PASSIVE DESIGN ELEMENTS OF TRADITIONAL AND MODERN HOUSES: CASE STUDY ON WEST COAST OF LIBYA

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UNIVERSITI SAINS MALAYSIA

2023

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by

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Thesis submitted in fulfilment of the requirements
for the degree of
Doctor of Philosophy

March 2023

ACKNOWLEDGEMENT

بسم الله الرحمن الرحيم

First and foremost, I would like to express my deepest gratitude to Almighty Allah SWT, all praise, and thanks for His boundless blessings, have strengthened and enabled me to complete this thesis.

And then to:

My supervisor, Professor Dr. Ahmad Sanusi Hassan for his endless support, advice, and supervision throughout the process of producing this research. His guidance and professional experiences as a lecturer, as well as a regional writer have indeed helped me to develop and complete this research.

As well as the staff of the campus and especially the School of Housing Building and Planning USM for providing all needed facilities and services to ease the operation of the study procedure.

My family, to my beloved parents and siblings whom I have missed dearly, it is whole-heartedly appreciated that your great advice and support for my life especially in my study proved monumental towards the success of this study, also to my small family, which is my wife that joined my life since I started studying my Ph.D., as well as my son Humam and daughter Bilqees.

My country Libya, through the Ministry of Education and Scientific Research of Libya, for the scholarship that has made my study abroad achievable by the financial support for covering the expenses of living and the study.

On top of that, I wish to thank all the people whose assistance was a milestone and supported directly or indirectly towards the success in accomplishing this thesis. Your effort, time, and understanding are highly appreciated.

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ELEMEN REKA BENTUK PASIF RUMAH TRADISIONAL DAN MODEN: KAJIAN KES DI PANTAI BARAT LIBYA

ABSTRAK

Kajian ini, bertujuan untuk memahami, menyiasat, dan menentukan strategi reka bentuk pasif antara halaman rumah tradisional dan rumah moden di kawasan pantai barat Libya. Pada akhir penyelidikan ini, kajian akan mencadangkan satu garis panduan untuk mengulas strategi reka bentuk pasif bagi reka bentuk rumah yang betul. Sorotan kajian mengkaji masalah reka bentuk pasif, seperti tipologi rumah, komponen, elemen, dan hubungannya dengan pengaruh reka bentuk pasif. Kajian ini menggunakan kaedah campuran yang menggunakan pendekatan kualitatif dan kuantitatif. Kaedah kualitatif digunakan untuk mengkaji kes ini melalui beberapa tahap. Pertama sekali, pengumpulan data telah dijalankan untuk mengenal pasti dan menyiasat kes yang dipilih, termasuk pengukuran dan dokumentasi fotografi. Seterusnya, pemprosesan data dilakukan melalui penjanaan komputer seperti lukisan AutoCAD, penjadualan nombor yang dikumpul dan penghapusan gambar. Peringkat ini diperlukan bagi penyediaan data untuk tahap terakhir iaitu analisis dan keterangan data. Manakala, pendekatan kuantitatif dikhususkan untuk mengendalikan soal sellidik yang dijana melalui beberapa tahap pemprosesan seperti soal selidik reka bentuk dan pengesahan yang diedarkan kepada responden yang disasarkan. Oleh yang demikian, data kuantitatif yang dikumpulkan dianalisis menggunakan perisian SPSS. Hasil kajian menunjukkan bahawa rumah dengan halaman tradisional menyediakan pencahayaan dan pengudaraan semula jadi. Pengaruh iklim memainkan peranan utama

dalam mewujudkan keselesaan termal dan pencahayaan waktu siang. Kajian juga mendapati bahawa penduduk di rumah moden terpaksa berdepan dengan isu lain seperti kekurangan privasi serta pengudaraan semula jadi dan pencahayaan pada waktu siang yang memaksa mereka untuk bergantung kepada peralatan buatan untuk mengimbangi keselesaan termal dan pencahayaan waktu siang yang baik. Kajian ini berakhir dengan perolehan jawapan kepada objektif kajian yang dikemukakan sebagai hasil hala tuju kajian yang mengenal pasti strategi reka bentuk pasif halaman rumah tradisional dan rumah moden. Seterusnya, menentukan faktor kelebihan dan kekurangan yang mempengaruhi strategi pasif. Kajian ini juga menjawab persoalan keselesaan termal dengan mengulas persepsi penghuni rumah halaman radisional dan rumah moden. Berdasarkan hasil kajian yang diperoleh, sebuah garis panduan umum diperoleh bagi meningkatkan tahap strategi reka bentuk pasif di rumah. Beberapa saranan dan cadangan kajian masa depan disimpulkan berdasarkan hasil yang diperoleh.

PASSIVE DESIGN ELEMENTS OF TRADITIONAL AND MODERN HOUSES: CASE STUDY ON WEST COAST OF LIBYA

ABSTRACT

This study, intended to understand, investigate, and determine the passive design strategies between the traditional courtyard and modern houses in the western coastal region in Libya. Therefore, at the end of this study, this research will propose a general guideline to address the passive design strategies through increasing the passive elements performance for a proper house design. The literature study reviewed the passive design matters, such as house typology, components, elements, and their relations to passive design influences. The methodology applied mixed methods which involved qualitative and quantitative approaches. It adopted the qualitative method to address the case study which was conducted in several phases. Firstly, the data collection was carried out to discover and investigate the chosen cases, including measurements and photographic documentation. Secondly, data processing was performed, which meant a computer generation of things such as AutoCAD drawings, scheduling collected numbers, and clearing photographs. These were needed to prepare the data for the last stage, which was the data analysis and description. Whereas the quantitative approach was dedicated to handling the survey questionnaires that were generated through several processing stages, such as, design and validation questionnaires that would be distributed to the targeted respondents. Thus, the collected quantitative data were analyzed by SPSS software. The results revealed that traditional courtyard houses provide natural daylighting and ventilation, the climatic influence plays a major role in creating thermal comforts and daylighting.

In the study, it was also found that the residents in the modern houses faced different issues represented in a lack of privacy as well as the natural ventilation and daylighting which affecting the optimum usage of passive elements and forced the residents to rely more on artificial equipment to compensate for thermal comfort and good daylighting. The study ended up with the answers for the research objectives as a result of the research journey that resulted in recognizing the passive design strategies in both traditional courtyard and modern houses. Furthermore, the researchers were able to determine the pro and con factors that influence the passive elements performance. Also, the research answered the question of thermal comfort level by investigating the house occupants' perceptions towards the traditional courtyard and modern houses. Based on these results, the researchers have produced a general guideline to increase the level of passive design strategies in the houses. Recommendations and future suggestions were advanced based on the obtained results and the findings of the study.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter introduces the topic of the study and provides an overview of the background of the study. It presents the statement of the problem, the research questions, the research objectives, the significance of the study, and the research framework. Moreover, an overview of previous related studies is provided in the chapter. The significance of the study and its scope are also provided in this chapter. The chapter ends with a summary of the chapter.

1.2 Research Background

Climate change is one of the concerns of the United Nations and has been steadily growing to be one of the main alarms because the energy demand increases. Gabril (2014) reported that about 80% of the world's energy is produced by the burning of fossil fuels, which release carbon dioxide and other pollutants into the atmosphere. Moreover, the growing demand for energy and expectations that the population will reach 9 billion in 2050 means that there is an urgent need to move towards renewable energy, such as solar, wind energy, and others, which also encourages green investment. The aim is to improve the energy efficiency of equipment, buildings, and lighting to achieve sustainability and to respond optimally to climate change. The United Nations and the World Bank have recently launched an initiative called "Sustainable Energy for All", according to which, 2030 will be the deadline to improve efficiency and double the share of renewable energy (Nation, 2017).

Based on the United Nations' Framework Convention on Climate Change, the so-called Kyoto Protocol, followed by several summits and meetings, such as the Marrakesh Accord 2001 in Morocco. In December 2012, Doha, Qatar also amended the Kyoto Protocol. All these agreements and treaties have urged the need for all parties to abide by the UN conventions on climate change. Among these items is the commitment of countries that depend in all their economies on the production and export of oil, as well as their high consumption of it due to its availability and lower production costs in those countries (Protocol, 2001-2012).

NASA has reported, in this regard, that climate changes have been steadily increasing since the beginning of the industrial revolution. Global warming and climate change have increased by more than a third, thereby causing deterioration, worsening environmental situations, along with their constant aggravation; not to mention the activities of people, in general, triggering multiple dangers. These are related to all types of wastes, automobile exhaust, factories, as well as power plants that burn fossil fuels, such as oil and coal, which can lead to the emission of carbon dioxide into the atmosphere. Moreover, the encroachment on farms, forests, and land use has adversely affected the destruction of the ozone layer. These phenomena have also caused the sea level to rise, ice to melt, and triggered global warming (NASA, 2017).

As mentioned above, the demand for energy usage is constantly increasing as population density increases. Most energy uses are from fossil fuels, which cause carbon dioxide emissions and lead to inflicting major problems. Carbon dioxide emissions (CO^2) reached their peak in 2012 with the gradual depletion of fossil fuel reserves readily available. People are, therefore, striving to find other energy sources that can be sustainable and environmentally friendly, such as renewable energy.

Scientists have observed a significant increase in carbon dioxide in the atmosphere over the past century, compared to the pre-industrial level of about 280 parts per million (ppm) in 2015. The average concentration of (399 ppm) CO^2 ppm, about 40% higher than in the mid-1800s with a growth rate of 2 ppm/year in the last ten years as there has been a significant increase in methane (CH_4) and nitrous (N_2O).

The human impact on the climate system is among many human activities that produce greenhouse gases. Thus, energy use is a large source of Carbon dioxide emissions, representing the largest share of GHG emissions, globally. Today, when people intentionally destroy the environment and erase the past, it may seem paradoxical to conserve the human activities that left deep traces in the area (Petruccioli, 2009).

According to the Organisation for Economic Co-operation and Development (OECD) Project, the challenges of climate change and global warming can be manifested in terms of several aspects, such as buildings and their communities, towards embracing effective environmental practices to adapt to current climate changes, as well as the socio-economics to eliminate the negative impacts. The government plays a key role in implementing the most appropriate policies through the evaluation tools for future monitoring. Also, the (OECD) has emphasized sustainable buildings, which are designed and built to have less or no risk on the natural environment (OECD, 2015).

Based on the LEED Building Certification system, there are several factors for sustainable designs to be recognized by LEED. These factors include planning and location, water and energy efficiency, sustainable site development, materials selection, and waste reduction, and indoor environmental quality so that it can ensure better performance of buildings. Moreover, the building design has been divided into

four categories: Building Design and Construction, Interior Design and Construction, Building Operations and Maintenance, and Neighbourhood Development. Furthermore, LEED represents a good assessment tool for the cities and their communities to address efficiency performance in existing cities and communities (LEED, online accessed 8-06-2020).

1.2.1 Sustainable House and Energy

Over the past years, initiatives of international policy frameworks have been developed to improve the environment for sustainable development. In 1997, the United Nations launched an international agreement, which is known as the Kyoto protocol that is related to climate change under the United Nations' framework convention. Under this agreement, all parties are obliged to reduce carbon dioxide emissions and eliminate pollution. Recently, however, the world has seen a large consumption in the mineral sources of the Earth, particularly energy and natural resources, which has indicated that human beings have not been taking good care of the environment and/or practicing climatic conservation. This way of life calls for immediate action to be taken towards establishing sustainable designs. This can be done by revising and addressing the system of how to design, construct, and operate buildings to be more responsive to the environment and meet the occupants' satisfaction (McLennan, 2004).

Although loud voices are calling for low-energy consumption, there is no unity or global definition for low-energy houses. Several studies in different countries have interpreted the low-energy house differently. In Australia, for example, it is called "smart housing", whereby in the UK, it is known as the "eco-house" or "carbon-neutral housing". Therefore, the countries worldwide share a similar concept of purpose for

the low-energy house (Anderson, Clark, Baldwin, & Milbank, 1985; Clarke & Clarke, 2001; Hawkes & Forster, 2002; Kibert, 2007).

Energy efficiency may be defined as a primary mechanism of a sustainable design process to eliminate the environmental damage, which is caused by energy consumption (Susan Roaf & Hancock, 1992). The eco-house is the cornerstone towards minimizing its impact on the environment and achieving sustainability (Sue Roaf, Fuentes, & Thomas-Rees, 2014). Thus, all the above definitions indicate the efficiency of energy performance in a building.

Many programs have been launched by countries; each has its specific label to distinguish its system of energy performance assessment in a building to enhance the best practices regarding the low-energy demand of houses. For example, the UK established the first environmental certification system in 1990, under the Building Research Establishment (BRE), which is known as the Building Research Environmental Assessment Method (BREEAM), followed by other concerned countries that have developed their programs and labels of building energy performance assessment, such as the LEED label in the USA and the Green Globes System in the German PassivHaus label, the Green Building Index (GBI) in Malaysia, and the Building and Construction Authority (BCA) green mark in Singapore.

1.2.2 Domestic (House) Energy Consumption in Libya

The Libyan government represented by the General Electricity Company of Libya with its duties in producing and providing energy for its citizens has been striving to meet obligations to the environment both locally and internationally. As part of the performance efficiency improvement, the electricity company has strived to use natural gas to some possible extent, which is considered the cleanest fossil fuel in reducing emissions. Therefore, the quantities of electricity generated by natural gas

amounted to 37% of the total energy generated during 2010. On the other hand, the company aimed to establish the stations of the joint cycle, which, in turn, contributed to the production of 3637 GWh without fuel during 2010. This has contributed to reducing carbon dioxide emissions and improved environmental performance even though it is still a minor contribution.

According to the official site of General Electricity Company of Libya that latest annual report available since 2010, as mentioned the GECOL is suffering of energy production due to many reasons, such as the increase of demand due the natural growth of population and the civil war consequences that erupted since in 2011. It is also noted that the electricity consumption is mostly at its peak in summer which proving that the highest consumption in housing sector which the residents using more air conditioners to relieve the summer heat for internal spaces that causing in electrical cut in summer (GECOL, Online accessed 1/06/2022).

Also, due to the importance of this topic, as well as the government's concern towards the environment and its desire to provide a safe and clean environment, it has been initiated to implement the project of linking the composite surveillance system. Therefore, the emissions are monitored centrally to take the necessary measures in case of exceeding international standards. In contrast, the Libyan government is represented by the General Electricity Company. As the company is a public sector company, which is owned by the country, it seeks to satisfy its citizens or customers, in general. Through the development of existing stations and the establishment of new plants, the government has provided coverage of the deficit and fulfillment of the energy demand. Figures 1.1, 1.2, 1.3, and 1.4 show the power stations that are distributed on the map, some are still working, while others are under construction.

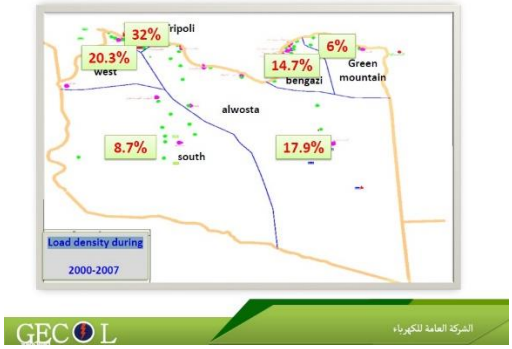

Figure 1.1 Load density during 2000-2007

Figure 1.2 The existing power plants, distributed on the map

Source: annual meeting 2013 (GECOL)

Figure 1.3 Under construction and commissioning power plants

Figure 1.4 Contracted power plants

Source: annual meeting 2013 (GECOL)

According to the official site of the General Electricity Company of Libya, that seeks to develop the company's services through establishing several programmes in parallel such as, rationalization of consumption for optimal use of energy, inviting a larger number of local and foreign companies to maintain the energy production sources and develop power plants in order to increase the energy production and covering the shortage of electricity (GECOL, Online accessed 1/06/2022). As shown in the above figures, it is obvious that there has been a significant scarcity in electricity production, not to mention an ever-increasing demand for energy use. This has resulted

in increasing the construction of power plants in addition to the expansion and development of existing plants.

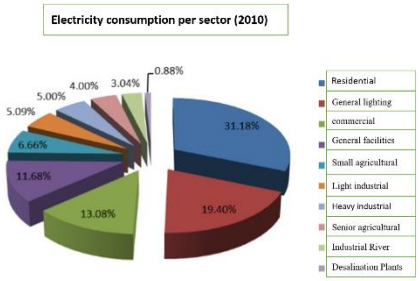

Figure 1.5 Electricity consumption per sector, report (2010).

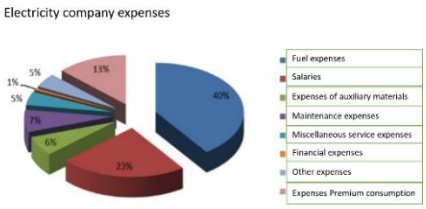

Figure 1.6 Electricity company expenses, report (2010).

Source: General Electricity Company of Libya (GECOL)

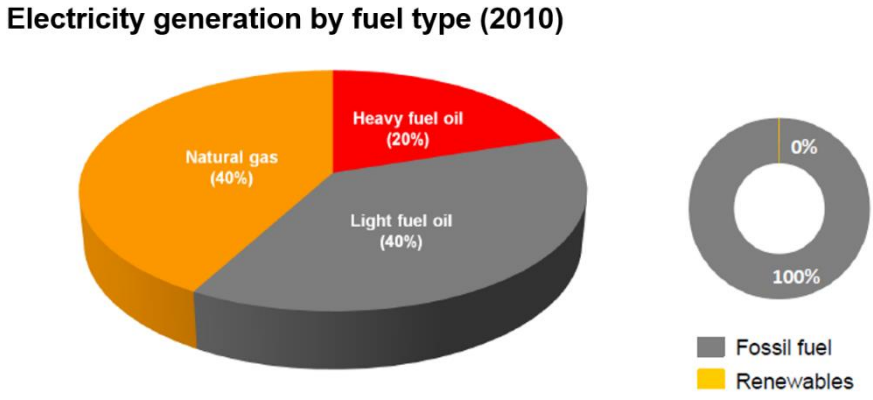

Figure 1.7 Electricity generation by fuel type (2010).

Source: General Electricity Company Of Libya (GECOL)

Based on the electricity company's report in 2010. The residential buildings were the highest consumer sector of energy as shown in Figure 1.5, whereby they recorded 6,422,881 MWh which is 31.18 % amongst other sectors. In terms of expenditure, the highest amount was spent on fuel as shown in Figure 1.6. This represents 40% of the fuel expenses amongst all the other sectors. In a related context,

as shown in Figure 1.7, there was not any contribution proportion regarding renewable energy.

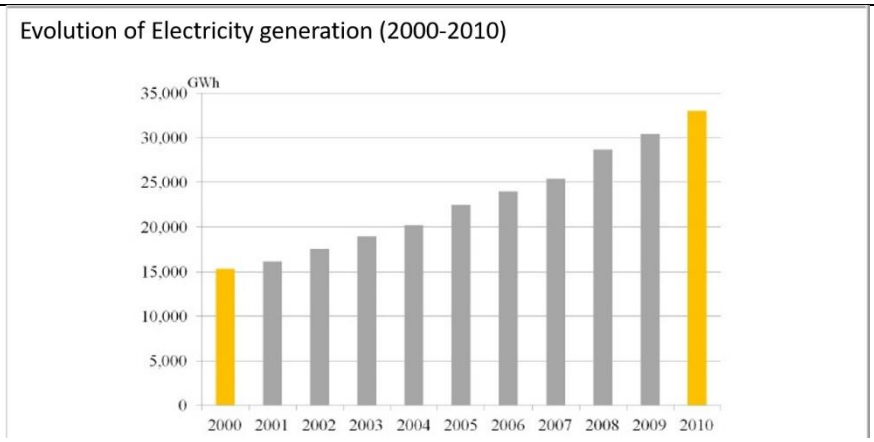

Figure 1.8 Evolution of electricity generation (2000-2010).

Source: General Electricity Company of Libya, (GECOL)

Libya is a member of the RCREEE "Regional Centre for Renewable Energy and Energy Efficiency", which was established in 2008. It is a non-profit regional organization and includes thirteen members of the Arab countries. The RCREEE organization aims to enhance and enable the practices of energy efficiency and adopt renewable energy as an alternative solution of bioenergy, and it is eco-friendly (Missaoui, Hassine, & Mourtada, 2012) and (RCREEE, Annual Report 2012). In a related context, the built environment in Libya is considered a large contributor to increasing the carbon dioxide emissions due to people's extensive use of energy, whereby the per capita of carbon dioxide emissions is about 1.98 tonnes, which is higher than the global average of 1.13 tonnes. Therefore, Libya has approved the Kyoto Protocol in December 2006, and it has established policies and regulations to enhance global warming prevention to meet the country's obligations towards the environment (GECOL, Online accessed 1/06/2022).

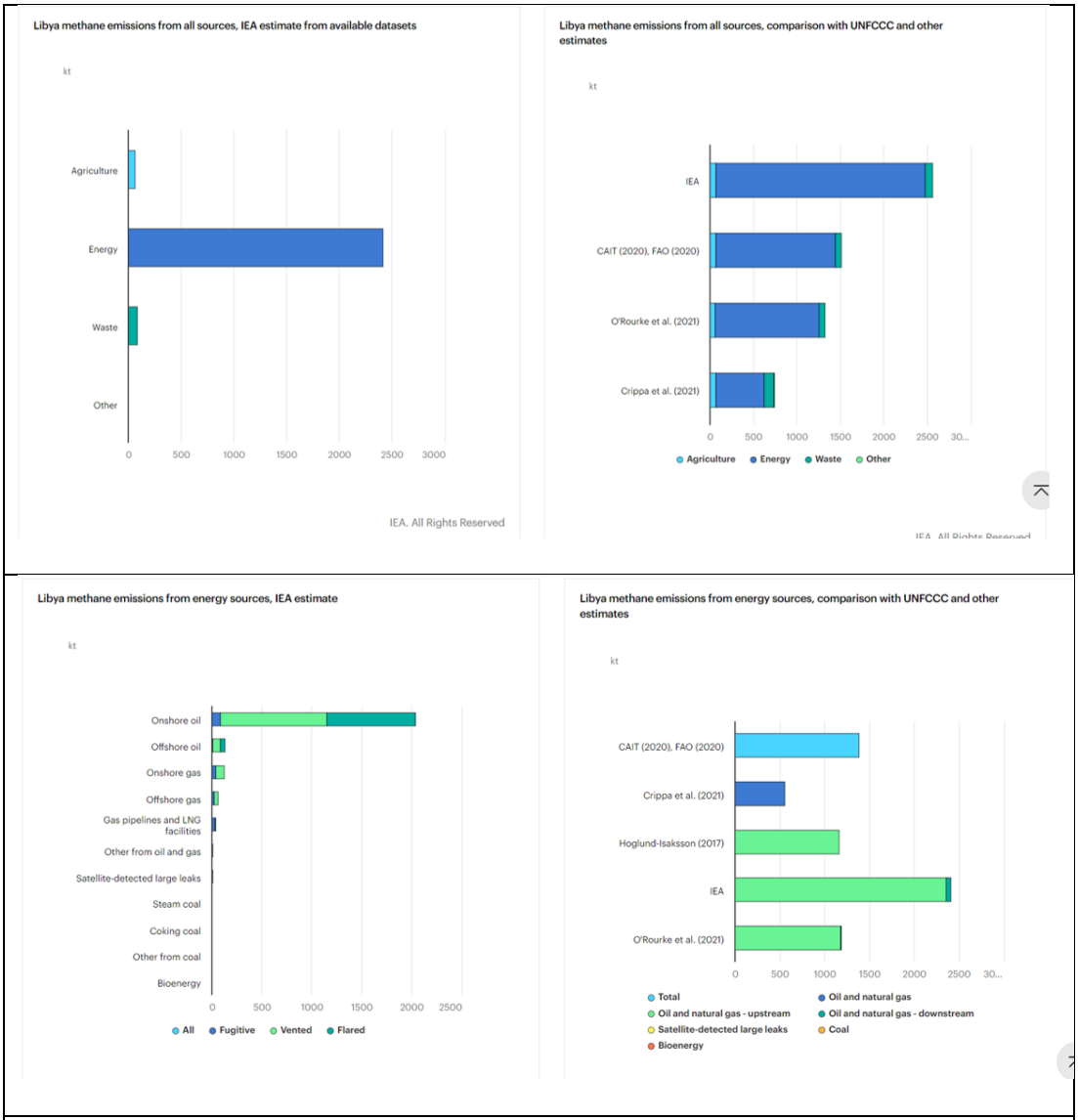

Figure 1.9 CO^2 emissions in Libya, Source: (IEA, 2022)

1.2.3 Housing Background

The international housing journals have concentrated the most on Australia, Europe, and North America regarding previous experiences (Barwick, 2016; Mallett, 2004). They have almost entirely neglected Arab housing and its affiliations (Cieraad, 2018). Also, it is stated in the feminist literature (McCarthy, 2018; Munro & Madigan, 1993) that, despite the arguments tending to assume the relevant concepts, they emphasized the concept of privacy, in particular, as it is universal. On the other hand, El Guindi (1999) has argued that the English language has failed to interpret the term

‘privacy’ and clarify the differences of the space’s usage in terms of privacy in the Arab World.

Hassan (1976) vision, like other later critics, is based on maintaining Arab cities and their architectural identity, emphasizing the rejection of westernization and the tendency towards modernity and change. Although westernization and modernization are distinct, they both originated in North America and Europe as practices of modernization, which is easily conflated with westernization trends. Therefore, the dominance of colonial powers in the Arab World, such as Britain, France, and Italy along different historical periods left significant influences on the people, their behaviors, and culture, in addition to several landmarks on the ground. Furthermore, the unity of the economic world system and the market depend on globalization as the main factor of change, in addition to embracing westernization (Elmansuri & Goodchild, 2019; Kiet, 2011).

1.2.4 Development of House Designs in Libya

Due to its strategic location, Libya had been conquered by different occupations, along with its history for more than 2500 years. At an earlier time, it was occupied by the Phoenicians, Carthaginians, Romans, Vandals, Greeks, Byzantines, Arabs, and Turks. Most recently, the British - French administration and Italians have ruled the country completely or partially, as cited by A. A. Amer (2007). Housing development in Libya has witnessed many changes to the houses in terms of design, form, construction method, and materials. The way in, which, these settlements have developed depends on the strategic importance of their ethnic origin and historical background, in addition to the colonial influence on the Libyan house development. The settlements are mostly concentrated along the coastal strip. There are only a few

inhabited pockets in the mountainous areas and a handful of scattered outcrops in desert areas (Fortea, 1989).

Basically, there are three types of houses in Libya for the traditional houses, with each type representing different climatic districts. The traditional courtyard house can be mostly found in the coastal area, and Tripoli's old city is the best example of the traditional courtyard houses. As for the mountain district, it is recognized by the underground houses, especially in Gherian and the surrounding mountainous area. Next, Ghadames compact city represents the desert region (Elwefati, 2007). Most of these cities still exist and are listed as UNESCO heritage sites. However, the courtyard house is the most common and spread across the country that it can be found among the neighborhoods of the inhabitants. Therefore, the study intends to undertake the traditional courtyard house as the case study beside the modern house in contrast. Furthermore, the targeted area that represented the courtyard house is the most concentrated of the population as it located in the west coastal region of Libya.

The colonial city was developed outside the old city and divided into three urban zones, including 1) new residential areas, 2) new central business districts, and 3) new industrial areas. The urban fabric in the colonial city is categorized by the systematic planning of wide straight streets and multi-story buildings, where the streets connect and lead to the main square. Moreover, the city has been attached with railways to connect it with other parts of the country. The city is more systematic and has high architectural and planning values, such as open spaces and arcades (A. A. Amer, 2007; Sufeljen, 2014).

Contemporary house development was introduced by the colonials and its flourish was increased with the discovery of oil; then, it was followed by the new authority in 1969, which is known as the AL Fateh revolution, which was led by

Muammar Alghdafi, who ruled the country till his stepdown in 2011, with what was known as the 17 February revolution at that time. The new government in 1969 had established many development programs, including the housing sector, to continue the country's development, which had begun after the discovery of oil, and improved the residents' living conditions. Thus, too many foreign companies flocked to the country to contribute to its construction and development. Other than new planning and designs, not to mention the construction methods, good quality of modern building technology in terms of building forms, spaces, and floors. However, this new technology of building construction has not considered the spatial environment and cultural requirements (Emhemed, 2005; Fortea, 1989). Unlike the courtyard house, which was inward-looking, the modern house design is entirely outward-looking, which causes social problems. The residents used to live in a courtyard house, which allowed them to use natural ventilation and daylight, and they enjoyed safety from outsiders; but in the new house, the situation switched the other way round. As mentioned before, the new house is outward-looking, which is not preferable by the residents, and the house owner must compensate for the natural ventilation and daylighting by using artificial methods (Aisha A Almansuri, Curwell, & Dowdle, 2010; Gabril, 2014).

At the present time, the housing in Libya is mostly constructed by mix developers which are public and private developers. However, the housing that built by private developer is more than the one that built by the public developer especially in recent years that followed the civil war in 2011 which most of public housing projects has been stopped due to the instability of the situation. In general, the housing consists of several types either single or double storey and high-rise apartments. Also, the housing positions are on many styles such as detached, semi-detached, and terraced

houses. Moreover, the houses that built by private developers spread over the country which is hardly to quantify it enumerate. In addition, houses takes their sizes and forms depends on the house's owner preferences (A. M. Ali, 2019).

1.2.5 Passive Design Strategy in House Development

The concept of a passive house provides indoor comfort with low-energy consumption. In Germany, the first passive house was built in 1991 as a research project to lessen the total energy demand of housing by improving the building performance, such as airtightness, ventilation, insulation, avoidance of thermal bridges, heat recovery, high-quality windows, as well as a domestic hot water system (DHW), lighting, appliances and auxiliary electricity (Schnieders, Feist, & Rongen, 2015).

In a passive house, the building needs to consume less than 80% to 90% of the heating energy needed in a conventional building with additional building costs of 5 to 10% to improve the building performance. The passive house design depends on the microclimate condition, then the orientation and shape of the building layout, and the shading situation. Also, the main factor of the passive house is the lower thermal flows through and within the building envelope. Moreover, it should benefit from passive solar gains, especially in sunny regions (Mihai, Tanasiev, Dinca, Badea, & Vidu, 2017; Schnieders et al., 2015).

In Abu Dhabi, a passive house for a single-family has been introduced. The house is inward-looking towards the private courtyard and no windows are overlooking directly outside. The bedrooms are located on the basement floor underground to reduce exterior loads. The courtyard is shaded with good insulation, which can be a sliding and translucent membrane. The house utilizes triple layers of solar protective glazing and cool colors to lower the daily average cooling load to 10

W/m^2, with a total resulting annual cooling demand of 32 kW h/ m^2 (Schnieders et al., 2015).

Plans and programs, which are expected to reduce carbon dioxide emissions and increase the efficiency of building performance, have become a significant concern worldwide. For example, some states in the US had targeted net-zero-energy performance in residential buildings by 2020, whereas in commercial buildings, it is projected by 2030. Japan plans to implement a zero-energy building by 2030. The Energy Performance in Buildings Directive (EPBD) was issued by the European Commission and required public sector buildings to be nearly zero-energy by the end of 2018, requiring all new buildings to meet this target by the end of 2020 (Andaloro, Salomone, Ioppolo, & Andaloro, 2010; Annunziata, Frey, & Rizzi, 2013). According to the *Passivhaus* Designer's Manual, which is the most comprehensive technical guide, it suggests providing the simplicity in the concept to be closer towards zero (fossil) energy standards. The *Passivhaus* Designer's Manual can provide adequate guidance for all those who wish to design and build *Passivhaus* and zero energy buildings, such as architects, engineers, and construction professionals (Hopfe & McLeod, 2015). The manual also provides:

- The latest guidance for anyone who is designing or working on a *Passivhaus* project.
- In-depth information on building services that could increase performance ventilation systems and provide ultralow energy cooling and heating systems.
- Comprehensive design guidelines that include thermal comfort, daylight design, indoor air quality, and economic environmental materials.
- Workable advice on the procurement methods, project management, and assuring the quality, as well as detailed work examples for references.

- Providing renewable energy systems, which increase the efficiency of *Passivhaus* and zero energy buildings.
- Practical case studies from several advanced countries, such as the USA, the UK, and Germany.
- Expert counseling of architects, engineers, and building physicists from 20 world-renowned *Passivhaus* designers.

Deng, Wang, and Dai (2014) proposed an integration system, which is involved with three types of energy-efficient measures: passive design, power generation from renewable energy sources, and a service system. First, the passive design strategy includes areas like orientation, geometric/ratios, and building envelope. Second, power generation includes renewable energy production, e.g., wind turbine, PV panel, fuel cells, hydroelectric power, combined heat and/or cooling, and power. Third, it includes energy efficiency technologies, e.g., appliances and equipment, lighting, hot water, and HVAC. Also, it is advised that there will be more investigation and evaluation for architecture, energy remains, and comfort.

Additionally, Zero Energy Buildings (ZEBs) has effectively adopted several factors to ensure high building performance, which has integrated ZEBs with both a passive and active technology PV system, solar thermal system, heat pump, and envelope insulation. These are the most popular and can be utilized with other passive techniques, such as natural ventilation, daylighting, shading, and high-efficiency appliances, e.g., heating, ventilation, and air conditioning (HVAC) (Yu, Gou, Qian, Fu, & Tao, 2019).

1.3 Study Area Background

Libya stretches on the Mediterranean Sea in North Africa between eastern longitude 9-25 and northern latitude 18-33 and it covers an area of about 175,954 square kilometers. It has the longest coastline in Africa, up to more than 1770 linear kilometers on the north coast makes it the fourth largest country in Africa and the 15th largest in the world in terms of land area. It also shares borders with Tunisia from the north-western and Algeria from the west. From the south, it shares the borders with Niger and Chad, Sudan from the southeast, and Egypt from the east of Libya. The desert covers most of the area, reaching approximately 90% of the total area. Thus, most of the population is concentrated on the narrow coastline and there are some sparse settlements in the outskirts of the country (L. C. Brown, Fowler, . Gary L. , Barbour, . Nevill , Cordell, . Dennis D. and Buru, . Mukhtar Mustafa, Accessed, 2021), (CIA, Accessed 2020).

Figure 1.10 Map of Libya.
Source: (L. C. Brown, Fowler, . Gary L. , Barbour, . Nevill , Cordell, . Dennis D. and Buru, . Mukhtar Mustafa, Accessed, 2021)

Throughout the long history of Libya, this strategic location has made the country a significant linkage center between Europe through the Mediterranean Sea towards Africa across the Sahara Desert, which connects the Arab countries of North Africa and the Maghreb countries with those of the Middle East (A. Amer, 2007; Emhemed, 2005). Most of the prominent natural features are the length of the Mediterranean coast in the north of the country. To the south, the spacious desert is barren, but it is characterized by some mountainous highlands, such as Tibesti Massif, which rise to 2200 meters, in the heart of the desert near the Chadian border (Daza, 1982).

1.3.1 Population Size

Libya is considered a large country in terms of area, but small in population. The population is not distributed equally over the country, because of the vast area of the country. Also, the factors of topography and climate differ greatly. Natural sources and food, as well as trading all, have a major influence on the population distribution, which helps in creating various characteristics of culture and people's lifestyles in each part of the country. The population is concentrated along the Mediterranean Sea, from the west to the east, especially in the west of the country, including the capital Tripoli and its neighboring cities. Additionally, there are some settlements to the south of the country and its outskirts, such as the mountainous areas and the edge of the desert (Daza, 1982), (Statistics, Accessed 2020).

Table 1.1 Distribution and percentage of Libyan population and percentage of Gender in Census of ,1984- 1995 – 2006

Census year	Distribution for the Libyan population			Percentage of the Libyan population			Percentage of gender
	Male	Female	Total	Male	Female	Total	
1984	1651562	1579497	3231059	51.12	48.88	100.00	104.6
1995	2231079	2158660	4389739	50.82	49.18	100.00	103.4
2006	2687315	2610639	5298152	50.73	49.27	100.00	102.9

Source: - Bureau of Statistics and Census, Libya. (Statistics, Accessed 2020)

The population census was recorded for the first time in 1931 by the Italian colonial government when it was conquering Libya, at that time, the country's population was estimated at 704,000. After the independence of the country in 1951, the Libyan government had made the first population census in 1954 with the help of the United Nations, the population amounted to 1,088,873 (A. Amer, 2007; Daza, 1982). According to the Bureau of Statistics and Census (2013), the population census in 1984 recorded 3231059 with a growth rate of 4.48 between censuses of 1973 and 1984. Thus, it was recorded in 1995 after ten years from the previous census of 4389739. Therefore, between censuses of 1984 and 1995, the growth rate was 2.52. However, in 2006, it recorded 5298152. Accordingly, the growth rate recorded 1.56 (Statistics, Accessed 2020), (GIA, Accessed 2020).

Table 1.2 The total number of the population during (1984-2014) per (1000)

Year	1984	1995	2006	2012	2013	2014
Total	3231.1	4389.7	5298.1	5878.1	6001.1	6103.1

Source: - Bureau of Statistics and Census, Libya (Statistics, Accessed 2020)

Based on the decision of the Minister of Planning 30/2012 on permitting the bureau of Statistics and Census to conduct the national population survey that was in the wake of the events of 17 February and the subsequent wars in Libya to provide data about the Libyan and non-Libyan inhabitants according to their demographic distribution and determine the numbers of deaths, missing persons, and displaced persons. Therefore, the estimated results of the population in 2012 was 5878.1/1000. The instability of the political situation in the country and the civil wars resulted in an internal and external displacement of many people. Thus, the collected data might be inaccurate. In 2013, the population was estimated at 6001.1/1000, while in 2014, the population was 6103.1/1000. Table 3.4 illustrates the variation in the population between (1984 and 2014) (GIA, Accessed 2020).

Table 1.3 Distribution of the population by region (Some largest cities and the importance of their location)

Region	Total number of Libyan/non-Libyan households			
	Average size of households	Number of individuals	Number of families	Number of households
Tripoli	4.97	940653	197682	189301
Benghazi	5.33	562067	112487	105381
Misrata	5.67	502613	93275	88711
Almergeb	5.48	448260	86413	81862
Zwara	4.92	292440	61088	59445
Aljaber algarbi	5.21	307616	61448	59017
Zawia	5.12	300894	60199	58761
Aljabel alakder	5.49	209978	42085	38276
Derna	5.26	164440	33644	31268
Ejdabia	5.94	130335	24295	21942
Sebha	5.88	116016	20738	19725
Sirt	6.09	117473	20970	19286

The national survey of population 2012
Source: - Bureau of Statistics and Census, Libya (Statistics, Accessed 2020)

According to the national survey in 2012, the population is concentrated in the northwest of the western region of Libya. Tripoli is the largest city, which is the capital of the country. It has a strategic location; it overlooks the north of the Mediterranean

Sea and represents an important hub for social and economic activities. Also, it represents an important link between Europe and Africa, as well as trading exchange, land, sea, and air transport. Other cities are surrounding the capital or along the Mediterranean Sea. To the east and south of the country, other Libyan cities have a social and economic dimension, such as Benghazi and its neighboring in the east, which is the second city after the capital in terms of its strategic importance. In the south, lies Sebha and its environs in the heart of the vast desert, which is the third important city in Libya. This city has its own cultural and social character as it comprises various races and cultures (Statistics, Accessed 2020).

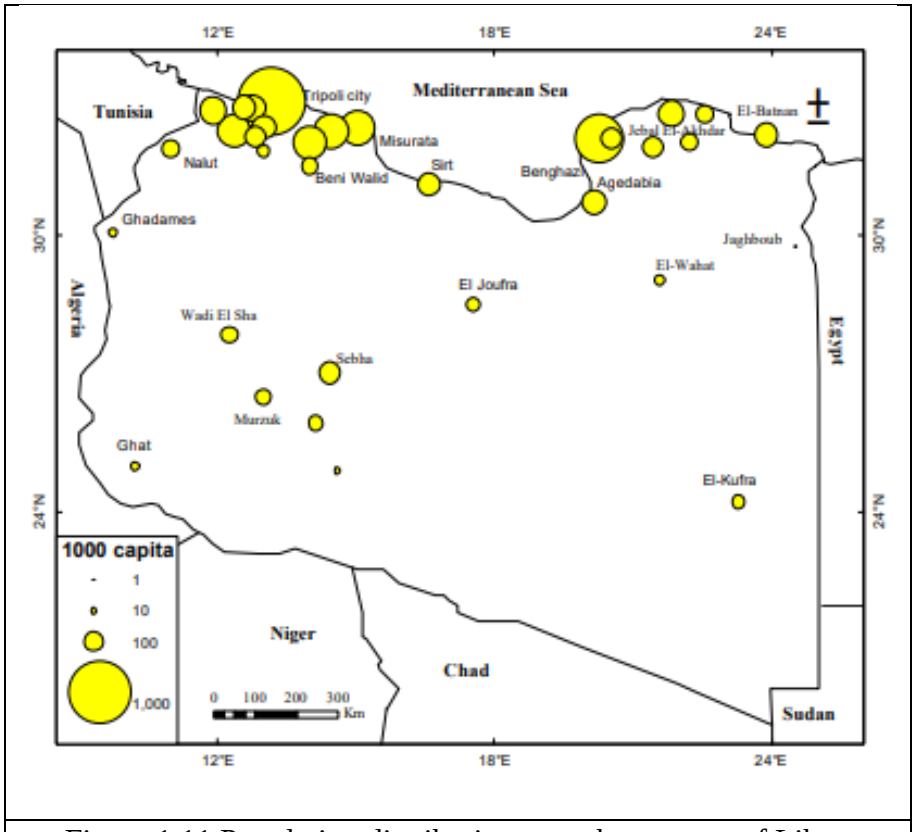

Figure 1.11 Population distribution over the country of Libya

Source: General Information Authority of Libya (GIA, Accessed 2020)

1.3.2 An Overview on Demography, Socio-culture, and Climate

Throughout different ages and times, Libya was subject to long periods of colonialism by many foreign countries. It was conquered by Phoenicians,

Carthaginians, Greeks, Romans, Vandals, and Byzantines and ruled parts of the country during different periods in history. Libya was also ruled by the Ottoman Turks from the 16th century until the conquering of Italy in 1911. Then, from 1943 to 1951, in the last period of colonialism, it was under a mixed ruling of France, Britain, and Italy, each of these countries was controlling some parts of the country until it gained its independence through the United Nations in December 1951. Based on the above outline, Libya has been invaded by different ethnicities and nationalities. Thus, many of them have very well merged with local people either by mating or by settlement and migration (Libya, April 2005).

1.3.2(a) Demographic Fabric

Libya's demography consists of several ethnic groups. These people have migrated to Libya due to multiple circumstances, and they succeeded in acquiring the Arab character. However, along with the Arab tribes, some minorities descend from other races. Some of them merged with the Arab tribes, such as Kuloglih (Karglih), Circassian, and others, which originated from the Turkish Ottoman era. Also, other ethnic groups are still maintaining their inherent identities, such as the Amazigh (Berber) in some areas of the far west of Libya, the western mountain, and the southern area of the country. These people have a strong bond with the Amazigh tribes in Algeria. The tribes of Tabu and Touaregs in the south of Libya also have a strong connection with the tribes in Algeria, Niger, and Chad (Tillisi, 1991).

1.3.2(b) Cultural Characteristics

Although there are some other ethnic minorities, Libya is characterized by Arabic patterns, generally. Due to the natural extension of the population, most of the border tribes have an extension in the neighboring countries, acquiring their own identity and social culture. Also, Islam is the religion of the country. Most of the people are Sunni

Muslims. The Islamic religion and the very conservative Arab origins exerted a great influence on the Libyan people and a clear impact on their culture and influenced its society. Based on that, the Islamic pattern and social privacy have high influences on architectural design. Therefore, the housing design considers social privacy and meets daily life requirements. However, recently, the new houses were designed to be like western houses and were far from the Libyan cultural influences. Due to urban development and modern technology, not to mention globalization that greatly influenced the design of houses. As a result, the Libyan people have modified these western houses to keep pace with current development and preserve cultural identity (Tillisi, 1991). Some of the basic points that are taken into high consideration in housing design in terms of social privacy are summarized as follows (Elmansuri & Goodchild, 2019; Sharif, Zain, & Surat, 2010):

- The separation between males and females, especially for the guest's reception. Mostly, there are two separate rooms for the guests, one for men and another for women. Usually, a reception room of men is opening directly outside or opens into the lobby of the main house entrance, which is considered a public space in the house. Meanwhile, the women's reception room opens inside the house provided that be nearer to the lobby.
- The division of internal spaces, the special status of prestige for adults in the house to preserve the privacy of the head of the family and keep respect between children and parents as well as the separation of boys from girls inside the house.
- Providing enough space for daily activities and housework. So that it cannot be viewed by strangers.

- Mainly, the house is built up with a back or sided service door to connect the house to the backyard so that the occupants of the house can practice their normal activities.
- The kitchen is usually placed at end of the house and close to the back-service door. So that it can serve the whole parts of the house, such as family members and catering to guests. Also, the wife can prepare food and do housework without any inconvenience from strangers.
- Safety and security are the most important aspects in these houses for the occupants in terms of house assault or theft.

1.3.2(c) Climatic Factor

The climate in Libya is relatively mild in spring and fall, while in summer is hot; in winter, however, it is relatively cold. Also, it is a varied climate dominated by the Mediterranean and semi-desert in the northeast. Desert climate in the south, cold winter, and hot summers, as well as rare rainfall. Nevertheless, the Green Mountain (Aljabel Al-akhder) is different; in summer, the temperature does not exceed 30°C and, in winter, it sometimes reaches freezing temperatures, resulting in the fall of snow in some cities. The desert climate is hot in summer in most of the country, except for a narrow strip extending along the Mediterranean Sea, where the most important cities are located. Some mountain areas are located in the north or south of the country. The rainfall is nearly enough to grow natural plant life. Also, it is varying in intensity and importance for life plant and humans by rain quantity. These areas are enough for the rain to grow forests and evergreen grasslands like those that grow in the Mediterranean climate (Ben-Mahmoud, 1993).