Building Sustainable Buildings in Jeddah

نحو بناء مباني مستدامة في مدينة جدة

by

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Abstract

The present study is centered on construction of sustainable buildings in Jeddah. The main purpose of the study is to ascertain the relationship between present-day sustainability concerns, their contributing factors and underlying effects in Jeddah in order to find suitable and sustainable solutions for the construction sector in Jeddah.

The study adopted mixed methodology approach, that is, both quantitative and qualitative methods. The survey instrument was a questionnaire targeting the buildings' occupants as they are best suited to understand the state of affairs of the developments. The qualitative study comprised of description of measurements (temperature, carbon dioxide, pollutants and relative humidity) in these buildings.

The results and findings showed that the majority of the buildings' occupants agreed on the poor state of air conditioning and ventilation. Additionally, it was clear that most occupants had experienced a bad odor at certain points around the structures. This was due to factors such as poor ventilation and comparatively high temperatures present in the buildings. Further analysis of the findings and results indicated that there was poor planning in the development of the buildings which deprived occupants' of comfort and sustainability.

It was recommended that the leadership of Jeddah should come up with strategies to ensure proper ventilation of these buildings in order to boost their adherence to sustainability. In addition, such measures will heighten the comfort of the occupants. In conclusion, it is advisable to come up with innovative ways of encouraging better strategies that can ensure the construction of environmentally friendly and sustainable buildings in Jeddah.

الملخص

تركز هذه الدراسة على تشييد المباني المستدامة في جدة. كما ان الغرض الرئيسي من هذه الدراسة هو التأكد من العلاقة بين الاهتمام بالاستدامة في الوقت الحاضر ، والعوامل المساهمة وآثارها الكامنة في جدة وذلك من أجل إيجاد حلول مناسبة ومستدامة للبناء والتشييد في جدة.

اعتمدت الدراسة على منهجية مختلطة، وهي الأساليب الكمية والنوعية. كانت أداة المسح استبيان يستهدف سكان المباني فهم يستطيعون تحديد ما هو الأنسب لهم و لوضعهم من هذه التطورات. تضمنت الدراسة النوعية تحديد القياسات لكل من (درجة الحرارة، وثاني أكسيد الكربون والملوثات والرطوبة النسبية) في هذه المباني.

أظهرت النتائج أن غالبية سكان المباني اتفقت على سوء حالة التكييف والتهوية. بالإضافة إلى ذلك، كان واضحا أن معظم السكان قد لاحظت رائحة سيئة في بعض النقاط حول المباني. ويعود السبب في ذلك إلى عوامل مثل سوء التهوية ودرجات الحرارة المرتفعة نسبيا في المباني. أشارت تحليلات أخرى من الاستنتاجات والنتائج أن هناك سوء تخطيط في تطوير المباني التي حرمت سكان المباني من الراحة والاستدامة.

يجب على الجهات المختصه في جدة أن تضع استراتيجيات لضمان التهوية السليمة لهذه المباني من أجل تعزيز الاستدامة، بالإضافة إلى ذلك فإن هذه الاسترلتيجيات ستزيد من راحة السكان. في الختام، فإنه من المستحسن أن تتوصل الجهات المختصة إلى طرق مبتكرة لتطبيق استراتيجيات أفضل يمكن أن تضمن تشييد المباني الصديقة للبيئة والمستدامة

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Chapter One: The Study

1.1 Introduction

The Gulf region has witnessed a diversity of changes during the last few decades. The capital obtained from oil markets provided a tool to promote development in all aspects of life in addition to the building industry. What used to be known as small desert countries with limited resources turned into desert urban developments in most of the Gulf region.

Building has become one of the major occurrences in this area. The KSA cities became models to others in the area. Jeddah has developed through its marketing and has become known on a global level. The Kingdom of Saudi Arabia (KSA) lies at the centre of a region which is undergoing constant changes. Over the past three decades, the KSA underwent tremendous development as a financial center, a commercial center, a technological breakthrough as well as economic innovation. These developments have risen the GDP to an impressive level. ("Import figures of Saudi Arabia". (CIA World Fact book.2014.).

However, the government of Jeddah is being more cautious in its steps toward development. The observer can easily figure that this caution relates to the determination to pursue excellence in urban development. In an attempt not to make any regrettable mistakes in urban design, in addition to full state commitment to sustainability in all possible aspects and applications, the government of Jeddah engaged in extensive research and studies before taking any decisions that would affect the future of the city.

The current study decided to use Saudi Arabia, Jeda City to plainly clarify the existing lin among. these two sustainable building and environmental design. A demographic study

conducted by Al-Hathloul and Mughal (2013) in regard to Saudi Arabia's demographic shift revealed that,this country has experienced a remarkable change .

Over the last thirty years, cities like Jeddah have seen significant fast growth. Just recently Jeddah was marked by walls but of recently it has now transformedinto a large city that has skyscapperscontending for the heavens. This growth was accompanied by housing activity in all areas of the city.

1.2 Background to the study

1.2.1 Urban identity

Rapid changes in the Kingdom of Saudi Arabia, which have taken place after the discovery of oil in a commercial quantity and the country's opening up to the western world, have made it hard to determine priorities for its people. The speed with which development has occurred and the hasty introduction of advanced technology experienced in the 1970s, in every field, including construction, planning, industry, education, etc., have affected all aspects of living in the country. Among those aspects which suffer most is the traditional environment. The attraction of the western way of life and the western concept of development have drawn Saudi attention far away from developing a clear understanding of their traditional residential environment, and of the value of its continuity(Aljoufieet.al, 2012a).

Cultural identity has a very high importance in Jeddah city and it has to be closely considered in the design of buildings. The researcher believes that an in-depth examination of the cultural values upheld in Jeddah together with building sustainable designs can transform Jeddah

into an ideal city in the modern world. The government of Jeddah dedicated huge financial allocations to initiate sustainable pioneer projects in order to establish standards for the KSA, the region and global citiesof similar environment (Aljoufie et.al, 2012a).

1.2.2 Urban facilities

Over the last three or three decades the speed of the city's growth has been truly spectacular. Advanced technology and the influx of people from different professions and cultures, a direct result of the huge increase of oil revenues of the country, have affected the urban and social conditions of the city. Also, with the introduction of automobiles, new building techniques and materials, the whole urban fabric of the city has been changed. A completely new form of housing has emerged and new physical communication networks have become necessary to accommodate the new mechanical means of transportation.

1.3 Environmental Sustainability Objective

Environmental sustainability problems are not evident at present, but the present situation which is not incorporating sustainability factors into city planning and building designs may pose real problems very soon due to the tremendous deficit in resources and pollution problems, which needs an urgent attendance immediately. (Municipality of Jeddah, 2014).

Decisions taken formerly, like replacing primary and secondary schools in certain areas with no roads connecting residents to their schools or previous planning to locate the routes near schools and vital facilities for the residents. These trips, if eliminated, would give rise to many advantages, such as less reducing the volume of traffic, reducing the amount of emitted CO2, reducing the amount of consumed energy, keeping buses in a good conditions for a longer time,

keeping the atmosphere cleaner, and giving chance to children to exercise when they walk to school and back every day. .

Additionally, global warming has emerged as a serious problem lately as a result of polluting emissions. Human activities on the environment in the name of civilization has for the recent passed impacted negatively on the planet causing negative effects on the sustainability of the global system(Aljoufie et.al, 2012a). These problems have affected water, land and air, and have disrupted the ecological system of the area.This study found it necessary to conduct thorough studyconcerning the entire topic of ecological degradation .

1.4 Research problems

It is very important to change the current techniques and designs in building in Jeddah in order to produce sustainable buildings which do not consume much energy, allow for good ventilation, locate streets in a way to avoid traffic jams, link important facilities to the residential areas with view to maintain the environment in a good condition.

To this end, the government has implemented a number of ambitious programs to build sustainable and encourage the private sector to build sustainably in order to maintain the environment in a good state for future generations. (Sustainable Buildings Task Group, 2013).

Despite that, designers are still using few techniques and incorporating few factors to achieve sustainability although they are fully aware of the problems and their solutions.Freshfindings regarding to construction of sustainable buildings reveals that few buildings in Saudi Arabia may be considered sustainable in terms of design, construction and functionality. This has made researchers to ask why is the situation like that despite the strong drive and call for designers and developers to uphold sustainable factors in their activities?

Ugwu et al., (2006) explains that there is a gap between aspirations and achievements. While policy-makers are calling for applying a wide scale of sustainability on a national level, the actual performance lag far behind the defined goals and scale of sustainability. In contrast, the national strategy is the one that needs to be actualized by implementing a comprehensive approach. Despite the much focus on implementing the objectives of the national sustainability strategy in each specific project, the extent to which this is translated into action is very low. The least thing that developers can do is selecting sustainable building material which is an easy task and easily attainable. (Godfaurdet al., 2005).

The revolution induced by the invention of farming and animal domestication in the Neolithic Age has been considered as the first revolution which affected the way people live in settled communities. Mankind has gone through a series of changes of city development. However, the invention of expanded cities accompanied with urban living in suburbs originated in the Industrial Revolution period. Starting from the Renaissance (14th to 17th centuries), Europeans started to introduce sophisticated machinery especially in transportation, such as ships. Communications were made easy by the improvement of printing techniques. This fact served the Industrial Revolution as it facilitated the exchange of ideas and mechanisms. Britain was the first to make the change on a global level, however, Germany and America followed and expanded the Industrial Revolution. Industrial facilities are seriously in cities as shown in Figure 1.

Figure 1.1: Carbon emission (Source: Guardian, 2011)

During the 18th century, the Industrial Revolution in Britain started to affect all ways of life, society, economy and the general image of Great Britain. In the next century the Industrial Revolution which swept America and Europe and turned the social life upside down, caused very significant changes in the patterns of living and building designs. This consequently gave the problem of sustainability important dimensions that affect health and safety of living things and the environment as a whole. (ValeandVale, 2013):

First, the need and legitimacy of government interference in building architectural modern cities.Second, the introduction of advanced technology to speed up production in large quantities.Third, the effect of mass production on fuel consumption, harmful emissions and destruction of the environment.

- Industry, railways, and trains have experienced a complete change mainly due to the production of iron, bar iron, and other metals

- Heavy machinery received a great a boost with the invention of iron which was suitable for such designs
- Steam engines and machinery technology were also crucial inventions of this era.
- The production of glass and ceramics changed the design from limited-sized small openings into wider glass windows in buildings.
- Creative ways of organizing business through technical and scientific knowledge were applied to its practices on a large scale.
- The textile industry introduced advancements in British machinery which was sold to many parts of the world.

1.5 Research Questions

This study will elaborately try to answer the following research

1. What are the links between the current sustainability problems and their root causes in Jeddah?
2. What is the local vernacular architecture on the inside environment in Jeddah?
3. What is the most suitable, applicable and sustainable solutions that can be implemented in the building industry in Jeddah?
4. What is the cost-efficiency of sustainable models?

1.6 The purpose of the study

The residential environment of Jeddah has undergone a radical change. Moreover the city's identity has been lost. It has become a copy of a western city in its planning and

architectural features. However, there is a growing tendency on the part of the authorities, professionals and residents to revive the traditional heritage of the built environment.

It seems that this will not be achieved properly, in the residential environment, unless there is a clear understanding of the housing situation of the city, including the nature of the changes that have taken place and the reasons for their occurrence. Moreover, we should not focus our attention only on the older traditional buildings, built before 1947, but also to enquire whether there are any merits in some of the new housing that has emerged in the city.

Consequently, the primary concern of this research is to investigate and analyse the new housing which has emerged, and its development, design concept, spatial organization and their exterior features. It is also hoped that the study will provide a good base for future study,which will be useful for decision makers, and will play a role toward offering a clear understanding onhousing conditions of the city.

There is a strong need for developing the technology of producing energy from renewable sources as the country has a real problem of sustainability due to its urban expansion. It is true that the country is oil producing country and it can cope with any arising problem currently, but there will come a time when environmental problems threaten environmental sustainability. Therefore, it is imperative that the country utilize oil revenues in developing energy from renewable resources while it still can reap income from oil exports.

1.7 Methodology

The methodology adopted for this research is based on both quantitative and qualitative approaches. The quantitative approach involved a case study research approach involving a detailed examination of three buildings contrasting in sustainable design approaches. In studying

the three types, there is measurement of the inside environment, cost-effect energy and sustainability in terms of consumption of polluting elements.

As for qualitative analysis, it involves description of the building, reporting how occupants feel and comparing and contrasting the measurements. Discussion of quantitative method and interpreting the measurement relies basically on describing facts using descriptive words that denote the state of affairs of the research subjects. So, quantitative and qualitative analyses are integrated to come out with a clear picture of the research methods, its outcomes, interpretation of outcomes and recommendations.

The study relied on measuring power consumption, CO2 emissions, inside and outside temperature, inside and outside relative humidity, and levels of inside CO2. Monitors were installed in the three prototype buildings for a period of time, and the results of the readings were compared and analyzed. The monitoring included the thermal performance, power consumption and CO2 inside levels.

The study also covered the sustainable applications used within the vernacular architecture of the Gulf region. It also covered the urban history of Jeddah and the current governmental initiatives toward shifting the growth in an environmental sustainable direction. The field study includes monitoring three prototypes to investigate the financial and environmental cost of each prototype.

1-Case Study One : Traditional building

.2 Case Study Two : Al Bayt Al Shabi

3 Case Study Three :School

The methodology also includes a questionnaire to be undertaken by the occupants of both buildings in order to uncover environmental awareness, passion toward sustainability and the limitations that need to be addressed in order to enhance environmental awareness. The questionnaire isdesigned to investigate occupants' satisfaction, thermal comfort and production levels induced by living in a sustainable building compared to its counterpart of a conventional building insides. The questionnaire shall also investigate the effect of living in a sustainable environment on the environmental awareness of the occupants.

Chapter Two: Literature Review

2.1 Overview

Building sustainability, the solutions about the best ways to implement building of cities, links between the problems and the roots causes of the limitations to develop sustainable cities, as well as the inside environment and cost-efficiency of sustainable models have attracted many studies. The literature review development in the current study offers insights, controversies, theories, and debates surrounding constructing sustainable building. It is from the literature review of the chosen works of literature and according to the research questions that I made an

analysis of extended scholarly works about sustainable buildings in Jeddah. Accordingly, the work evaluated the reality of the identified research questions. Thus, the literature established whether there are links between the current sustainability problems and their root causes in Jeddah, local architecture on the inside environment in Jeddah, most suitable, applicable and sustainable solutions that can be implement in the building industry in Jeddah, and the cost-efficiency of sustainable models.

2.2 Understanding the Concept of Vernacular Architecture

At the onset, we require an understanding of the development of cities and how they follow a particular architecture depending on the beliefs of the locals or the entire social activities. Also, there is the necessity to recognizing how to reflect or reveal the combinations of various aspects related to the local style of building. It is after grasping the basic concept and vernacular architecture that we can understand sustainable building in Jeddah. As such, we have to recognize the aspect of vernacular architecture to have an adequate analysis of Jeddah as the specific study that the research questions wish to establish and verify the sustainability of buildings.

Vernacular architecture can be described as the simplest form where human beings address their needs. In this regard, there is the need to recognize that human beings have awareness of the sustainable and potential positive effect where they follow and apply an interactive framework acting as a guide. Thus, the concept of vernacular architecture is the understanding of sustainable issues regarding the salient features understood by the locals or those interested in construction. According to Halicioglu (2012), local architectural can be described as using locally accumulated designs, lifestyle, prevailing socioeconomic conditions,

materials, and the traditions. Human beings have constructs that show the relationship of various factors such as the economic, material, social, and ecological factors (Lawrence 2006, cited by Halicioglu, 2014).

Consequently, vernacular architecture is about continuity, and this translates into sustainability. In this regard, we can understand that a vernacular settlement is a consideration of sustainable environment and thus the urge to maintain an environment that promotes the current societal culture though there is a room for adjustment. However, evaluating this adjustment and how it has come to be is because of the recent changes. The experienced shifts in the energy cost are one of the trends that have caused a variation and hence embracing the modern culture and forgetting the ingenious architecture.

One of the best ways to understand the vernacular architecture is by gaining appreciating sustainability (Halicioglu, 2012). Vernacular architecture is the use of ingenious techniques to preserve the conditions that the society experience at the current state. In another understanding of vernacular architecture, defined in terms of sustainability, can be realized as a well-thought study to the climate conditions and allowing the region attain another level of exploration but retain most of the characteristics that the society believes are part of the culture or should be left to prevail (Halicioglu, 2012; Naciri, 2012).

There are basic elements that society considers thus the relationship between sustainability and vernacular architecture. As such, the primary feature guiding the society is the idea of continuity. However, we have to appreciate that the traditional knowledge of vernacular architects has not been the only technology that the current society has embraced. Altogether, it has been proven that there are low-tech methods for constructions that perfectly adapt to the

brilliance of the locals, and the reason the vernacular building has been ignored. As a result, there are other prevailing buildings that have given a break to the old development. Looking keenly on the vernacular architecture, Edwards (2012) states that originally, local architecture started being used when man choose to use natural resources close to him. Accordingly, we can understand how human has changed the framework to design buildings to reflect a harmonious relationship between the environment and the sociologic facet present in the community. Currently, there is unsystematic where the society has lost the focus of connectivity (Edwards, 2012).

2.3 Geographical Context and Building Designs

The best approach to understand the sustainable building in Jeddah is to recognize the geographic and the climatic context that Jeddah resides. Jeddah geographic location bases our understanding of the relationship between climate and the design of the buildings. Jeddah forms part of the Saudi Arabia. For the past few years, Saudi Arabia has been experiencing a steady growth, and this means that the region's growth has been attributed to the expansion of different urban settings. Unfortunately, the region has not attained considerable sustainability in some areas calling for serious consideration about the building designs (Kamal, 2014). It is thus interesting that we take we take into account Jeddah as the particular section of Saudi Arabia to help us understand more on the sustainable buildings and the factors that stimulates the decisions on designs of the buildings.

Kamal (2014) asserts that Jeddah the second biggest city in KSA and is situated on the Red Sea's eastern coast. The city has been one of the earliest centers of the diverse populations, and this can be identified from the current population that occupies the territory. Jeddah depicts a climatic

condition with hot-humid effect. Regarding the temperatures, Jeddah records about 38degrees Celsius and a relative humidity that has more than 85 percent. As a result, the region experiences significant heat during the day while there is warm fog experienced at night. Thus, as we base our understanding on the climatic conditions, we can verify the relationship between the climate and the building designs in Jeddah.

Saudi Arabia has a history of traditional architecture as the region evolved as one of the places that had refined building, technology and art (Aina, Al-Naser&Garba, 2013). Jeddah, as well, evolved to be an important part due to its central role as a trading port. Thus, the region had the effect of cross-culturalization. The trading activities with European, Asia, and the Middle-Eastern nations enriched the region with the traces of arts as well as architecture. For instance, the Hajj pilgrims who visited the area introduced a variety of skills and ideas to the locals, who in turn were influenced. Also, there was the introduction of the construction skills from various activities in Egypt. Kamal (2012), gives the examples of Rowshans and the Marshrabiyas as prominent features that came from Egypt and introduced to Jeddah as a result of influence. Kamal gives the following basic equation to show the influence of the Egyptian style on Jeddah traditional architecture.

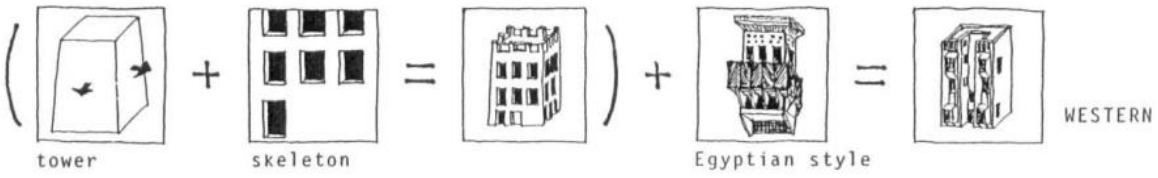


Figure 2: Basic equation that shows the influence of the Egyptian style on Jeddah traditional architecture (source: Kamal, 2012 p.7

2.4 Climate

Of equal importance, it is appealing that we realize how the indigenous architecture of the traditional Jeddah evolved, and the entire building pattern influenced by external factors. However, we have to take into account that climate had the central focus or stood as the chief factor for the whole organization and the construction techniques. As well, the climate had a role in the features and the materials of selection. .Aina, Al-Naser&Garba (2013) observed that to regulate thermal comfort, some of the methods used include natural methods, passive methods and ingenious methods. This technology worked together with Jeddah city's hot and humid climate. Understanding of the passive features can be realized through the explanation of the form of settlement, layout, material, house form, and the construction system (Aina, Al-Naser&Garba, 2013). One of the characteristics that can help us have an in-depth insight of Jeddah old settlement is Al Balad (Arif Kamal, 2012).

Adding to the climate factor is the house form. House form entails the consideration of the elements such as privacy, segregation between the males and the females, as well as the response to humid climate as shown in figure 2 below. These factors played a critical role in influencing the design and the structures that the people build or house to live. Traditional Jeddah architecture had plan forms with variations based on the stylistic character. For instance, there were multiple units resembling a palace, and this was associated with the rich people. The following figure 2 shows the plan of one of the designs. The plan has the Ground Floor Plan, Elevation, and a Section of a typical traditional house in Jeddah. The first part is the Ground Floor Plan, the second is the Elevation, and the third to the far end to the right is the typical house.

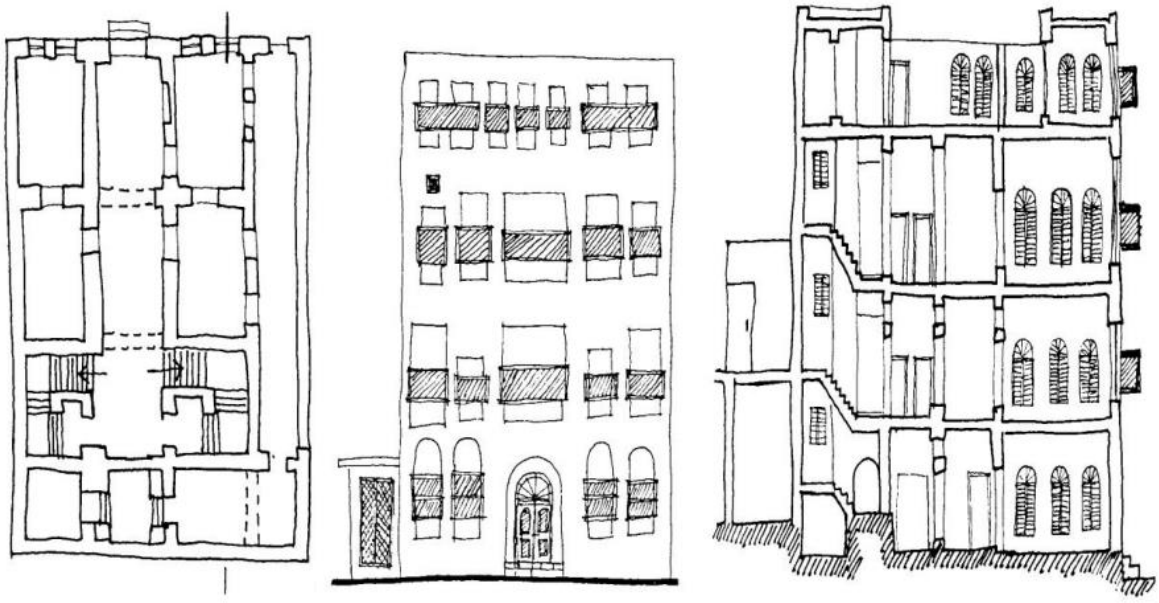


Figure 3:The Ground Floor Plan, Elevation, and a Section of a traditional typical house in Jeddah (Source Kamal, 2012 p.10)

2.5 Jeddah Historical Building

One of the guiding research questions is to establish the links between the current sustainability problems and their root causes in Jeddah, and this can be understood when we have the analysis of development of Jeddah historical building. Jeddah City has a similar long history resembling the historical development of the entire Saudi Arabia. The City had many structures built a long time ago. The interesting fact of these structures is that they exhibit the unique culture and that the city was remarkable as well. Jeddah began as a fishing settlement that later gained significance as the center of two holy cities. In this manner, Jeddah was the port of the Makkah and Madinah cities (Al Mazloum, 2012). The original setting of this city was that it had an area of 1.5 square kilometers, but today the town has grown to be a historic setting that extends to the Arabian Peninsula. At around 1838, the Portuguese had taken their trade activities

in Jeddah. In 1947, Jeddah had not expanded and had the area of 1.5 square kilometers, making it a typical town though distinguished by tower houses, coral blocks that had elaborate wooden balconies, as well as mosques surrounded by walls (Al Mazloum, 2012).

In the verge of the tenth century, the city had increased population and hence could be termed as populated. The population had amassed wealth and had increased activities as traders and thus could make fortunes from ever-present trade. Up to this point, the region had not experienced significance changes in terms of the styles used for house building. However, the introduction of increased European activities paved the way for a western-style form of structural design. It is from this experience that Jeddah expanded and is still in the process of growth. According to Al Mazloum (2012), Jeddah has the longest water front or the Cornish in the entire world. However, the existence of the city was not a smooth experience. Jeddah experiences instances where it was demolished. For instance, in the late 1940s there was the demolition of the city walls.

Besides, Jeddah has other fascinating development that can be used to appreciate its historical development and hence identify what links exists between historical development and the sustainable buildings. As mentioned, Jeddah was inhabited more than 3,000 years, and this was due to the factor of strategic location. The region was close to the Red Sea in the western part of the Arabian Peninsula as the discussion on climate earlier stated. The region had connections with the trade routes that attracted other merchants. The climate factor and the trade development formed two of the prominent historic components that exposed Jeddah to the outside world. The historic development is the sense of the prosperity and the extended stability in the region. The then administration was also committed to create a sense of security, and

hence growth became evident. Commerce, banking, and the center of industry were the eventual result growth of the Jeddah city. Of importance, Jeddah provided the population with other facilities such as the health as well as educational services.

Interestingly, there was a change of focus where the suburbs experienced steady growth thus confining development within the premises of the city. As the city experienced growth, there were efforts to preserve the entire Jeddah's heritage. For instance, there were projects that involved the restorations of the older buildings. The source of finance to cater for the restoration initiative came from the Jeddah Municipality as well as individual support from private sector (Herbig, Jäger-Klein, Mayer, Mortada&Styhler-Aydin, 2013). Consequently, there were major boosts to restore the old Jeddah. The authorities had the dedication to preserve and value the heritage of the city.

In the recent past, the restoration and the preservation of the vast resources in terms of information and related materials have taken a positive development. The authority has initiated relevant structures and promoted the historic value of the city's buildings. One of the measures has been integrating the building techniques to build some of the features. The restoration work has elevated the value of the traditional structures. Construction of Jeddah city has also been successful thanks to municipalities regulations. One of the primary challenges that the city has faced in its development that forms an interesting concern in our historic understanding is the situation where the city lost its relationship with the modern city or the harbor. Al Balad became the heart of the modern urban as the ancient city. Despite these challenges, the municipalities renovated the city. However, the challenge of the lack of effective sustenance made some of the development to decay. In addition, we have to note that the city became and has become an

influential feature that allows trade to take place. Looking keen at the traditional architecture, one can identify some of the eye-catching features such as the traditional markets and the street and the historic mosques are some of the already existing history in the current time. Therefore, it is the preservation of these structures that forms part of the historic development the city has to show the relationship its relationship with the various historic development ever witnessed. However, destruction of some structures minimizes an extended understanding of the celebrated progress of the city from the time of its experienced contacts with the outside world to the time that one may perceive the city as independent and being controlled by the municipal authority.

2.5.1 Planning Historical Development

According to Daghistan (1993), it is critical that we recognize that planning and implementation are essential factors in the development of a city. The planners have the responsibility of facilitating necessary procedures that stimulate effectiveutlilization of resources as well as how to execute the projects. The planning function is organized in a way that facilitate a relationship between various agencies as well as other planners involved in influencing and making crucial decisions related to investments. Turing our attention to Jeddah, planning formed a significant function. There were essential linkages with the private sector though the link was not as direct as most of the projects decisions have, especially those under the guidance of the government or related agency. Traditional Jeddah had this effect where the private sector did not get significant or direct link with the policy formulation. The chief reason leading to this scenario of limited association with the private sector was the pressure of work (Daghistan, 1993). Daghistan states that the pressure of work was to keep with the volume of the development

applications. Thus, the critical aspect of the associating with an integrated process failed to understand the importance of planning regarding the involvement of the private parties.

As long as we need to understand the development of a city and its sustainable development, we have to appreciate the implementation process as well as its management. It is a well-known recognition that implementation has the features of mobilizing, managing, controlling, and organizing the resources utilized if the planner has to achieve the set objectives of a given plan. As such, there are implementation issues regarding the approval by the relevant authorities. Jeddah development in the realm of implementation and related processes shows that the authority had strict adherence to their obligation. The Municipalities was the chief interested party that ensured that the disputes about the interpretation as well as the application of the main policies followed a clear and defined provision (Gadou&Quazi 2009). However, there were policies that required no particular group to take action. The Master Plan policies were not defined clearly as there was no group within the City Planning Department that had the responsibility to taking those initiatives regarded as general policies (Gadou&Quazi, 2009). Gadou&Quazi states that it was the obligation of the Municipality to allocate those functions and ensure that the private sector expressed their ability or worked in accordance with the expressions stipulated in the Master Plan.

Gadou&Quazi (2009) continue to assert that "The implementation of the Chronicle Action Area Plan took a very clearly defined structure" (25). The reason that some development had to have a clear and defined arrangement was the degree of prestigious development as the significant element required for the development of the city. For instance, Gadou&Quazi reports that the Mayor had the direct interest in facilitating practical development by supervising.

Another reason that made the entire process to be critical was the requirements in terms of skills, the management design, and the consultations procedures. For these reasons, the whole process was to integrate an arrangement that would ensure that incorporation of the decisive controls. Thus, relatively selected individuals had the responsibility to make decisions relating to the political as well as the administrative developments within the Municipality. The need for efficiency and the idea of overcoming problems on financial and administrative provided that the authority avoided failures on large and complex schemes.

2.5.2 Spatial and the Physical Arrangement

The context ofthis part regards the structure of the city and the population growth. However, it is worth differentiating the concept of geographical context already discussed and the physical structure or boundary. Spatial and physical structure may be related to the geographical setting or area distribution. Therefore, this section discussed physical boundary that defined the city in its historical development. The previous section had the literature about geographical setting with a discussion about the entire region expansion rather than the confinement of the city. It is well known that the city was confined to an area surrounded by the walls. The extent of development and the entire sustainability of the city may be seen as one confined to the walls and then one that achieved expansion after the demolition of the wall. “Up until 1947, Jeddah citystayed as an Arabs traditional city that did not have a population exceeding thirty five thousand. The population lived within the city wall which unmistakablydefined the city parameters” (Daghistan, 1993). Makkah and Madinahcorridors served as a stepping-stone for the city’s development. It was this association with the corridors of the two destinations that made the entire settlement possible.

The development that opened the region is the economic activity and particularly the discovery of the oil as well as it exportation. At the time the city was confined, it served a traditional role as the principal port. The increased level of the imports is an attribute that sustained the growth of the city, and this change has been to date. The removal of the wall led to an explosion of the city's population to about 150,000 in 1961 (Daghistan, 1993). The early 1970s had the population reach half a million, and by the year 1987 its rose over 1,300,000 (Ministry of Municipal and Rural Affairs (1989)cited by Daghistan 1993). The disappearance of the wall led to a considerable boom that resulted in the physical expansion of the city. Jeddah's population has for the last five years rose to about 3.4 million, and become a large city. The city continues to be a gateway to most commercial dealings. As aforementioned, the population has grown due to the fact that the city has been the center of major commercial activities. At that time when the city had not been exposed to the outside world, it was characterized by small organically grown villages surrounding the wall. As a result, the significance of an urban setting was not defined though the area functioned as the place where non-urban population settled.

One of the common developments within the city setting is the spatial challenge caused by the informal settlements or the unplanned settlement (Karimi& Parham, 2012). The characteristic of a developing city has the appearance of multiple socio-economic problems, and this is shown by the inadequate of basic services. The UN-HABITAT defines a slum as settlement within the urban setting whereover half of the total population has insufficientaccommodation as well as lacking the basic services.

The emergent of slums in Jeddah was facilitated by the fact that the migrants from the poor families were looking for places to settle. Also, these populations were searching for cheap

places hence creating the informal settlements. However, the challenging effect of the unplanned areas where one would access the common facilities though there lacks the necessary conditions that would promote affordable living (Berardi, 2013). On the other hand, Jeddah has experienced challenges as a subsequent subdivision of living places leading to increased population densities.

2.6 Sustainable Architecture

One of the ways to understand the literature about sustainable architecture is to appreciate the relation between the concept of sustainability, sustainable architecture, and sustainable development. Accordingly, this understanding bases the foundation to ascertain Saudi Arabia development regarding the housing design and the association between the housing design and the components of social, culture, and economic association. However, there is the need to understand the concept of Architecture and how human beings responds or have been responding to the needs of standard deigns that promotes the need of comfort and shelter (Al-Hassan &Dudek, 2008). Al-Hassan &Dudek (2008) states that architecture is response human beings have regarding the need to have suitable shelter and comfort. As a result, human beings identified and continue to find a sustainable way to design a building that would cater for the social needs as well as the common needs of the shelter.

Architectural development is a form of civilization that has moved to be one of the critical developments integrated in the social and economic aspects. In this manner, individuals have identified architecture as one of the fundamental form of appreciating what the environment offers, and then replicating this with suitable structures that would safeguard the entire composition or the uniqueness that the surrounding offers in terms of natural resources such as land (Al-Hathloul& Mughal, 2004). Accordingly, the entire aspect of architecture and

architectural design is the manifestation of the human ability to organize the aspects of coordinating, executing, and conceptualizing the whole notion of building (Salama 1995 cited by Al-Hassan &Dudek, 2008). Also, ascertaining the development of architecture and the associated elements integrated in the form of deigns and building of notable structures offers the connectivity with the cultural, scientific, social, economic, and technological experiences. Al-Hassan &Dudek (2008), therefore, states that structural design demonstrates the relationship that exists between the aspects of the human lives and the high quality of environment.

2.6.1 Understanding Sustainability and Sustainable Development in Architecture

Regarding sustainability, it refers to the environmental, economic, and the blend of social responsibilities. There has been an increasing concern about the energy and the environmental interests regarding the concept of sustainable architecture. Taleb&Sharples (2011) assert that the main drivers for promoting sustainability are the concern of the health issues as the primary factor related to the ecological effect. In development of sustainable buildings, there is the need to consider the notion of the climate and the responsive aspect of responding to the design. The responsive development thus emphasize the systems as well as the energy sources that has the aims of maintaining the aspect of designing a comfort building that has environmental conditions. For instance, window location has the greater importance as it provides the functions of effective natural light, ventilation, and the comfort cooling (Taleb&Sharples, 2011).

On the viewpoint of historical development and the significant effect of sustainability and the nature of land, human beings have made efforts to identify how to have an effect on the flora and fauna (Robichaud&Anantatmula, 2010). As a result, human beings have identified activities

such as agriculture, urbanization, mining, and forestry among other activities to change the landscape. However, the changes have proved to be catastrophic for the organisms and the human beings. As the human beings have increased their effect on the lands, they have been finding the best as well as efficient ways to promote and support themselves and other organisms. The primary need for the various activities is to utilize the material resources while maintaining the natural environments in the best way possible (Robichaud&Anantatmula, 2010).

Sustainable development, sustainability, and stability have a relationship as they explain the entire concept of sustainable architecture. Environmental crisis resulted in the concept of stability that was the search of a best solution to create sustainable development (Sharifi&Behnoud, 2013). Regarding the concept of stability, it refers to creating a design appropriate for the environment as the population saw the need to have a surrounding that would favor major development in terms of social, economic, politic, or culture.

Accordingly, the relation between these concepts helps us to ascertain the measures of architect as well as the greater understanding of environment design and influences on the environment. Also, appreciating the sustainable development is a way to finding the solutions that guarantees human welfare as well as survival. Architecture reflects the significant form of the prevailing economic activities. Sharifi&Behnoud states that architecture follows the family income, and there is a relationship between the family income and the desire to own or construct an expensive house. The materials to use, furniture, thermal conditions, domestic space, garden, and equipments among other related structures follow the income of individuals. A building, therefore, has the characteristics of the human activities and processes. Also, we need to recognize that increased manufacturing processes have a relationship with ecology. As a result,

one has to take into account the fact that the entire process of constructing and designing structures has the influences on the environment as well as the global ecological system composed of the humans, inorganic, as well as the living organisms (Sharifi&Behnoud, 2013)

2.6.1.1 Environmental Aspect and Suitability

A sustainable urban structure is a relationship between the economic and institutional procedures, the urban structure, and the social livelihood to show a transformation in the existing environmental or socio-economic frameworks (Berardi, 2013). In another understanding, the concept of sustainable buildings is an elaborate arrangement where there is a design developed appropriately and acts as a guide to the particular context. Similarly, GhaffarianHoseini et al. (2013) state that environmental assessment is a critical element in the sense that sustainable buildings should relate to the level of environment. As such, there is the need to consider factors that promote efficiency.

One of the essentials to consider is the performance evaluations of sustainable indicators that would promote would not effect negatively on the environment (Alyami, Rezgui& Kwan, 2013). For instance, the need to reduce the energy level enhances energy efficiency and utilization of those measures that would promote the extent of influence in the residential buildings. In this regard, a majorprocedure about devloping sustainability and heightening the correctness of the corresponding structures. Further, one may understand sustainability as criteria for identifying the challenges and creating a unified structure or theory that can be used as a reference to an interactive as well as an integrative system.

2.6.1.2 Saudi Built Environment and the Oil Industry

The discovery of the oil in some parts of the Kingdom of Saudi Arabia brought a new dimension regarding the building structure as the level of population increased (Al-Jamea, 2014). Oil, as the chief economic factor, constituted the backbone of the rapid urbanization in the region. As a result, this rewarding economic development brought a new image, accommodation requirements, style, and life pattern (Al-Jamea, 2014). The operations that the oil companies brought resulted in significant changes where the traditional setting of the Saudi society as well as its settlements regarding the physical organization has to change. There was a new pressure leading to increased urbanization. A notable development is that the models followed the designs initiated by the oil companies. For instance the Aramco's oil company introduced a program in the 1950's with considerable effect shown in the symbol of the constructed designs such as the detached house or villa (Al-Jamea, 2014). Al-Jamea, (2014) summarized the effects in the following figure.

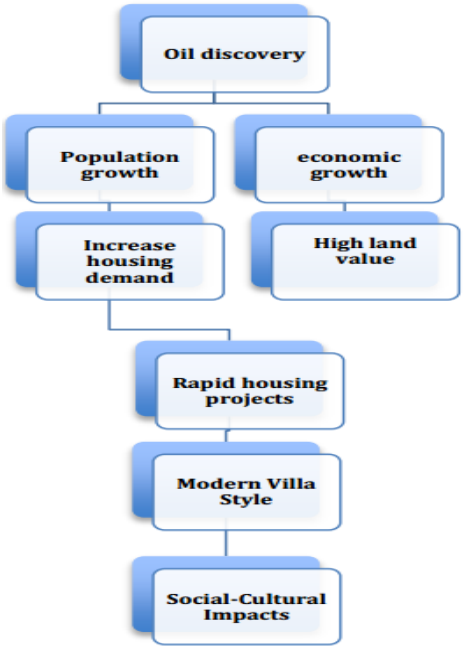


Figure 4:oil industry effects on Saudi built environment

(Source Al-Jamea, 2014 p.39)

2.6.2 Green Design and Sustainable Architecture

Also known as sustainable architecture, Green design and related studies have attracted many studies. The primary reason for increased studies is the urge to build the through an assessment where the performance of the building is developed and appreciated. As a result, many researchers have developed the urge to understand the current theoretical perspectives of sustainable buildings. One of the confirmations that earlier studies affirmed is about the theory of sustainable and more so the green buildings. Thus, prior studies have highlighted the need to

identify and consider sustainable energy performance as well as indicators for evaluation of the green implementations (GhaffarianHoseini et al., 2013). According to GhaffarianHoseini et al. (2013), green implementations contributes to building energy efficiency, material efficiency, and thermal performance as the considered significant parameters of green design. Accordingly, throughout performance assessments, it is vital to take sustainable performance indicators into full consideration. In addition, there is need to appreciate other factors for effectiveness of sustainable buildings on the decreasing use of the energy and adverse effects on the environment. The addition factors include enhanced energy efficiency, passive design techniques application, and the reduced energy demands. Additionally, utilization of appropriate building techniques has influence on the energy distribution for residential building.

According to GhaffarianHoseini et al. (2013), another understanding of green buildings is in the viewpoint of renewable energy. In this regard, one cannot talk about sustainable without talking about approaches made regarding emissions of CO2 due to consumption of energy associated with the development of building construction (Doukas, Patlitzianas, Kagiannas&Psarras, 2006). The primary reason to consider the emission of CO2 is that energy performance has hugeimpact on sustainable development especially on the constructedsurroundings. Green design is intertwined with the energy deliberation, and thus talking about building one has to consider the concept of energy and particularly the emission of CO2. Thus, state that renewable energy sources (i.e. solar, waves, and winds) and sustainable energy sources(i.e. waste to energy) have a significant role when it comes to sustainable developments (GhaffarianHoseini et al. 2013). On the other hand, reviewing the concept of sustainable building in the various studies demonstrates an interconnection between the design of

energy efficiency and the advanced integrated technologies to cut the demand of energy as well as consumption seen in terms of heating, cooling and electricity among other renewable sources of energy. In this regard, the performance of sustainable design is a considerable criterion in view of the sources of renewable energy.

2.6.3 Concept of Cultural and Social Sustainability

Though the understanding of sustainability may be understood to incorporate the aspects of economic, socio-cultural, and environmental, this study has the literature of these components understood from another perspective. As such, I will ascertain the development of sustainability where I have the literature that differentiates these elements of sustainability. Thus, the current study will enhance the recognition of sustainability from the perspective of the fundamental constituents of environmental, economic, and socio-cultural sustainability. One of the critical elements in the development of sustainability is the economic, social and cultural characteristicswith regard to housing or building development. House is a vitalconstituent in the constructed environment and significantly impacts sustainable development. A building embraces the characteristics of social, economic, as well as the cultural aspects (Al-Jamea, 2014). According to Al-Jamea (2014), sustainable development can be understood as an integrative process coupled with holistic quality of life which is ecologically possible.

In another way of understanding, sustainability of settlements characterizes spatial, environmental conditions, geographical location, human development, local values, aspirations, and institutional ability and organization (Reffat 2004 cited by Al-Jamea 2014). Thus,with regard to the sustainable development, the primary concern of housing is living up to the needs

of persons and the whole environment. In this manner, one has to understand that housing is more than the urge to meet the basic needs but it is the ability to meet or improve the internal and external conditions of the given environment (Al-Jamea, 2014). The housing needs of the environment changes over time and the population due to the fact that the population has to have the adaptive capability. Accordingly, the housing adaptability has and continues to conceive the underlying concept of social suitability. In this regard, the designing of the house has to show the elements of sustainability where it meets the users' needs. On the other hand, the user has the responsibility of utilizing the house in the best sustainable manner (Gamboa, 2008 cited by Al-Jamea, 2014). In terms of social sustainability, the building is designed in such a manner that it incorporates the social element component in a manner that considers lowering of risk, enhancing livability as well as family life, and promotes security.

According to Chiu (2004), cultural and social sustainability have substantial overlaps and there is a difficulty to separate the two and hence are considered to go together. However, according to Chiu, there is a need to consider that these two components have considerable differences and areas of concern. Regarding the social component, it may tangible and includes social cohesion, social equity, social inclusion, social conflict, and social equality among other social elements. On the other hand, culture dimensions have the inherent characteristics of major aspects such as the music, arts, religion, and literature (Chiu 2004 cited by Al-Jamea, 2014). As such most of the dimensions of the cultural aspects are tangible. Thus the social and cultural aspect in the viewpoint of the sustainable house design has the function of meeting the human needs in terms of social and the culture preservation. The two concepts have a significant role as well as effect when it comes to the environment and the idea of sustainability. However, one has

to consider that there the cultural and the social needs differs, and thus are not universal or standard. The variation depends on the given society as it tries to integrate the major components or urge to achieve the cultural needs and hence find the solution for implementing the housing designs.

According to GhaffarianHoseini et al. (2013), believe that the 21st century should entail smarter and greener cities though this has not been the endeavored effect, and hence promoting the fundamental aspect of sustainability has not been an achievement. One of the means to ascertain the representation of suitability of construction is the identification of the intended role of sustainability. According to Blewitt (2014), sustainability is the representation of a new and extended approach of designing that embraces and integrates the notions of greener infrastructure. In this manner, the notion bases the reviewing process intended to establish a link between adoption of various aspects that conform with the environment of the current cities environment in the aspects of the people, economy, and the entire society.

2.6.4 Other Parameters for Sustainability and Suitability Assessment

Geological and geomorphological factors are other parameters considered regarding suitability assessment of building development and the entire designs required for planning of city housing in the urban setup (Youssef, Pradhan, Sefry& Abdullah, 2014). According to Youssef, Pradhan, Sefry& Abdullah (2014), these two factors can be categorized under the components of the physical factors due to the fact that they affect the physical part of the urban setup. The physical factors incorporate the elements of slope, elevation, lithology, structures, and the elevation. The slope of the land has a substantial effect on the organization of the urban

setting and thus affects the entire process of urbanization. The level of the slopes increases the cost of building a sustainable structure. For instance, the erosion intensity has an associated cost and, therefore, affects the stability of the slope. The level of hazard increases with the degree of the landslide. According to Bathrellos et al (2012), areas preferred for urbanization are those that have the gentle slope. The sloping aspect is thus taken into account due to the orientation of the given constructions towards the direction of the sunlight or the amount of heat exposure. Bathrellos et al (2012) continue to sate that the soil and the geology features affect the urban development. In areas where there are solid rocks, the cost of urban suitability is high. The excavations required to promote a suitable degree of urban development regarding the housing design incur considerable cost. In some settings, there is the presence of thick and high density composition of sand and other elements such as the crystalline schist, volcanic, gravel, and alluvial deposits (Youssef, Pradhan, Sefry& Abdullah, 2014).

2.6.5 Sustainable Housing Design in Saudi Arabia

Jeddah, among other largest cities in Saudi Arabia, has continually experienced shortage of housing due to this characteristic of large cities since the region has been expanded significantly in the recent years (Al Surf, Susilawati&Trigunarsyah, 2013). As we consider our discussion on geographical and climatic conditions that characterises the entire region of Saudi Arabia, we identify that the region has harsh dry climate. In this condition, the country experiences scarce natural resources. Thus, the challenging effect is the environmental concern adding to the elements of the social and cultural factors. As a result, Saudi Arabia experiences a challenge in identifying the best measures regarding the application of sustainability. There are

factors that validate the sustainable development in Saudi Arabia. According to (Al Surf, Susilawati&Trigunarsyah (2013), limited natural resources, growing social awareness, economical effects, rapid urbanization, and environmental effects are the central factors that challenges the application of sustainability in this region. It is this understanding that one can ascertain that Saudi Arabia has a crisis in sustainable housing development. Jeddah, for example, has the characteristics that show a clear picture of the housing crisis in the region.

The continued growth of the unplanned settlements or the slums shows that the Jeddah has limited plans in terms of suitability and that it fails to accommodate the populations who have sought a living settlement in the area. According to Abdulaal (2011), there is a demand of 47,500 units required to meet the demands of the population living in the city. Also, the city continues to experience population growth as people influx the town (Abdulaal 2011 cited by Al Surf, Susilawati&Trigunarsyah, 2013). Due to this strenuous growth of Saudi Arabia cities, there is an increases strain in the economy. The housing sector, among other sectors, is the most affected. One of the reasons is the level of income among the low as well as the mid-income earners. The main challenge is that though there are efforts made to meet the needs of secure housing, there is no sufficiency in living up to residents needs with regard to culture aspects. Adding to the challenges experienced is the growing crisis due to lack of government regulations. The government has failed to integrate sustainable methods that would help meet the needs of housing sustainability.

2.6.5.1 Saudi Arabia Sustainability Status

Saudi Arabia urban development follows a similar fashion of most of the Muslim cities. The characteristic development is that there is a particular pattern that guides the homogonous arrangement of the housing design (Aina, Al-Naser&Garba, 2013). Pacione also highlighted the importance of the traditional city of the Islamic nature and the need of the public (Aina, Al-Naser&Garba, 2013). According to these writers, the irregularity of conventional design is not an indication of lack of directive. However, the arrangement portrays harmonious and coherent incorporation of differentfeatures to complete the arrangement. Figure 2 shows this arrangement.

Figure 5:Traditional Courtyard

(Source: Aina, Al-Naser&Garba, 2013 p.534)

Despite the general arrangement characterized by the traditional urban setting, there are considerable variations as the city experienced extended growth. Jeddah City is a typical scenario

that shows peculiar development. The traditional Jeddah city has a different arrangement from other cities due to its space. Jeddah emerged as a city or marketplace surrounded by the residential quarters (Al-Hathloul& Mughal, 2004). In spite of this change, the social and communal activities of the city development surrounded the designing of the mosque. Figure 2 shows the variation of the design development based on function as well as location. Jeddah old city had the narrower lanes and the wider streets that served different functions. The narrower lanes served the role of connecting to the residential quarters. On the other hand, "the broaderlanes functioned as shopping areas and passage of goods" (Aina, Al-Naser&Garba, 2013)

Figure 6:Old Jeddah Street Patterns

(Source Aina, Al-Naser&Garba, 2013p.535)

Figure 7:Old Jeddah narrow Street

(Source Aina, Al-Naser&Garba, 2013p.535)

2.6.5.2 Contemporary Saudi Arabia Urban Development

Saudi Arabia urban contemporary urban development started dates back to the 1930's when the regulations regarding sustainable building on the standpoint of street patterns and other forms of constructions. It was during this period that modern technologies as well as other planning models came into reality without the influence of factors such as the local traditions and the socio-cultural elements. The government provided orders and other regulations that formed the foundation of the contemporary urban design. Accordingly, the regulations influenced the pattern of the development of cities. In 1970's, there was major boost from the economic boom resulted in urban transformation. A notable development is the inauguration of the "Five Year

Development Planning" (Aina, Al-Naser&Garba, 2013). According to EbenSaleh (2002), the government initiated the plan of transformation by integrating a program that directed systematic intervention. As such, the government promoted a campaign that regulated urban production through a new form of building patterns in terms of the site-coverage limits. A characteristic that represents the contemporary development of Saudi Arabia urban design is the urban structure that followed the pattern of the constructed houses in the neighborhood. For instance, Al-Malaz followed a similar pattern of rectangular blocks as the government headquarters moved from the city of Makkah to Riyadh (Mandeli, 2008).

2.7 Cost-efficiency of Sustainable Models

Guy, S. and Moore S. (n.d) offer a deliberation on sustainable architecture and the diverse constellations of the ideas and other knowledge about the standard approach to social and environmental conditions regarding the models and the certainty of scientific as well as technological development as human beings celebrate the development of sustainable architecture.

Accordingly, Alwaer& Clements-Croome (2010) assert that building performance for the past has shown maturity and increasing concern about the building design. According to these authors, "sustainable designpertains:

a. Achievingadvanced environmental performance standards
b. Making investments in fresh values
c. Reexamining designs 'smartness and how to incorporate them in buildings,

As such, there should be a differenceamidaspects of smart, Green and sustainable, and that these components are critical in for the value of sustainable buildings. Sustainable building requires a

continuous process that balances the environmental, economic sustainability and social systems. In the event when there is implementing sustainable practices, there is a tendency to alter the initial costs, certain figures of the green features, commissioning, and the additional design services (Du Plessis 1999 cited by (Alwaer& Clements-Croome, 2010).

2.8 Intelligent Energy Concept

The entire process of effective costs has to change based on the size and nature of the project, but there is the necessity that the project meet sustainable levels, and this can be done through measures that allow flexibility. Guy & Farmer (2001) state that the operating costs and other related procedures to promote healthier development to increase the level of sustainability have to be put on considerations. Intelligent buildings have to be technologically aware, healthy, be flexible, adaptable to cope with changes, and sustainable. Alwaer& Clements-Croome (2010) understands a sustainable smartconstructionto be an intricate system withthree interlinked basics in the form of people, products, and processes. Regarding the people, they are the owners, users or the occupants. On products, the authors identify materials, pieces of equipment, facilities, automation and controls, and structure. On the viewpoint of the processes, Alwaer, H., & Clements-Croome identify performance evaluation, maintenance, and facilities management as the issues related to processes. The inter-relationships between the three issues of people, products, and processes offer the best combination of the economic, environmental, and social values (Alwaer, H., & Clements-Croome, 2010; Chen, Clements-Croome, Hong, Li &Xu, 2006).

Frost & Sullivan (2011) assert that the energy demand has seen a faster growth than the level of its supply, and this means that there is a need for a definite sustainable level. Also, the differences in the energy levels call for a clear necessity for increased efficient generation

delivery as well as the energy consumption. Frost & Sullivan (2011) describes the change in the global energy demands and shows the world energy management. Frost & Sullivan (2011) continue to state that the solutions to sustainability are combining the generating capacity for renewable sources that promote efficiency of energy usage. On the other hand, Frost & Sullivan (2011) understands that there are challenges on the supply side while trying to incorporate energy generating technologies.

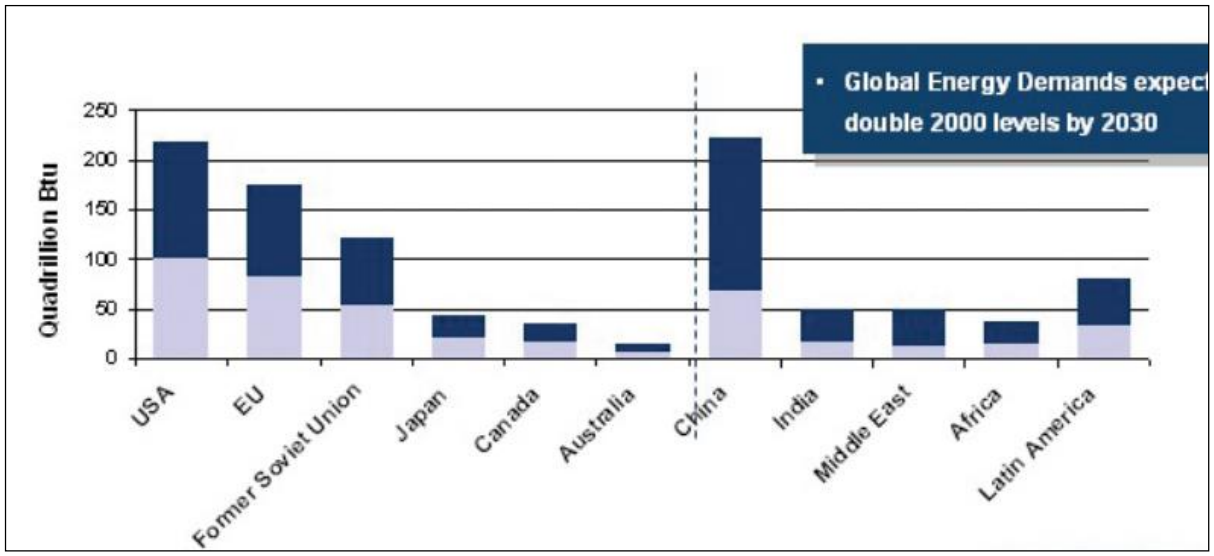
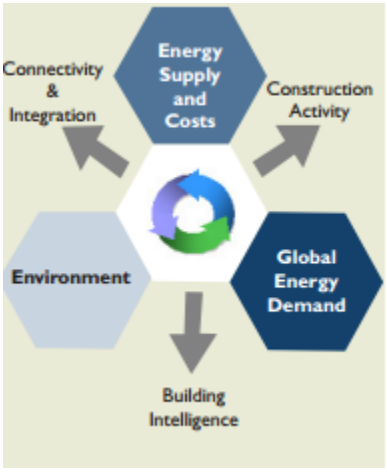


Figure 8:Classification of Global Energy Demands by Areas (2000-2030)



Source: Frost & Sullivan (2011)

2.9 Other Issues on Sustainable Architecture

There are debates, controversies and arguments regarding revolution or reformation, technology, clear definitions or standardization, or what to embrace and abandon on the viewpoint of sustainable architecture. According to Guy and Moore, the diversity in the images and structures of what encompass sustainable architecture is the component or what this sustainable architecture looks like, location, materials, as well as technologies to incorporate. Guy and Moore (2007) assert that the three decades of debate regarding sustained architectural design have failed to develop a consensus forum around the best universal practice and cite Guy and Moore, 2007). Accordingly, there lack an understanding that suitability matters in terms of definition with the aim of ascertaining specific interpretation regarding the setting and the objectives.

In this thesis study, there are many pictures in terms of figures presented to illustrate the sustainability features of development for Jeddah City from the past to the present day. The features that the pictures aim to promote are the environmental as well as other suitability

conditions that affect the green design. The thesis identified features such as the space of the buildings, the arrangement of the buildings, and the materials used for construction. Also, the literature was used to identify the techniques used in the buildings. The information about the buildings in Jeddah City indicated the components of the system of construction for the purpose of identifying the discontinuity with the architectural design, the materials used, the traces of the removed elements, and the peculiarities of the architectural elements. The organization of the gathered information followed the research questions.

In addition, the investigation of power consumption, inside and outside relative humidity, levels of CO2 emissions, and the inside and outside temperatures formed the analysis of the current study. Some of the data were obtained from previous records about the environmental investigation of the prototype buildings in Jeddah City. The information has the effect of buildings on the sustainable lifestyles as well as attitudes. The data is presented in the form of figures, tables, bar graphs, pie charts, frequencies and percentages where applicable.

2.10 Jeddah Building with Reference to Climate

Jeddah is located at $21^{0}42^{'}$N, $39^{0}10$'E, 15m (19ft). See map (figure 3). According to the literature review, Jeddah is a subtropical desert encompassing low latitude. Jeddah is situated near the tropical desert. The persistence climate state means that the City records a high level of annual temperatures. The annual mean is about 28.4 degrees (see figure 4).

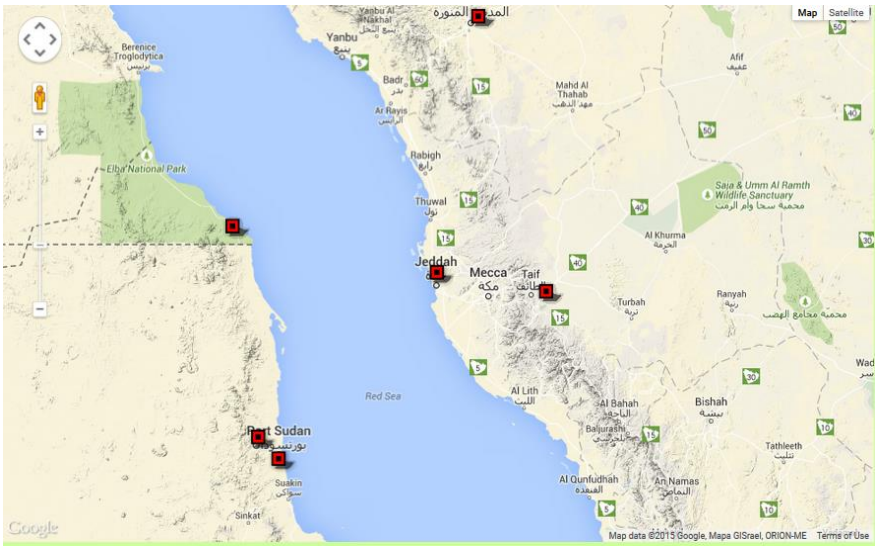


Figure 9: Location Jeddah City

Source: (http://www.jeddah.climatemps.com/map.php)

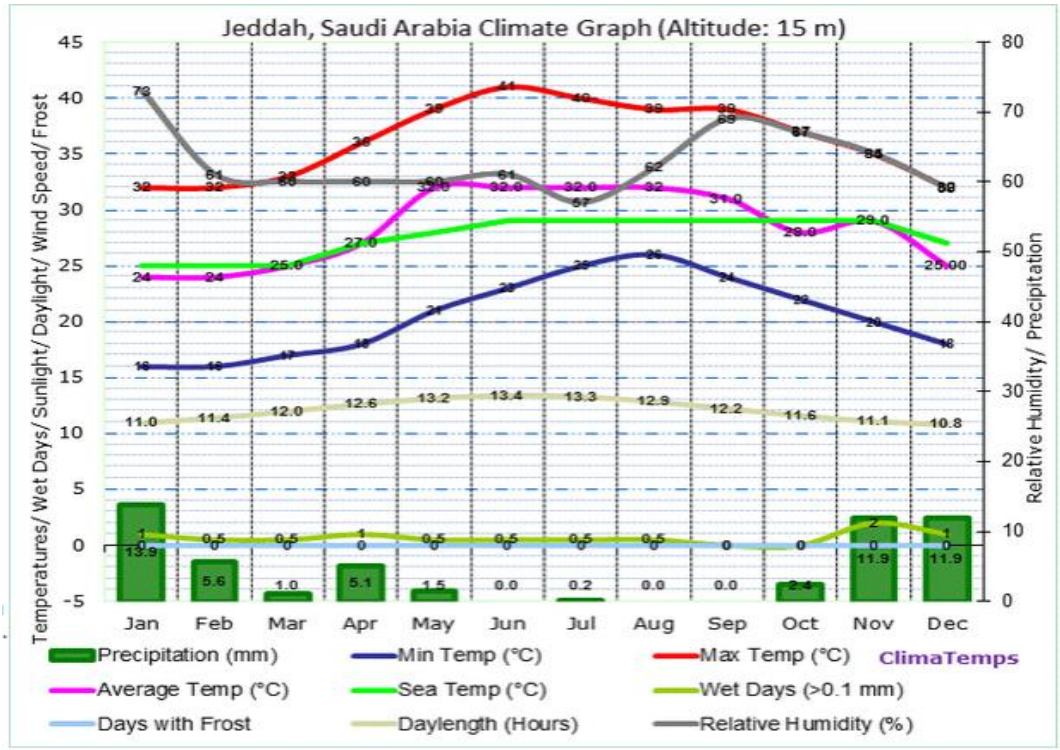


Figure 10:Jeddah Climate Graph

Source (Jeddah *Climate & Temperature* http://www.jeddah.climatemps.com/)

The traditional Jeddah followed the climatic conditions through an entire spectrum that had unique settlement pattern. Arif Kamal (2014), reports that Jeddah evolved as a city that responded appropriately to the specifications of climate in terms of the construction techniques, the material of selection, the passive structures design, as well as the spatial organization. The current study had some pictures showing the design of Jeddah arrangement of the structural features. The structures are airy, light and tall that have indigenous features that maintain the thermal comfort. Arif Kamal (2012) states that Jeddah features support the humid levels, especially during the daytimes.

2.10.1 Humidity Levels and Wind Speed

The land and the sea breezes and the temperature variations affect the humidity levels in Jeddah City. During the night, the breezes tend to be dry coming from the landward but the temperatures raise the level of the relative humidity. The day temperatures lower the level of the relative humidity thus bringing moist air. Thus, Jeddah City has high temperatures as well as the humidity during the summer periods. Kamal (2013) states that associated pressure affect the change in the humidity and temperature. On the other hand, the city of Jeddah has prevailing winds from the North West. As stated earlier, the city is located on the Red Sea shore, and these winds are sometimes light and moderate for most period of the year. Conversely, the Southern winds at times blow during the winter and is accompanied by the rise in the temperatures. Besides, the City experiences rainfall accompanied by thunderstorms that fall during the winter

season. Further, the region has a low pressure that emerges from the west to the east side meeting with the pressure from the Sudan region.

2.10.2 Microclimate Modification

In light of the literature review discussion we can identify some criteria for consideration that were evident in planning as well as the building layouts in Jeddah with respect to climate factor (El-Shorbagy, 2010; Al-Lyaly, 1990). The objective during the hot period for the buildings is minimizing the exposure to direct radiation of the sun and thus avoids additional gaining of heat. Eventually, there is the cooling effect because of the cooling potential from the NNW prevailing winds as well as sea breezes from the west. Thus, the ventilation was a plan directed towards optimum conditions and the maximum solar radiation protection. It is from this understanding that we note that town layout respected and corresponded to the waterfront contour. The street system followed a regular pattern that followed the advantages of the prevailing winds and the sea breezes (See figure 6). The planning of the old Jeddah saw narrow and flanked by the tall houses. The streets channel breezes reduced the volume of the air that traveled thus increasing the velocity rates. There was an increased speed that created low pressure in the upper parts of the streets thus following the atmospheric pressure. In this manner, the air is drawn by the pressure differences proportional to the velocity intensity.

Figure 11: Traditional Jeddah City with its Old Urban Form

Source: Al-Lyaly, S. M. Z. (1990).

2.10.3 Settlement Pattern

The settlement pattern is a characteristic that relates to the climatic aspects and the City in the context of sustainable designs. The buildings are made separate wherever possible with the aim of allowing the free movement as well as allow air flow around the structures. Jeddah has a street pattern that appears to be controlled and follow the planned microclimate.

Figure 12:Old Jeddah Street Pattern

Source (Kamal, 2014 p 10)

The description shows that Jeddah followed a convection system that followed the microclimatic conditions thus combining the temperature differences as well as the ventilation system of the settlement of traditional Jeddah (Arif Kamal, 2012). In addition, the houses of Jeddah followed the considerations of response to the humid climate as the factor with great influence on the designs. Also, the City had different houses based on the family levels. The variations in the stylistic characteristics and the domestic architecture followed a unique settlement pattern. For instance, Jeddah settlement pattern had variations based on the wealth levee, the climate and the combination of the houses. Thus, the houses had airy structures that allowed ventilation (Kamal, 2013).

In addition, Jeddah had a cross-ventilation element as a necessity for the buildings. The climate factor has the role to integrate the desire for privacy by allowing openings. Thus, the climate was a component that allowed the climate and privacy to incorporate design.

Fathy(1986) states that the cantilevered space had an opening that acted as a cooling effect, therefore, allowing the air movement.

Figure 13:Ventilation and privacy representation of old Jeddah City: Rowshans

Source (Kamal, 2012 p17).

Figure 14: Façade Covered with Mashrabiyas

Source (Kamal, 2014 p.19)

Air movement dictated the pattern of the urban planning for Jeddah City. In the light of the climate conditions, buildings in Jeddah had a grouping in terms of blocks and times there were terraces forming relatively dense tall buildings with the presence of narrow streets and some alleyways (Kamal, 2013). Al-Lyaly (1990) states the buildings formed a haphazard conjunction, side-to-back, or back-to-back though the majority of these houses were semi-attached. However, the common feature was that the building blocks tend towards the incident of the prevailing breezes and the natural ventilation (Al-Lyaly, 1990).

Jeddah City modern streets appreciated change than the setting of the traditional alley. There was a difference in the level of the maximum temperatures. Kamal (2012) asserts that there are two primary factors attributed to the differences in the air temperatures. The first factor

is the increased absorption of the solar radiation in new streets. The presence of the marble and asphalt and the bricks that constituted the significant parts of the surface caused the increased heat absorption. Also, the new specification in angle measurement affected the surface area than the traditional alley to a great extent that there was a rise in the solar energy (Chen, Clements-Croome, Hong, Li &Xu, 2006). The second factor concerns the heat generated by the car engines leading to rising in the level of heat thus affecting the atmosphere. The new heating levels meant that at night narrow the alley became heater during the first durations of the night.

2.11 Environmental Conditions

2.11.1 Jeddah Comfort Conditions

It is interesting to note that Jeddah City had structures that followed the modification of comfort zones. The region is considered as extremely hot while at times the climate is cold. The fluctuation in the level of the temperatures is a factor that has branded the designs to follow a system that could cater for the shifts in the climate. The fact that there are temperatures above or below the comfort zone indicates the precautions that the designers used in the suitability of night and day conditions. The comfort analysis shows that Jeddah experienced discomfort during the critical season, the summer. The region experiences a sensational heat, and the levels of the temperature are elevated thus corresponding to the comfort state. The radiant temperatures, the air velocity, and the sensation of heat are the main environmental conditions that affected Jeddah City.

At extreme temperatures, the effect of the air velocity causes the heat exchange as well as the increasing evaporation capacity thus leading to the cooling efficiency. Accordingly, Jeddah

comfort depends on the speed at which the room moves across the air supply within the rooms. The design of the structures in Jeddah has the inside comfort that depended on the control of the radiant sun. Another thing identified in the house design of the Jeddah City was the improvement in the thermal comfort and the call for the shading effective foe the openings, the thermal insulation and the light external coloring. The design accommodated the climatic conditions of the night to limit disturbances during the night that would delay the sleeping ability. Also, the presence of various designs considered the heat stress experienced during the day.

The thermal comfort of in Jeddah City shows a mechanical means that provided the suitability of the regular building structures. In this manner, the changes in the energy consumption have led to a change in the perspective in which the constructions follows the climate conditions and experience of the environmental condition. In the description of the sustainable buildings in Jeddah City, it is apparent that the display of the buildings followed the experience of appropriate principles between the rational resource use, as well as the logical analysis. The traditional buildings for traditional Jeddah are, therefore, climatic responsive and evolved from the centuries of experience and the nature of the climate.

2.11.2 Vocabulary Factor

One of the essential factors the thesis identifies is about the vernacular architecture Jeddah City presents. Jeddah City, just like the contemporary structure in Saud Arabia, had the approach based on the interpreting forms as well as masses of the past (El-Shorbagy, 2010). It is evident that language exists alongside the modern architecture and the elements as well as the functions of the Islamic-Arab designs. The buildings and the projects were comprised mainly of

similar architectural elements. The Nassif House in Jeddah City is one of the representations of the opportunity to interpret the traditional Saudi Arabia. The design of the Nassif House showed the essential vernacular of the Saudi Arabia houses that includes the courtyard, mashrabiyyah, and the windcatcher (El-Shorbagy, 2010). The vernacular architecture element in the Old Jeddah City followed the Islamic-Arab houses that maintained the people's characteristics especially about the culture and the traditions. Jeddah designs maintained coherence and unity between the landscape construction and the inhabited spaces.

Figure 15: Nassif House in Old Jeddah City

El-Shorbagy, A. M. (2010). Traditional Islamic-Arab House: Vocabulary and Syntax. ***International Journal of Civil & Environmental Engineering IJCEE-IJENS*****,** ***10*****(04), p.19**

The Muslim architecture, therefore, are the true expression of the architecture that offers the comfortable element in terms of the living conditions. The structures in Jeddah City followed the specific forms of shapes according to the presence of the natural resources and the source of energy to help in reducing the humidity levels and creating the natural ventilation. A feature that shows the characteristics of the buildings in the City is the windcatcher (Kamal, 2014). The

introduction of the wind-catcher as a device in the architecture design shows that the Muslim followed a similar level of design that would promote the level of sustainability in terms of vernacular architecture.

2.12 Economic Factors

The discovery of the oil brought a new dimension in architectural design in Jeddah. The presence of oil paved a new dimension to the expansion level in the urban areas. As a result, the particular emphasis was on the vigorous transition that the oil economy brought in Saudi Arabia (Taleb&Sharples, 2011). According to El-Batran (2008), population growth, high urban prices in the land, municipal planning weaknesses, the illegal resident, and the migration to the cities led to rapid urbanization. El-Batran continues to state that the rapid urbanization led to unplanned settlements. Jeddah City developed unplanned settlements leading to a lack of efficient infrastructures a number that rose to 50 unplanned settlements with the land area of 4,800 hectares. Accordingly, the tremendous growth that the oil sector brought increased the demand for housing thus dictating the new means of house design. "Even when one managed to secure housing, it was neither sustainable, nor efficient in the provision of cultural needs of the occupants" Al Surf et al. (2013). Al Surf et al. (2013) assertion means that the presence of economic development around the urban setting of old Jeddah failed to reinforce or pay respect to the inhabitants and the environment. The design no longer sustained the luxury effect and that the new generation had to find means of survival.

2.13 Overview of Thermal Comfort Conditions for Jeddah City

The influence of the temperature, air speed, temperature, and relative humidity regarding the thermal comforts for the Jeddah City shows some significant development that pertains to

sustainability. The current study identified interesting facts on Jeddah comforts and the discomfort conditions as will be reported in this section of the analysis. Most of the data for the analysis obtained from the questionnaire is from the month of January to July 2015 (the period of the study). Also, the analysis also integrates other studies done on Jeddah thermal conditions. In this approach, the study measured the concentration of Ozone, nitrogen gas, and the presence of CO2 continuously for the past 48 weeks. Further, the study identified other studies to monitor the parameters of wind speed, relative humidity and the temperature. The study used the thermal performance digital electronic monitors to measure the relative humidity outside the building, and a record of the changes in the temperatures noted.

The best method identified for the study was to check if the AC was running all the times and this helped in monitoring the temperature performance in courtyard and the School, among other traditional building within Jeddah City. Recall that Jeddah City is a coastal town and thus the humidity level is very high during most parts of the year, and more so in the summer season. The sea temperature is at the highest level during the summer season. With respect to measurements we obtained and those recorded by other studies, we noted that the humidity level is lower during the winter and high in the months of January. The resulting detailed historical information on the monthly averages for the period under study will be presented in the following analysis. The study however aimed to maintain relevance regarding the current and historical weather trends calculated and recorded for the past two decades. Besides, the current study maintained the significant of its research questions and maintained to follow the data that related to Jeddah City humidity levels.

2.13.1 Historical Monthly Averages for Jeddah City

The study involved recording the monthly averages based on data collected. Though some information analysis based on each month, the analysis also based recording of two, three or more months for the period under research.

In January, the temperature level was high during the daytime, and the study recorded 83^0 F, an equivalent of 28^0C. At night, the temperature dropped and averaged 18^0C (64^0F). The relative humidity was around 59%. Regarding the level of precipitation, the recorded amount was around 0 mm. On turning our attention to the water temperatures for the coastal part of the city, the recorded temperature levels averaged 27^0C. The level of temperature during the month of January made people feel uncomfortable but staying in the water for an extended period provided affordable comfort. During the month of February, the temperature recorded was around 29^0C during the day and 18^0C at night. Using the past forecast data, this month experienced sunshine for an average 11 hours. The heat index was high and the comfort the heat conditions affects individuals. Concerning the average wind speed for each day, the speed was around 15km/h. The maximum speed recorded in the past is about 74km/h. About the water temperature, the sea averaged 26^0 C and thus swimming would be enjoyed during this month.

Additionally, the information for the other months is as follows. The daytime temperature for March was around 31^0C and the average temperature for the night dropped to a minimum of 19^0C. The relative humidity for this month was 58%. The precipitation value for this month was about 0 mm. With reference to the estimated hours of sunshine; the past forecast data shows that the sunshine averages 11 hours for the month of March. The wind speed recording was about 15 km/h. According to historical data, the maximum speed for the March is about 83 km/h. On the

viewpoint of the water temperature, the value averages 26^0C and thus showing a high temperature level. The result for the temperatures regarding the month of April through July showed an interesting characteristic. The temperature level of April record at 35^0C and this temperature rose to 39^0C for the month of July. Concentrating on the heat index, there was a maximum of heat conditions. On the other hand, the precipitation level showed decreased values as the level of temperatures increased.

The table below shows a record of yearly weather trends. The table has information on weather averages as well as extremes and regards the maximum and minimum temperatures by the Ministry of Defence and Aviation. The value of the table is to show the historical relevance, and this complements the current study.

Temperatures (Deg. C) Relative Humidity (%) Surface Wind (Kts) Pressures (hpa)
Precipitation (mm)

M	MX °c	MN	MX	M	YY	DD	MN	yy	DD	MX (%)	M N Kts	M hpa	PRE V Dir	M	M X	DD D	M	M	M	M	Ext mm	yy	Ext	yy	DD
J	20.2	9.0	14.4	31.5	2006	27	-.5	1989	07	100	3	47	SSE	6	35	16	7.5	948.2	1020	11.7	54.6	1993	25.7	1993	12
F	23.0	11.0	16.9	34.8	2006	08	.5	1989	07	100	4	38	SSE	7	31	18	7.1	946.2	1017.6	8.5	53.9	2005	37.5	2005	25
M	27.3	15.0	21.1	38.0	1980	28	4.5	1992	04	100	3	34	SSE	7	55	30	8.0	944.4	1014.2	24.7	108.9	1995	52.5	1995	21
A	33.3	20.3	26.8	42.0	1999	27	11.0	1989	01	100	3	28	SSE	7	70	35	9.0	942.7	1010.9	22.3	106.6	1995	30.0	1995	28
M	39.1	25.7	32.7	45.1	1998	28	18.0	1990	14	95	1	17	N	6	51	32	7.8	940.2	1007	4.6	39.5	1993	29.5	1993	12
J	42.4	27.6	35.4	47.0	2003	11	16.0	2004	17	45	1	11	N	7	40	35	5.8	936.4	1002.3	00	0.0		0.0		
J	43.5	29.1	36.6	48.0	1998	25	23.6	1991	03	54	2	10	N	7	40	10	6.1	934.0	998.5	0.0	0.3	1980	0.3	1980	20
A	43.2	28.8	36.3	47.8	2003	07	22.7	1989	26	64	2	12	N	6	**	7	7.1	935.2	1000.3	0.2	5.6	1998	5.6	1998	28
S	40.3	25.7	33.2	44.5	1999	01	16.1	1989	22	70	1	14	N	5	30	1	6.7	939.7	1006.3	0.0	0.0		0.0		
O	35.0	20.9	28.1	41.0	1987	03	13.0	1984	21	92	3	21	SSE	4	35	35	7.4	944.8	1012.9	1.7	27.1	1982	10.2	1982	13
N	27.7	15.4	21.4	36.0	2006	04	7.0	1988	15	100	2	36	SSE	5	**	30	8.7	947.5	1017.3	7.9	98.0	1997	45.8	1997	02
D	22.0	10.6	16.1	31.0	1991	12	1.4	1990	29	100	4	47	SSE	5	30	30	8.3	948.7	1019	13.0	97.8	2003	70.0	2003	03

Max43.5

Figure 16: Historical Table showing record of maximum and minimum temperatures for Jeddah

MX 43.5 48.0 100 *** 108.9 70.0

MN 9.0 - .5 1

M 26.6 26 6 7.5 942.4 1010.6 7.9

Number of Days with Occurrence of following Weather Phenomena

Month	Thunder Storm	Precip	Mist	Fog	Blowing Dust	Dust/Sand Storm	Haze
01	.9	05.8	04.7	0.9	02.8	0.1	12.4
02	2.2	04.8	02.5	0.3	05.2	0.5	14.0
	3.7	09.8	02.0	0.1	06.8	0.9	16.5
03							
04	4.4	10.0	00.9	0.0	08.1	1.4	17.2
05	1.9	03.5	00.1	0.0	08.4	1.3	21.0
06	.1	00.0	00.0	0.0	06.0	0.3	17.0
07	.0	00.2	00.0	0.0	05.8	0.3	16.4
08	.2	00.2	00.0	0.0	04.6	0.2	15.0
09	.1	00.0	00.0	0.0	02.8	0.0	12.3
10	.3	01.2	00.4	0.0	01.8	0.2	12.3
11	.7	03.4	02.2	0.0	02.9	0.2	11.7
12	1.3	06.3	04.8	0.8	02.3	0.0	12.8
Total	15.8	45.2	17.6	2.1	57.5	5.4	*****

LAT,N=Latitude in Degrees Minutes and Seconds, North of the Equator
LONG,E=Longitude in Degrees Minutes and Seconds, East of Greenwich
mm=Millimeter
Ext=Extreme
Kts=Knots
YY=Year
DD=Day
Press=Pressure
Dir=Direction in 16 points Compass
DDD=Direction in Degrees
hPa=Hectopascal
Deg C=Degrees Celcius
MO=Month,
MX=Maximum
MN=Minimum
AVG=Average
M=Mean
PREV=Prevailing
Precip=Precipitation

Source http://www.pme.gov.sa/Riyadh%20Old.htm

2.13.2 Ozone Formation and Jeddah City Atmosphere

According to Alghamdi et al. (2014), there has been a rapid increase in the level of industrialization, urbanization, and human activities effect on the air quality for the Jeddah City. Some of the emissions such as the BTEX have significantly increased though at the time of the study the data had been scarce. However, the current study managed to assess the concentration of the BTEX compounds as well as seasonal variations information for Jeddah City background and its relations with sustainable buildings. Alghamdi et al. (2014) measured the air temperature, the wind speed and direction, atmospheric pressures, and relative humidity continuously using the compact weather model and thus recorded the measurements of the atmospheric pollutant elements. The study raised the station sensor to 6.5 metres high and hence

no interference with the local buildings. Figure 11 is the graph that shows the annual concentration of the BTEX for the period under study.

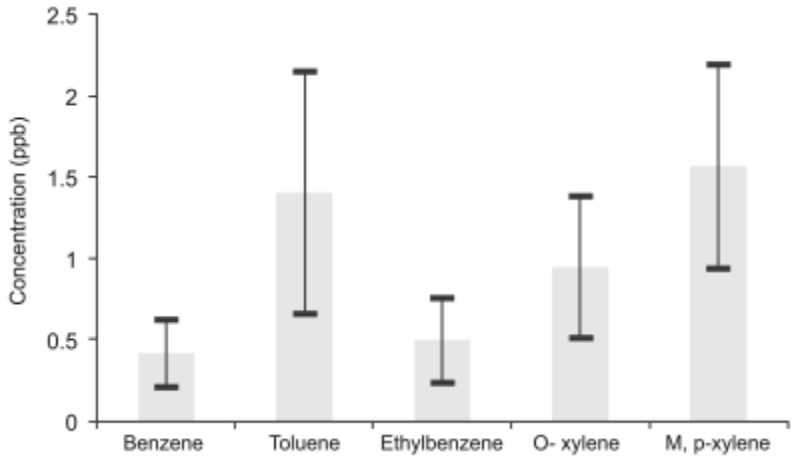


Figure 17:Yearly mean of BTEX compounds concentration throughout the research

Source:Alghamdi et al. (2014) p474.

From thefigure11, Alghamdi et al. (2014) recorded that the *mp*-xylene and the toluene were the abundant compounds present in the Jeddah City. The recorded daily average was had a range of 0.09 to 1.10 ppb (a mean of 0.41±0.21ppb) for benzene, the measurement for toluene was 0.18 to 4.46 ppb (and had a mean value of 1.40± 0.75 ppb), ethylbenzeme value was 0.12 to 1.62 ppb (and a mean value of 0.49±0.26 ppb), the record for *o*-xylene according to the study was 0.25 to 1.90 ppb (0.94±0.44 ppb mean value), while *m,p*-xylene had 0.38 to 2.98 ppb (and a value mean of 1.56±0.63). It is from these measurements that Alghamdi et al. (2014) concluded that the measured concentrations can be described locations and the differences in industrial processes, human activities intensity, industrial activities patterns of and use, BTEX chemical removal processes, and the traffic intensity, among other factors. As a result, the local conditions

that includes the differences in the industrial activity, fuels used, and climate influenced the profile of the BTEX compounds (Alghamdi et al., 2014). The analysis of the ozone data by Alghamdi et al. (2014) for Jeddah City found that there were traces of NO_x saturated atmosphere. The concentration in the rural centres showed a higher value of ozone relative to the concentrations in the rural setting.

Based on previous studies regarding the concentrations high particulate matter, the study identified that the presence or lack presence of particles affected the construction work and that the atmospheric conditions were critical to Jeddah City development. Jeddah City is within a desert climate and thus experiences the high presence of dust particles in the air (Munir et al., 2013). Figure 13 shows a table of studies conducted in Saudi Arabia, and this was useful for the analysis of the current study.

Table 1. A brief review of previous studies in Saudi Arabia.

Name, year and location	Main pollutants and results
Nasrallah and Seroji, 2008 Makkah, Saudi Arabia	TSP, PM_{10} and $PM_{2.5}$ Daily PM_{10} concentration ranged 191–262 $\mu g/m^3$, TSP concentrations reached 665 $\mu g/m^3$. Chemical analysis showed high levels of sulphate, ammonium, nitrate and chloride.
Nasrallah and Seroji, 2007 Makkah, Saudi Arabia	NO_2, NO, NO_x, non-methane hydrocarbon (NMHC) and ozone. Hourly mean NO_x levels reached more than 800 $\mu g/m^3$ and ozone hourly level reached 160 $\mu g/m^3$in Makkah. Highest level of ozone was recorded in May and lowest in February.
Al-Jeelani, 2009a Makkah, Saudi Arabia	NO_2, SO_2, CO, ozone, methane (CH_4) and total hydrocarbons (THC) as well as some meteorological parameters (temperature, wind speed and wind direction), November 2002 to October 2003 were measured and analyzed. Daily cycles of these pollutants were analyzed.
Al-Jeelani, 2009b Makkah, Saudi Arabia	NO_2, SO_2, CO, ozone, CH_4 and THC and WS, WD and temperature. CO, NO, NO_2 varied during the day, whereas SO_2 concentrations were relatively constant. Ozone concentration was associated with photochemical activities.
Othman *et al.*, 2010 Makkah, Saudi Arabia	PM_{10} PM_{10} was high during Hajj season than other months
Kutiel and Furman, 2003 Middles East	Dust storms Middle East, Sudan, Iraq, Saudi Arabia and the Persian Gulf, are the regions that reported the greatest occurrence of dust storms.
Khodeir *et al.*, 2012 Jeddah, Saudi Arabia	$PM_{2.5}$ and PM_{10}. The main sources of $PM_{2.5}$ and PM_{10} were (1) heavy oil combustion; (2) resuspended soil; (3) a mixed industrial source; (4) traffic source; (5) other industrial source mixture; and (6) marine aerosol.
Sabbak, 1995 Jeddah, Saudi Arabia	Iron (Fe), zinc (Zn), cobalt (Co), chromium (Cr), nickel (Ni), lead (Pb), manganese (Mn) and sodium (Na). Fe and Na were the major components of the air dust.
Alharbi *et al.*, 2012 Saudi Arabia	Saudi Arabian dust storm event and its reasons. Large-scale atmospheric instability, high surface winds, and dry rich dust sources cause dust storms in Saudi Arabia.

Figure 18: A figure showing the table of brief studies done in Saudi Arabia

Source: Munir et al., 2013 p 902

2.14 Cultural, Social, Lifestyle and Attitude Factors

One of the adopted methodologies for the current was the use the questionnaire survey to determine the effect of the selected buildings in Jeddah City on the sustainable lifestyles and attitudes. About 150 users of the buildings were chosen to respond. The analysis of their response showed fascinating development on building suitability and the awareness to the level of environment awareness. A majority of the respondents acknowledged that the presence of fine particles was a significant factor in promoting the level of building appropriateness. According to Munir et al. (2013), increased exposure to particulate matter leads to problems associated with

the chronic respiratory and the cardiovascular diseases, alteration of the host defenses, and thus premature death or the possibility of the developing cancer.

Munir et al. continue to state that the particulate shape, as well as size, is crucial factors in controlling the degree to which the particles penetrates into a respiratory tract. Also, these authors asserts that where and how the particles are deposited, the rate at which these particles are cleared, and the reactive surface area are factors to identify the regions where the concentration is high and thus favour the area to have human activities or man-made buildings. The respondent stated that they were keen to identify the variety of places where the particles had high concentrations. Jeddah City has served as the centre of social and cultural activities such as serving the religious purpose where people concentrated to perform Hajj (Munir et al., 2013). Consequently, the respondents were to state that the level geographical conditions, the suspension of the particles, and the atmospheric conditions were critical factors that influenced the efforts made to build structures.

2.14.1 Islamic Law Factor

Given the variety of the ethnic groups present in Jeddah City, one might ask how the groups identified integrated harmonious effect with the urban social life without much disruption, and how the population achieved sufficient cohesiveness to sustain itself as the entity to fulfil the needs of the whole approach to sustainable buildings. The current study identified many aspects regarding the social factors of the Jeddah City, particularly the Shariah (Islamic Law). According to Al-Lyaly (1990), Shariah Law is an integral part of developing heterogeneous cosmopolitan society and that Jeddah identified the vital approach towards

determining the overall social unity for the old town. In agreement with the research questions and the need for identifying the suitability factors, the current study appreciates that Jeddah City had a tight organization that followed parochial communities (Al-Lyaly, 1990). Additionally, the result of the survey showed that the majority of the population felt that the spatial grouping by the social status created some basis of the differentiated form of structured developed. However, the study observed that despite the separation in terms of quarters, each quarter can be identified as microcosm (Al-Lyaly, 1990).

Shifting the focus to other scholars' effort to define the Islamic culture and the formation of the urban settlements, the research isolated the effects of Islamic Law to account the entire development of sustainable structures. For instance, Aina, Al-Naser&Garba (2013) has examined the need to have a framework of the urban formation for Jeddah City and developed that Islamic legislative principles founded the progress of urban structure. Al-Lyaly (1990) identified that the primary structure and the planning principles include: (a) the right way; (b) respect of privacy; (c) right to property ownership and usage (d) avoidance of creating harm to others. Therefore, the Islamic Law helped to resolve issues regarding the right and respect to privacy. In the context of the housing or dwellings, the critical aspect of the family and the social setting was to promote the visual privacy that involves design that recognized the vital element factors. Adding to this significance is what the study identified as individual usage concerning the diverse architectural spaces. The study realized that the population are sensitive to the issue building and rebuilding with greater significant attached to privacy and protection. Consequently, the building followed a pattern that catered as well as understood the social factors, particularly privacy and ownership.

2.14.2 Cost-efficiency factors

According to Kamal (2014), the Kingdom of Saudi Arabia has witnessed a fast pace regarding the residential buildings because of the rapid escalating population. Particularly, Jeddah has witnessed increased residential buildings since the area has recorded immense level of sustainable economic growth. The current work found that the level of the suitability has not been attained. The mechanical means to provide the thermal comfort fail to provide suitability because of the initial and the recurring costs. The non-availability of the artificial resources of adequate energy on a regular basis has been the major challenge for sustainable designs. The level of energy consumption rise has generated environmental pollution resulting in effects such as the ozone layer depletion and the global warming. An urge to reduce the greenhouse gases has caused to conscious designs.

However, the designs have failed to display an effective association that considers appropriate use of the available resources. Buildings from the area, therefore, fail to establish cost-effective models responsive to the green architecture and the environment concerns. According to Kamal (2014), the most critical development for a moderate climate is to recognize the need for a heating demand for the buildings and hence an improvement in the thermal insulation. Also, Kamal (2014) argues that saving the energy is an approach that facilitates an installation of systems that considers the solar presence of increased solar radiation. Result from the analysis of Jeddah City buildings selected for this study shows that the orientation of the structures and the size failed to modify and raise the option of effectiveness. Most of the corresponding costs for the Jeddah City buildings failed to appreciate the need for a structure that

is cost-effective. The heat demand requires a housing orientation that maintains a favourable condition in terms of cooling effect. As a consequence, a cost-effective model is one that considers the quality of the structures such as windows, doors, and other ventilation. The overall size of the window should have a surface that has the concern of the sufficient daylight and one that regulates the heating demand (Kamal, 2014). Some of the Jeddah City designs show that there are additional costs required regarding the insulation materials. The investigation of the cost-effective designs for this City shows continued energy costs for reducing the level of carbon emission as well as the level of the temperatures. Therefore, Kamal (2014) argues that some of the initiatives to enhance the door comfort have failed to go beyond the gain from the technological advancement.

Chapter three: Methodology

3.1 Overview

From the preceding discussion, the main objective of the current research study is to identify pollution levels or the degree level to which most buildings in Jeddah region lack sustainability. Moreover, the target of this work is to come up with a viable solution that can mitigate such pollution and enhance the purity of the environment as well as secure the lives of the inhabitants. Accordingly, this section will talk over the research methodology undertaken for

investigating the objectives of the research. This section will mainly discuss two main parts. The first segment will be the case study approach that will include a thorough evaluation of three sampled buildings to determine their levels of sustainability and adherence to environmental perseveration in terms of their designs and structures. The three buildings, in this case, are the sha'abi house, one of the schools in the region, and the villa house in Jeddah area.

During this appraisal, the target will be to measure the temperature level of the inside environment of these buildings, to determine the degree of carbon dioxide gas, and to establish the extent of humidity in the rooms within these structures. Moreover, the study shall seek to find out the cost-effectiveness of energy consumption in these buildings as well as verify their suitability in regards to the emission and consumption of pollutant elements. Establishing these quantitative aspects of the research will help the leadership in Jeddah take necessary measures that this paper will propose, to combat the looming environmental problem that might arise shortly.

A quantitative methodology will be done using survey questionnaires. In this approach, the occupants of the buildings are the primary respondents to the questionnaires since they are the people that best understand the conditions of the buildings. The objective of this approach is to determine the comfort level of the buildings with regard to environmental factors like, pollution, temperature, moistness, and the level of carbon dioxide gas.

3.2 Case study Approach

Different IAQ (indoor air quality) measurement tools were used for determining the levels of carbon dioxide, temperature, relative humidity, and pollutants in these structures. The following is a detailed description of the measurement process of each component.

3.2.1 Relative Humidity

Since the research requires a high level of precision, an all-in-one moisture meter that is a combination of both the pin-less and pin moisture meters was used to establish the moisture content of the three buildings. According to Grainger (2015), this type of moisture meter can determine the percentage MC (moisture content) on all surfaces irrespective of the building materials in use. Furthermore, it can locate the areas that have a high concentration of moisture and pin-point the exact position that has moisture buildup or damage. The gadget was placed on each floor of the buildings and the readings taken on the scale of zero to one-hundred percent. The pin-less side of the meter that operates on the theory of electrical impedance was able to provide a nondestructive moisture measurement in substrate substances like the concrete floor and the ceiling roofs of the buildings.

Figure 19:Pin-less/ pin moisture meter

Further, the noninvasive or the pin-less side of the moisture meter was able to measure the humidity of the wooden substances in the houses on its wood %MC scale that ranges from

5% to 30%. In addition, the pin-less end of the gadget was placed behind the bathrooms, under vinyl floors, on the shower tiles, and in other different sections of the house to determine the level of dryness of such areas. The ability of the gadget to read up to a distinctive depth of three-quarters to one inch into a subsurface made it easy to detect problems arising from moisture buildup in instances where the visual indicators do not exist. The readings on this gadget from the three sample buildings were then noted down in a tabular form.

The pin side of the moisture meter was helpful in pinpointing the exact location that moisture buildup or damage occurred. For instance, at one point the pin-less side of the instrument was able to indicate that there was a high level of humidity behind one of the bathrooms in the building. However, it was not possible to locate the exact position that had the moisture buildup. Thus, it was vital to use the pin-type side that uses the law of electrical resistance to locate the exact position of damage. The two pins of the instrument were inserted in different positions on the surface of the floor and the percentage MC readings taken accurately to find out the level of dampness.

The pins were able to sink up to a depth of about 5/16 inches, thereby giving a comprehensive reading of the situation. The readings were also taken on wooden surfaces in the buildings on a scale that ranges from 5% to 40% MC. During the measurement, the small percentage moisture content reading could range from 5% to 12%, the moderate content could range from 15% to 17%, and the high content could read above 17%. Besides, the instrument was able to give a signal indication using different colors of light whenever there was a detection of a new moisture condition in the surrounding. For instance, the green light on the moisture meter always indicated that the area was dry and of small or zero moisture content. A yellow

light on the measuring equipment was a sign of the presence of moderate moisture in the environment of the building. Lastly, the indication of red light on the gadget was an indication that the area was under high moisture content that is not suitable for the residents.

The choice of this instrument that has both the scales and the light indicator was to clear up any mystification that might come up in interpreting the percentage moisture content. For example, a person might wrongly interpret the higher rate on the scale to mean low moisture content and a high level of dryness while interpreting low percentage reading to indicate a low degree of dryness and high moisture content. As such, the use of this instrument with a combination of both aspects was helpful in determining the correct level of humidity in the three buildings as shown in the table of results. To maintain accuracy, the measurements were taken twice a day for three weeks before calculating and documenting the averaging measurements in table 1 below.

3.2.2 Temperature

The measurements of temperature were taken to establish the degree of coldness and hotness within the three buildings. Further, the findings could help to figure out the comfort level and the reliability of the three structures and give an explicit recommendation for necessary adjustments. The viable instrument used for this purpose was the thermal imaging camera, which is one of the indoor air quality (IAQ) measuring equipment. According to Williams (2009), a thermal imaging camera is one of the reliable non-contact equipment that can accurately scan as well as visualize the distribution of temperature in an entire room or a machine. The camera converts different temperature to images with different colors by detecting

the invisible infrared rays from the objects and changing them to images. The objects will often appear brighter while the cooler items will be darker. Thus, it was easy to differentiate the areas with high temperatures from those with cooler temperatures. Another advantage of using this type of camera is that it can detect substances even in the dark, thereby making it easy to use even at night.

Figure 20: Thermal Imaging Camera

Before placing the cameras in their designated areas in different parts of the building to detect the temperature level, it was necessary to make the necessary adjustments to ensure high-quality images and accurate results. The first setting was to focus the lens of the thermal camera for precise and quality images. The second step was to set the emissivity of the cameras to ensure the capturing of the correct temperature of the objects. The emissivity of this camera was set at a lower level for objects with high reflective surfaces while a setting of higher emissivity was adjusted for substances with lower reflective surfaces. Care was taken to ensure that the emissivity settings were correct in all cameras because a wrong setting could make colder objects to appear hotter and hotter substances to be colder.

The third setting on the cameras was the reflective temperature adjustment that allows one to recompense for the temperature of the surrounding items that reflects on the primary object. For instance, a reflection of light from a glass outside the room can increase the temperature of the walls. Thus, it is necessary to adjust the camera to compensate for the additional rise in temperature and come up with accurate results. To execute this setting, the camera was moved around any area of the target where there was a suspicion of interference by an outside object. In case the cold spot or the hot spot could move around with the camera, then it was a confirmation of interference but if the spot remained still then the measured hotness or the coldness of the object was real.

The last aspect of settings done on the camera during the evaluation of the buildings was thermal tune it. In this situation, the temperature span or range of the camera was adjusted to improve its viewing while in the manual mode. The setting allows the camera to bring out different colors that depict different temperatures in the building. As such, it was easy to detect areas with high temperatures and regions with relatively low temperatures. After the settings, the cameras were focused on different walls of the buildings, the floors, the ceilings, and various items in the building. To ensure accuracy, the procedure was performed several times for three weeks in all the three buildings and the results recorded in the table 1 below.

3.2.3 Carbon Dioxide

Carbon dioxide (CO_2) gas is one of the most dangerous effluents that can lead to discomfort of people in any building. Moreover, it significantly contributes to the pollution of the environment and depletion of the ozone layers that can result in catastrophic infrared rays from

the sun and the lethal acidic rain. As such, it was necessary to determine its level in the three buildings and make a comparison to understand which one is the most appropriate for human inhabitation. The indoor air quality tool that was used to detect the level of carbon dioxide in these structures was the non-dispersive infrared CO_2 detector. The CO_2 sensor was placed in sampled rooms of the three buildings to establish the standard of the carbon dioxide gas.

The equipment uses an IR (infrared) lamp that directs light waves via a tube containing air towards another IR light detector that records the quantity of light that hits it. After reading the results indicated by the detector, which is a measure of the light that the carbon dioxide in the room failed to absorb, the difference between the quantity of IR light that the detector received and the quantity that the IR lamp radiated was calculated. The result of the calculation was recorded in the table 1 below and is an indication of the level of CO_2 in the building.

3.2.4 Particulates

The primary pollutants in this study include dust particles and other small materials that might not be visible. Research indicates that such particles can lead to congestion of the human trachea, the fact that can lead to complication in the breathing system. Moreover, people who stay in areas where there are many dust particles might develop sore eyes that can impair their eyesight. As such, residents of those areas are not often comfortable since they are living in an environment that does not favor their health. Furthermore, dust particles in the environment often lead to the pollution of the environment and contamination of rainwater. Therefore, it is prudent to regulate the amount of dust within the surroundings of Jeddah to ensure safety and well-being of the residents.

To establish the number of pollutants within the three buildings in Jeddah, the study used the particle counter - one of the indoor air quality tools shown below.

Figure 21:Particle counters

The instrument can detect and record the number of particles passing through its area of focus. During the appraisal, the hand-held type of particle counter was used due to its portability that could make it easy to move it around the building. The counter was moved from part of the room to another in different rooms within the three buildings. Since the device is relatively small, it was necessary to remain in the room for a longer period of up to six hours to decide the dust level present in the room. The findings were then recorded in a table as shown below in table 1.

3.2.5 Electricity Consumption

The consumption of electricity also contributes indirectly to the pollution of the environment within the Jeddah region. Excessive use of electricity will call for an increased production of power using oil and other non-renewable biofuel energy sources. As such, the more the need for the power in the houses, the more the burning of petroleum and that will translate in the pollution of the environment. Moreover, excessive consumption of energy leads

to high cost of living, the situation that leads to lack of comfort among the residents of the houses in Jeddah. The simple watt-hour meter is an instrument used for measuring the level of usage and energy consumed in each of the three buildings.

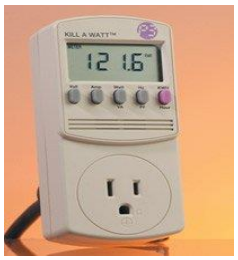


Figure 22: Simple watt-hour meter

The gadget was connected to the electricity meter of the building, and the meter plugged into the wall. The reading on the meter was then taken from every building and the result recorded in table 1 as shown below.

- **Measurements of air components in the three buildings**

Components	**Sha'abi House**	**School**	**Villa**	**Average**	**Digression from ASHARE Max**
Temperature	27	28	26.3	27.1	0.9
CO2	1008	1978	1560	1515.33	515.33
Humidity	72	70	69	70.33%	9.33%

Particulates	20 mg/m3	33 mg/m3	18 mg/m3	2 3.67	No ASHARE reference
Electricity Consumption	8.763 (KWTH) per capita	13 .8	7. 00	9 .85433	7-15 (KWTH) per capita world consumption per capita

Table 1: Measurements of air components in the three buildings

3.3 Quantitative methodology

The primary reason for the use of quantitative approach as a means of appraising the environmental suitability and the level of comfort of these buildings in Jeddah is to get responses from the residents. The questionnaires also allow for the collection of a large quantity of information from several people within a very short period and at a relatively lower cost. The questionnaires in this study were designed to give deeper insight into the condition of the buildings in Jeddah from the perspective of the residents.

There were eight closed-ended questions in the questionnaires, and the respondents were supposed to respond by stating whether they agreed, disagreed, or they were neutral. The questionnaires were administered to a hundred respondents, thirty in each of the three sampled buildings in Jeddah area. The response rate was 90% for each of the building, thus n=90. The participants were selected randomly, with an apparent consideration of both genders to give an even feedback. The questions in the questionnaires aimed at determining the level of temperatures, humidity, pollution, carbon dioxide, and electricity consumption in the buildings through the behaviors of the occupants

3.4 Research challenges and limitations

The current study has a pre-determined time limit which the researcher was able to overcome through a strict timetable. The researcher conducted daily tasks based on the strict timetable for predetermined milestones. In addition financial setbacks were an additional problem during data collection. The likert scale limited due to pre-specified results.

3.5 Ethical Considerations

The researcher was keen to abide with the ethical principles. He sought permission first from the respondents using a preliminary letter. No personal data was collected from the respondents.

Chapter Four: Discussion of the results

4.1 Overview

The project uses two approaches to determine the conformity of the buildings in Jeddah region to the environmental policies as well as to determine their comfort level to the occupants. The objective of the quantitative evaluation of the buildings was to determine the indoor environmental conditions of the construction by examining the level of temperatures humidity, electricity consumption, particulates, and carbon dioxide gas in the building. Further, the purpose

of the case study analysis was to confirm the results of the quantitative appraisal by getting the feedback from the residents of these buildings using questionnaires.

4.2Quantitative analysis

4.34.2.1 Questionnaire of Sha'abi House

o.	Statement	Agree	Neutral	Disagree
1	Is the ventilation in the building poor?	15	9	6
2	Do you feel difficult breathing or experience sore eyes?	20	6	4
3	Are there times that you smell a bad odor in the building?	18	7	5
4	Are there some regions in the structure that is dumper?	22	5	3
5	Are you comfortable with the drainage system in the building?	6	3	21
6	Do you believe that the dust particles in the building relatively higher?	17	8	5
7	Do you believe that the temperature level in the building is relatively higher?	14	8	8
8	Do you believe that the electricity bills are relatively higher?	15	5	10

Table 2: Questionnaire of Sha'abi House

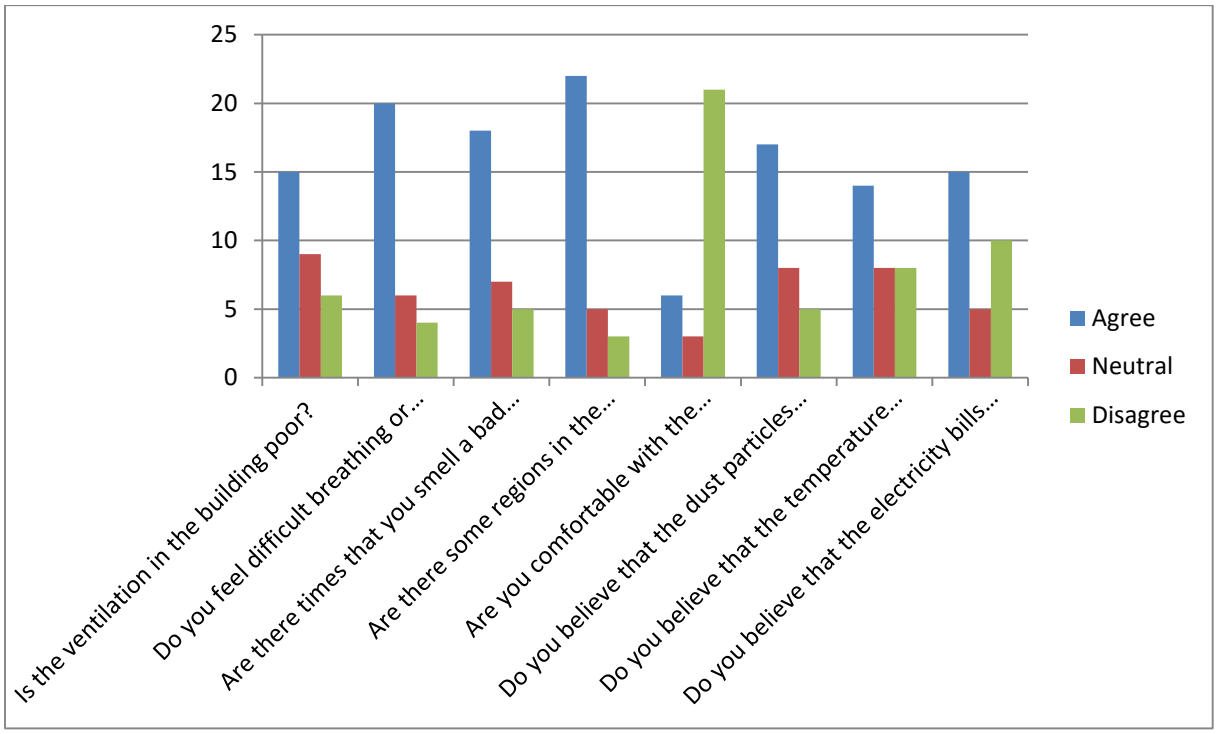


Chart 1:Graphical representation of Sha'abi Hous

4.2.2 Questionnaire of a School

o.	Statement	Agree	Neutral	Disagree
1	Is the ventilation in the building poor?	20	8	2
2	Do you feel difficult breathing or experience sore eyes?	19	6	5
3	Are there times that you smell a bad odor in the building?	25	3	2
4	Are there some regions in the structure that is dumper?	15	7	8
5	Are you comfortable with the drainage system in the building?	0	10	20
6	Do you believe that the dust particles in the building relatively higher?	18	8	4
7	Do you believe that the temperature level in the building is relatively higher?	26	4	0
8	Do you believe that the electricity bills are relatively higher?	16	8	6

Table 3: Questionnaire for a School

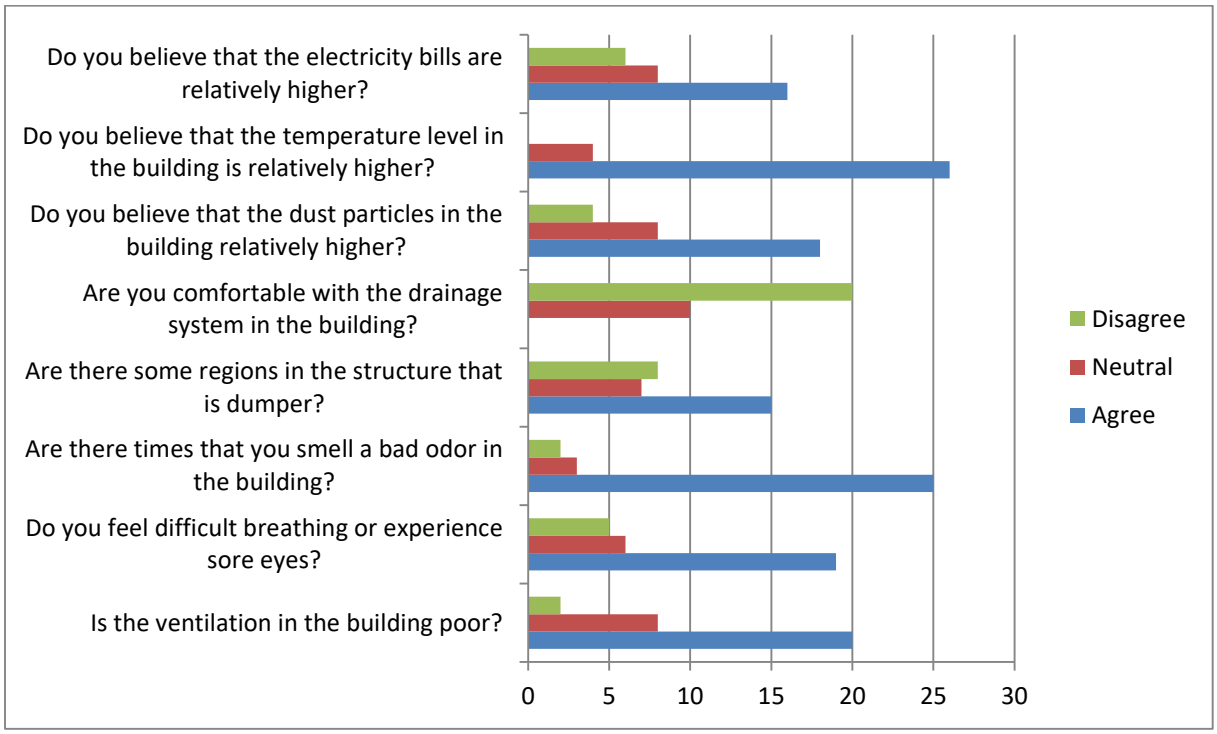


Chart 2: Graphical representation for a school

4.2.3 Questionnaire of a Villa

o.	Statement	Agree	Neutral	Disagree
1	Is the ventilation in the building poor?	17	10	3
2	Do you feel difficult breathing or experience sore eyes?	15	10	5
3	Are there times that you feel bad odor in the building?	10	10	10
4	Are there some regions in the structure that is dumper?	20	4	6
5	Are you comfortable with the drainage system in the building?	8	7	15
6	Do you believe that the dust particles in the building relatively higher?	19	5	6
7	Do you believe that the temperature level in the building is relatively higher?	13	9	8

8	Do you believe that the electricity bills are relatively higher?	21	5	4

Table 4: Questionnaire of the Villa

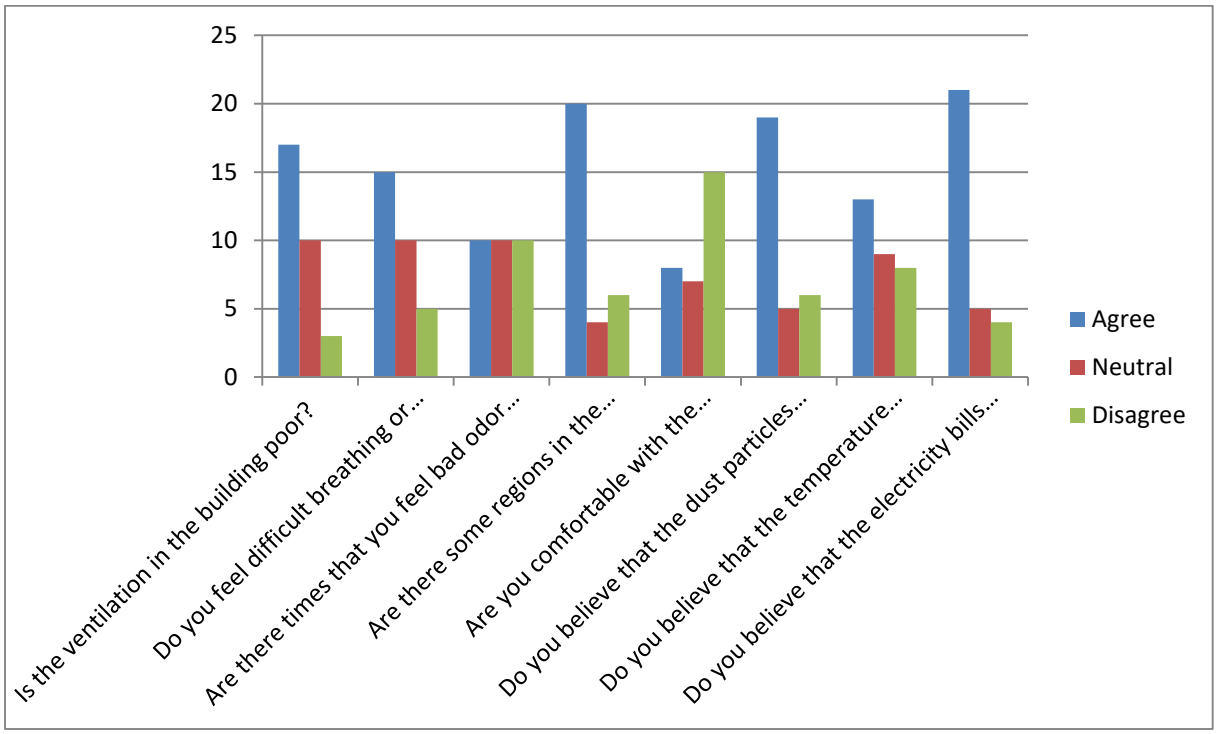


Chart 3:Graphical representation of the Villa

4.4 Discussion

4.4.1 Humidity

From the first examination, the result indicates that the humidity level in all the three buildings is relatively higher in comparison to the 61% standard humidity level as set by the international engineering standard body, ASHARE. Sha'abi house records the highest humidity level with a positive eleven deviation from the international standard level. The main reason for this high humid condition in this building is that it lacks proper ventilation that hinders the

proper circulation of air inside the houses. Observations indicate that the doors and windows of the building are relatively smaller and are sometimes closed hence limiting the flow of air.

Moreover, the designs of the floors are relatively poor hence thwarting the flow of water outside the building. For instance, most floors in the bathrooms and kitchens are flat thereby making it hard for water to flow outside the building in case of any spillage. Similarly, the humidity level in the school is relatively high due to poor designing and construction of the floor and the roofs. As such, a lot of water collects in several corners of the building resulting in damp and humid conditions inside the building.

The humidity level of the school also exceeds the international humidity standards by about nine percent. Even though the humidity level in the villa is relatively small in comparison to the other two buildings, the level still supersedes that of the ASHARE standards by 8%. The main reason for this high humid condition is poor designing of the floors and roofs of this building, the fact that leads to accumulation of water in some areas of the building. Moreover, the ventilation in this building is relatively poor hence hindering the flow of air in the rooms. As such, it is important that the constructors of buildings in Jeddah region consider making the floors of the structures in a manner that facilitates drainage and reduce humidity in these buildings. In that way, they will be augmenting the comfort ability of the occupants and improving the sustainability of the buildings in Jeddah.

4.4.2 Temperature

The temperatures in the three buildings were also relatively higher than the international standards of 26.2 ^{0}C. Sha'abi house has the highest temperature disparity from the ASHARE

standards by a measure of positive 1.8. The primary reason for this rise in temperature is the poor ventilation in this building that blocks the movement of fresh air through the building. Moreover, observation indicates that the residents do a lot of cooking using the electrical gases that result in heating of the houses. Such practices lead to pollution of the environment because as they use more energy, the government will have to combust more oil to produce the needed energy, and that leads to environmental contamination.

The temperature level in the school is also relatively higher in comparison to the international standards. The study depicts that most of the classrooms have poor ventilation in proportion to the number of students in them. In this light, the heat radiated by the student's body contributes in heating the room thus leading to an increase in temperature.

Similarly, the high level of temperatures in the villa is due to inadequate ventilation, which arises from poor designing and construction of the building. As such, it is difficult for the air to flow in and out of the three buildings, the fact that leads to an increase in the temperature. Therefore, the authority in Jeddah should take the initiative to ensure that all the buildings in the region have proper ventilation to facilitate the exchange of hot air and cold fresh air into the buildings. Additionally, the leadership should advise the residents of Villa and Sha'abi house against excessive use heating equipment such as electric cookers to reduce the room temperature and preserve the environment. The approach will ensure the comfort of the occupants of the building and sustainability of the houses in Jeddah area.

4.4.3 Carbon Dioxide

The study result also indicates that the level of carbon dioxide in all the three buildings is comparatively higher than that of the ASHARE level of 1000.00. Sha'abi house again records the highest level of carbon dioxide gas in its internal environment at 1978.00 cm^3. The reason for this inflation in the CO_2 level is the poor ventilation in most rooms of the building. As such, the carbon dioxide gas that mostly comes from the exhalation of air by human beings concentrates in the house instead of finding its way to the external surrounding. Furthermore, the gases that come from other activities in the rooms such as cooking do not find their way out, thus leading to high level of carbon dioxide gas in the room. Likewise, the school has poor ventilation due to poor designing and construction.

The numerous students in the classrooms exhale large quantity of carbon dioxide gas, but the latter does not find its way to the external environment because of reduced exposure to air. The villa also records a slightly higher level of carbon dioxide gas in comparison to the ASHARE standard level of 1000.00 cm^3. Observation indicates that poor designing of these houses that put limited ventilation spaces is the significant contribution to the high level of CO2 gas in the buildings. In this regard, most of the inhabitants are always uncomfortable while inside the building because high levels of carbon dioxide gas causes difficulties in breathing. Therefore, it is necessary that the authority in Jeddah advise the designers and constructors to consider aerating the rooms to improve the flow of air.

4.4.4 Particulates

Even though there are no ASHARE standards for the particulates level, the research indicates that the dust level in these three building is relatively high and can be hazardous to both

the environment and the people. The school building has the largest level of particulates at 33 mg/m3, while the Sha'abi house is second with particulate concentration of 20 mg/m3, and villa has the lowest particulate level at 18 mg/m3. The primary reason for the high particulate level in school is that the many students who stir up dust as they walk or play.

Besides, the poor aeration in the building does not allow the dust particles arising from such movements to escape to the outside environment. As such, the particles concentrate in the room hence raising their levels in the building. Similarly, the poor ventilation in the sha'abi house and villa are the primary reason for the high level of particles in such premises. Furthermore, the construction sites of these buildings encourage dust particles to enter the room since they are next to areas of mining. As a recommendation, the designing and construction of houses in Jeddah region should give priority to the ventilation as its absence leads to discomfort in the building.

4.4.5 Electricity Consumption

The result of the study also indicates that electricity consumption in the three buildings exceeds the ASHARE standards by approximately 7-15 (KWTH) per capita. The school building is leading in the use of power because of the computers and other heavy machinery it uses to enhance their study. On the other hand, Villa and sha'abi house record high level of electricity consumption because most residents there have many electronics that consume a lot of power.

For instance, due to high temperatures in the rooms, almost all the inhabitants of these buildings have roof fan to at least cool down the chambers. In addition, some of the residents have electric cookers, fridges, televisions, electric irons, and radios among other electrical appliances that consume a lot of power.

Research indicates that excessive consumption of power will automatically lead to the pollution of environment because the government must extract and burn more oil to produce electric power. Moreover, it reduces the comfort level of the residents since they will have to part with extra money in payment of electricity bills. Therefore, all the buildings in Jeddah should have a design that guarantees proper ventilation to reduce the need for cooling the rooms. In this way, the buildings in the region will be sustainable, and the comfort level of the residents will increase.

4.6 Quantitative Approach

The result from the quantitative survey using the questionnaires indicates that most people in all the three buildings agree that the buildings have inadequate ventilation. In addition, a majority of the respondents indicate that they often have trouble in breathing, and sometimes they experience sore eyes. As such, it means that the air around the buildings has excessive dust particles and high levels of carbon dioxide that causes difficulty in breathing and sore eyes.

Further, the outcome indicates that most of these people of smell bad odors coming from around the building. It is most likely that such foul smell is arising from dump conditions that cause high humidity within the buildings. Moreover, the bad small is due to poor designing and construction of the buildings that creates improper aeration in the building. As such, fresh air cannot flow in to remove any bad smell within the houses and the schools. Most people in these

building also feel that the drainage systems within the houses are not appropriate, hence making them uncomfortable. Further, most of the respondents believe that there excess dust particles within the building that could lead to health complications.

The response signifies that the ventilation in the building is poor hence encouraging concentration of particulates within the houses. Another response confirms that most of the inhabitants of these buildings believe that the temperatures are relatively high within these structures. Additionally, the majority of them believe that the cost of electricity is relatively greater in these houses in comparison to other buildings. It means that they spend a lot of electricity in fans and fridges as they try to cool down their rooms. Therefore, it is evident that most of the buildings in Jeddah are not comfortable and lack sustainability due to their poor design and constructions. As a recommendation, the authority of Jeddah should ensure that the ventilation in these buildings improves to augment their conformity to environmental policy as well as make them comfortable for inhabitation.

Chapter Five: Conclusion and Recommendations

5.1 Conclusion

The conclusion is based on the primary and secondary findings in addressing the following questions as covered in chapter 1:

- What are the links between the current sustainability problems and their root causes in Jeddah?
- What is the local vernacular architecture on the inside environment in Jeddah?

- What is the most suitable, applicable and sustainable solutions that can be implemented in the building industry in Jeddah?
- What is the cost-efficiency of sustainable models?

Based on the results, the present condition of buildings in Jeddah does not observe sustainability principles. The measurements of temperature, humidity, CO2, and particulates exceed the international acceptable level. However, the villa type represented more comfort because it is a closed type of building, which makes it less exposed to the outdoor atmosphere. Needless to say, Saudi Arabia globally ranked to be amongst top in CO2 emissions as an oil producing country. Moreover, the measurement of the air components showed that they exceed the ideal level set by ASHARE standards. This is due to the fact that the educational building and the traditional house were open and exposed to the outside atmosphere more often than the villa.

This leads to the conclusion that Jeddah still has a long way to go to attain sustainability. Since Saudi Arabia is among the highest consuming country of electricity, it means that it actually produces much electricity by burning much fossil fuel, and, consequently, emits huge amounts of CO2. This electricity is mostly consumed to air condition buildings, and this is a normal rate because the country and Jeddah, in particular, have undergone a tremendous process of urbanization.

The surveys showed that the sample's opinions were nearer to dissatisfaction with current condition as embodied in lack of comfort in the three types of building in terms of feeling hot, opening the windows, taking off the jacket, feeling tired without an obvious reason and sweating. This indicates that the level of comfort among the occupants is not satisfactory.It is apparent that the residential environment of Jeddah has experienced radical changes. The traditional heritage

for the Old City's buildings shows that there is a need to include and appreciate the factors of the nature to have a convenience and convincing focus towards suitable buildings.

The study has provided a thoughtful approach that Jeddah City has been a historical economic hub, the platform centre for commercial business opportunities, and that has promoted technological advancement, an experience that has followed the needed approach for sustainable buildings. There are two imperatives that are required for the shift to sustainability in buildings in Jeddah City:

1. a need to examine the importance of the state interference to make the crucial, strategic and fundamental shifts was one of the primary reasons for the current study;
2. global warming which created global energy shifts and environmental pollution based on the industrial and technological advancement apparent in the recent centuries other than the demographic explosion formed the reason for the current study.

5.2 Recommendations

Based on the results above, the current research adopts the following recommendations.

1. The current authorities Jeddah City have to recognize the need to have designs that caters for the effects emerging from the presence of the warm temperatures and the level of humidity. Accordingly, a shift in the climate is an incentive rather than a hindrance to developing suitable structures. Not only do the defects of the atmospheres, water, and the entire ecological system direct new knowledge for Jeddah City authority, but also offer

an opportunity for whole Kingdom of Saudi Arabia to integrate green designs that uphold sustainability.

2. It is for the beneficial part that Kingdom of Saudi Arabia recognizes the call for policies and strategies that would generate and maintain the mobilization, management, controlling, and organization of the resources to achieving the plans for sustainable building in Jeddah. Among other changes in the region's economic development, the oil economy has generated environmental problems that will eventually distort suitable buildings. Through the Kingdom of Saudi Arabia has made a commitment to effectively implemented strategies that support sustainable development, there necessitates increase national development plans that directs steady progress in terms of environmental legislation. Some of the plans that could complement sustainable buildings in the cities are implementing sustainable energy planning, waste management, and managing the marine pollution and the ecological effect.
3. There calls a need to have measures to cater for increased additional costs that go beyond the adequate technological standards. Jeddah City is among the fastest growing economy because it has embraced financially viable development from the gains of the available energy resources. The main challenge to this benefit is that there are increased costs in terms of improving the thermal comfort. The emissions from the energy resources in the form of CO2 and thus the global warming have attracted increased costs to have additional thermal comfort conditions. Measures such as increasing the size of the windows to allow maximum daylight as the attempt to improve the thermal insulation has not been effective. The authority must go beyond the current technological standards.

Investing into appropriate comfort and suitable designs would help save the additional costs.

4. Following the standards of the climate-responsive design, especially the vernacular architecture to design new houses, could improve the level of energy of performance for Jeddah buildings (Taleb&Sharples, 2011). Together, the authority and the public should foster a transition to the sustainable energy that addresses the need for practical buildings that retrofit the existing buildings.
5. An effective way for Jeddah designers to control the internal humidity is situate passive ventilation through cross ventilation. Also, to ensure good ventilation, the designers should have suspended timber floors. Besides, insulation can significantly reduce the level of humidity (Pacheco, Ordóñez&Martínez, 2012).
6. Initiating public awareness programs with the intent to instil the need to have efforts to appreciating conservation of the natural resources would be another path that Jeddah City to follow. The most effective way to make this happen is to initiate efforts where the occupants have information about how to participate actively in energy conservation to promote optimal performance (Pacheco, Ordóñez&Martínez, 2012).
7. The government through the relevant agencies should allocate the fundamental resources and hence create awareness as regards to sustainable architecture among the relevant parties including the general public, engineers, and the architects.
8. The Municipalities must adopt creative measures in encouraging the energy conservation sites as well as the building design. Adopting the latest effective codes and having the

necessary professionals or trained personnel to facilitate the implementation of the process could create and encourage energy conservation.

Significantly, there is hope that the study will provide a good base for future study, will be useful for decision makers, and will help provide a better understanding of the housing conditions of the city.

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Appendices

Appendix (A)

Table (1) Pollutants Limits for "Healthy Indoor Environment"

PARAMETER	IDPH	ASHRAE	OSHA PEL *	ACGIH TLV **
Humidity	20% - 60%	30% - 60%	N/A	N/A
Temperature	68° - 75° (winter)	68° - 75° (winter)	N/A	N/A
	73° – 79° (summer)	73° - 79° (summer)		
Carbon Dioxide	1,000 ppm	1,000 ppm	5,000 ppm	5,000 ppm
	(<800 ppm preferred)			
Carbon Monoxide	9 ppm	9 ppm	50 ppm	25 ppm
Hydrogen Sulfide	0.01 ppm	N/A	20 ppm	10 ppm
Ozone	0.08 ppm	N/A	0.1 ppm	0.05 ppm
Particulates	0.15 mg/m^3 (PM 10) (150 $\mu g/m^3$) 24-hr 0.065 mg/m^3 (PM 2.5) (65 $\mu g/m^3$) 24-hr	N/A	15 mg/m^3 (total)	10 mg/m^3 (total)
			5 mg/m^3 (resp.)	3 mg/m^3 (resp.)
Formaldehyde	0.1 ppm (office)	N/A	0.75 ppm	0.3 ppm
	0.03 ppm (home)			
Nitrogen Dioxide	0.05 ppm	N/A	5 ppm	3 ppm
Radon	4.0 pCi/L	N/A	100 pCi/L	4 WLM/yr (working level months/year)

Appendix (B) Questionnaire

Building Sustainable Buildings in Jeddah

SECTION A: Personal information

1. Gender
☐ Male
☐ Female
2. Age
☐ 16-30
☐ 31-45
☐ 46-60
☐ Above 60

SECTION B: Questionnaire of Sha'abi House

No.	Statement	Agree	Neutral	Disagree
1	Is the ventilation in the building poor?			
2	Do you feel difficult breathing or experience sore eyes?			
3	Are there times that you smell a bad odor in the building?			
4	Are there some regions in the structure that is dumper?			

5	Are you comfortable with the drainage system in the building?			
6	Do you believe that the dust particles in the building relatively higher?			
7	Do you believe that the temperature level in the building is relatively higher?			
8	Do you believe that the electricity bills are relatively higher?			

SECTION C: Questionnaire of a School

o.	**Statement**	**Agree**	**Neutral**	**Disagree**
1	Is the ventilation in the building poor?			
2	Do you feel difficult breathing or experience sore eyes?			
3	Are there times that you smell a bad odor in the building?			

4	Are there some regions in the structure that is dumper?			
5	Are you comfortable with the drainage system in the building?			
6	Do you believe that the dust particles in the building relatively higher?			
7	Do you believe that the temperature level in the building is relatively higher?			
8	Do you believe that the electricity bills are relatively higher?			

SECTION D: Questionnaire of a School

o.	**Statement**	**Agree**	**Neutral**	**Disagree**
1	Is the ventilation in the building poor?			
2	Do you feel difficult breathing or experience sore eyes?			
3	Are there times that you feel bad odor in the building?			

4	Are there some regions in the structure that is dumper?			
5	Are you comfortable with the drainage system in the building?			
6	Do you believe that the dust particles in the building relatively higher?			
7	Do you believe that the temperature level in the building is relatively higher?			
8	Do you believe that the electricity bills are relatively higher?			