nature, environmentally sensitive design, etc) 'sustainability' is the capability of natural and cultural systems which have continued over time. Sustainable design must use the alternative approach of traditional design. Present new design approaches must recognize the impacts of every design choice on the natural and cultural resources of the local, regional, and global environments. Sustainable design principles need to be known as well. Applying the concept of economy of resources to conserve energy, water, and material. Caring about life cycle design of the building phases (pre-building phase, building phase, and post building phase) is also substantial. Paying attention to human design concept is also important when it comes to preservation of natural conditions, in urban site planning, and human comfort. Those three standards are those which each building should involved with in order to call them sustainable.

Modern buildings use energy very intensively because they rely too much on mechanical and electrical systems for heating, cooling, cooking and lighting. Traditional, (vernacular, or indigenous) buildings, on the other hand, used little energy for heating, cooling, and lighting, and whatever energy they used was natural and renewable. Because modern buildings use about 50% of all our energy, they are a major cause of energy depletion, pollution, and global warming. Producing efficient mechanical and electrical systems is not the primary way of reducing energy consumption in buildings. Rather, it is the design of the building

itself that will have the greatest impact on reducing energy requirements of buildings. For example, modern buildings rarely use shading, natural ventilation and heating devices, while traditional buildings have always done so. As such the case of the courtyard house of *Casbah*, and the *Chebek* area of *M'zab* house indicate good solutions.

Vernacular architecture around the world is impressively rich with ingenious techniques early dwellers used to protect themselves from diverse weather conditions they were subject to. Two great examples of well-thought vernacular architecture are located in Algeria is *Casbah* (in the Mediterranean zone), and *M'zab* in the South of the Algerian Desert. Their climate conditions, lifestyle and traditions are probably a good example for studying their architectural techniques. They allow the creation of independent microclimates in these regions. They show architectural and clever techniques early dwellers used ın order to protect themselves from different weather conditions. The impressive techniques of vernacular architecture can be an inspiration for our modern sustainable movement. According to the three sustainable principles and the evaluation has been made in this research we may recognize that both *Casbah* and *M'zab* houses have valuable characteristics:

Firstly, is the economy of resources. where energy conservation is assured by using different techniques (in passive heating and cooling, in insulation systems, in day lighting, and the use of materials) consumption is low embodied energy. Water conservation in both case studies was significant especially in reducing its consumption. In the conservation of materials that can be recycled and reused and the size of buildings and systems were properly taken into consideration as well.

Secondly, we conclude from the evaluation of both *Casbah* and *M'zab* that valuable techniques in pre-building phase (where materials used are from renewable resources) and harvested or extracted without causing ecological damage. Most materials have a long life and demand low maintenance.

Thirdly, is humane design. Both case studies preserved natural conditions by respecting the topography of the site, and urban design. Promoting mixed use development was taken into consideration. Finally, in terms of design for human comfort, each case study has its own techniques in providing thermal, visual, connections to the exterior, providing operable windows, providing fresh and clean air and in accommodating persons with different physical abilities.

5. 2 Specific Conclusion

The two vernacular case studies in Algeria indicate many valuable sustainable techniques. These can be summarized as follow:

1- To conserve energy, houses should be oriented in a suitable direction and protected from the undesirable sun and wind. In order to benefit from the sun and the wind house orientation is to have preferable sunlight and ventilation for cooling and heating.

2- Use of a central open space, "patio" in the Mediterranean regions, *''chebbek''* in the Arid regions, as a source of daylight and fresh air, and in order to improve interior thermal comfort both in winter and summer.

3- For thermal and acoustic insulation, natural local materials such as stones might be effective.

4- For a functional day lighting, the number and the size of the openings should be studied according to the orientation of the sun, and the nature of the space. As well as the height of the surrounding buildings, each house must get the sunlight it needs without any obstacles.

5- Use elementary, local, and easy materials, which do not need energy for processing and transportation. This reduces ecological damage and energy consumption.

6- To conserve water, having a well is beneficial as well as tanks to keep and collect rainwater. Using natural water sources with sewage system. This helps and reduces energy-intensive municipal treatment activities.

7- Conserve on materials, using durable materials, which might be reused and recycled preserves the energy embodied in their manufacturing.

8- Size of a building should be well thought. Non useful spaces effects on the function of the building, suitable with sufficient spaces make a building durable.
9- Use recycled, and durable materials made from renewable materials, and obtained from the local site itself. This reduces the ecological environmental damage.
10- The contour of any site should be respected without making great changes on the topographical or natural form.
11- For human comfort, create visual privacy according to the lifestyle of the house's inhabitants. At the same time, there should be an exterior visual connection to enjoy the views from the outside.
12- The building should be useful for the all members of the house, because the more it is useful, the more it is considered durable.

5.3 Recommendations for Future Research

Future studies should consider another kind of vernacular Algerian architecture: The *Kabyle* House or the *Chawi* House, both have a great deal of valuable issues and methods as regards sustainability.

Additionally, comparisons can be made between some case studies. This is how we may understand better the effects of different climatic conditions and lifestyles on our vernacular architecture.

Another possible extension might be, the creation of modern sustainable vernacular housing units in a specific region of Algeria. In doing this we can make a combination of the old and the new (i.e. vernacular and modern architecture) in order to create modern housing units which are sustainable.

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