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Prospects for improvement in the design of residential buildings in Jeddah integrating passive ventilation systems and enhanced family interaction

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Abstract

Background: This thesis proposes that in order to provide house residents with an environmentally, socially, and culturally sustainable dwelling, three key factors must be considered together: the architectural design, the family social life within the house and the environmental technologies and systems employed to maintain thermal comfort. Currently, the majority of the existing literature focuses on linking only two of these three research areas, therefore there is a lack of existing research linking these three areas.

Since the economic boom in the Kingdom of Saudi Arabia in the 1970s, subsequent decades have seen many innovations in the design of housing types in Jeddah, and other Arab cities. These have included so-called 'modern style' apartments and villas, while traditional house types have come to be seen as obsolete and unpopular. In line with these changes, air conditioning has been developed and widely adopted in residential buildings. As a result, the layout and spatial organisation of residential units have radically changed. Traditional passive ventilation features – such as the courtyard, windcatcher and others – have disappeared and so have the social spaces associated with them. Family members have therefore become isolated within their separate living areas and this has had a negative impact on the quality of social interaction within the family dwelling.

Aim: The aim of the thesis is to explore the prospects for improving the design of residential building by reintroducing some traditional passive environmental systems. It is based on the proposition that the use of these traditional environmental systems would allow a more family-oriented spatial organization, therefore improving both the social aspects of living in the house and enhancing its energy performance.

Method: the research follows a mixed method approached that includes three phases. Firstly, an observation of Jeddah building typology. Data for the second phase were collected through 302 questionnaires which subjected to descriptive statistic for frequencies and Chi-square statistical test. The third phase included 23 semi-structured interviews where the data were thematically analysed. In both phases the data collected (questionnaires and interviews) counted as a dwelling. This research design allowed the researcher to highlight the changes that have happened in Jeddah residential buildings over time and after the introduction of air conditioning. Additionally, to collect and analyse house residents' views regarding the potential for revised spatial layouts (incorporating passive ventilation systems inspired by traditional Jeddah houses) to lead to better family social interaction, as well as lower energy consumption.

Finding: The research main finding is that changing to passive ventilating systems could affect spatial organisation which may in turn effect social interaction. Data revealed that most Jeddah house residents would accept the use of traditional passive ventilation elements designed in a contemporary way. The finding also suggested that these design alternatives could result in lower residential energy consumption – helping to reach the Saudi Vision 2030 – at the same time as providing dwellings that are more culturally and socially satisfying for Jeddah house residents to inhabit.

Author's Declaration

I confirm that the work presented in this thesis is my own. Where information has been derived from other sources, it has been indicated.

Acknowledgement

شكرا لك ربي ... خلقتني، علمتني رزقتني واكرمتني

فلك الحمد ولك الشكر حمدا كثيرا

شكرا الى من أورثاني ملامح وجهيهما ... امي وابي

شكرا الى نبض قلبي ... هديل زوجتي

شكرا الى الشموع التي تنير حياتي ... ابنائي حسين وفارس ومالك

شكرا الى سندي في هذه الحياة اختي واخواني

شكرا الى من تناثروا حولي لدعمي ومساعدتي ... عائلتي وأصدقائي

Firstly, I would like to express my gratitude and thanks to Allah for blessing me with the ability to study and work hard for my future.

Then, often, it is hard to explain what I want to say because words are not enough to reflect my feeling and show appreciation for what people surrounding me have done. So, I decided to use simple words.

I would like to thank my father and mother for their endless love, support and prayer for me, my lovely wife "Hadeel" who believed in me, my sons "Hussain, Faris and Malik" who inspire me to always do my best and being patient about my different moods and not spending much time with them, my family and friends who have encouraged me and supported me.

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Chapter 1: Introduction

1.1. Introduction

In Jeddah city, while designing a residential building, the architect and the house residents mainly focus on the resident's physical needs such as the number and size of rooms and the spatial organization which is reflected in the form of the residential building. Besides that, the architect is mainly responsible for the type of environmental technology and systems used in the residential building. The term 'environmental technology' used in this research relates to mechanical air conditioning types such as the window unit, the split unit and the central unit. In addition, the environmental systems relate to the passive ventilation system that requires using different elements such as the windcatcher, courtyard and others.

Unfortunately, in recent years, focus has been increasingly placed on the house residents' physical needs and reflecting these needs through the building form depending on the different air conditioning technology and systems. In other words, it is common to focus on the spatial organization of the house and the resident's needs because the air conditioning is a flexible layer that can be added and adapted to any residential building design.

This thesis will test the view that focusing on the house residents' physical needs on the spatial organization and the environment technology or systems used only while designing the house does not provide the house residents with a satisfactory dwelling because, to a high extent, it does not reflect the house residents' way of engaging with the different spaces and the house residents' social needs. While the social needs, in this research, to encourage the residents to interact in one space for a longer period of time because of the importance to religious and cultural practices. Furthermore, each of the research areas have different sets of complex factors that influences its provision, for example, the spatial organization is regulated with the municipality building regulation, the cost, the lot and building size and others. Another example: the residents' social interaction is controlled by the resident's culture and lifestyle. Finally, the environmental technology and systems are affected by availability, the building size, cost, and others. Consequently, the residential building's spatial organization, the resident's social needs and the environmental technology and systems used must be combined together well to provide a dwelling for the residents. Moreover, if one of the three areas is changed, the other two areas could be affected and changed. This thesis will explore this three-way relationship and will assess the attitudes of different stakeholders to potential changes in housing design strategy.

This thesis is divided into nine chapters that are distinct in their character yet share common narratives of how the links between the spatial organization, the house residents' interaction and the environmental technology and systems used in the residential building could provide a more effective and sustainable dwelling for its residents. In addition, it shows how affecting any of the three areas could lead to affecting the other two areas. The content of each chapter is summarized as follows:

Chapter 1: is an introductory chapter that sets out the research gap, scope, aims and objectives. In addition, it highlights the research questions, and contribution.

Chapter 2: is the literature review. This chapter shows the links between the three research areas such as the link between the spatial organization and the residents social interaction, the link between the environmental technology and system and the spatial organization and the link between the environmental technology and system and the family social interaction.

Chapter 3: a technical literature review that discusses Jeddah microclimate, ventilation, cooling and thermal comfort.

Chapter 4: shows the methodology that the research was expected to follow to answer the research questions.

Chapter 5: this chapter gives a background of Jeddah city and the different building typology. This chapter has two residential building case studies from different periods, one from the 19th century and the other is a contemporary residential building. In addition, there is a third contemporary residential building case study that was built using a traditional design. The discussion in this chapter compares the different spatial organization and the environmental technology used between the two buildings.

Chapter 6: illustrates the results of the Jeddah house resident's questionnaire survey.

Chapter 7: illustrates the result of Jeddah house residents' semi-structured interviews.

Chapter 8: discusses, based on the literature and finding, if the house residents will use the passive ventilation system or not. This chapter also shows the researcher's recommendations.

Chapter 9: is the conclusion.

1.2. Research gap

The majority of the contemporary residential buildings are dependent on providing the residents with functional spaces without considering the quality of living within these spaces such as the resident's social needs, thermal comfort, natural ventilation, natural lighting, a good view or others. According to Heidegger (1971) the typical 'functional' house could be described as a gathering of spaces for the resident to reside in but not to actively engage with. On the other hand, Heidegger (1971), Mallett (2004) defined dwelling as the place that its residents can engage with, control their living space and how they spend their time in it. Chermayeff and Alexander (1963) point out that the reason for not having dwellings is that the building does not really reflect the resident's needs within the house. These needs could be either social or physical needs. However, it should be noted that these scholars failed to give a clear justification as to why the house residents are not engaging with the space and how to provide a high-quality space that helps the house residents to engage with it. Banham (1984) and Lea (1994) associated the reason for not engaging with the space to the change in the technology in the building, especially the daily used technology, such as the environmental, media and other types of technology that could affect the function and geometrics of the space and the lifestyle of the residents. Selwyn (2003) argued and pointed out that technology in general is making life easier and should help to engage with the space. Selwyn (2003) also added that the different technologies do not have any effect on the house resident unless they totally accept and depend on it. Such expositions are unsatisfactory because the house resident might not have the power to decide what environmental technology or system could be used in the house or might not be aware of what other alternatives could be used. Moreover, Al-Jamea (2014) stated that focusing on providing functional buildings will not lead to having sustainable buildings. One possible explanation for not having a sustainable building could be that the residents are applying changes in the space that could affect the design. These changes could be the way in which the house residents are reflecting their way of engaging with and using the different spaces. Another explanation could be that these buildings use high energy consuming gadgets such as air conditioning.

Changing to the use of air conditioning or passive ventilation systems in the contemporary house could have an effect on the spatial organization especially that it is necessary to design a house that benefits from the outdoor weather conditions (AlAnzi et al., 2009, Konya, 2013). Unlike the traditional houses that depend on passive ventilation systems, the air conditioning is the most important environmental technology for Jeddah house residents nowadays because of the harsh climate conditions. Interestingly, the majority of the contemporary houses depend on different air conditioning units. Moreover, Al-Kodmany (1999), Basalla (1988), Lawson (2001) discussed how using new different technologies could change the architectural design and how it could also change the social and cultural values, for example, fragmenting the living room or changing the use of the room; particularly because the house resident's habits and way of living have changed nowadays (Mandilaras et al., 2013). Consequently, these changes lead to changes in the house design and the family social interaction. On the other hand, Rapoport (1969) argued that the house residents' needs of the space and its function remain the same even after using new different technologies, but the image of the space could change. In other words, the house residents' social requirements did not change but the way of reflecting it on the house changes. Unfortunately, most studies in the field of technology failed to link the effect of improved technology on both the architectural design/elements and social interaction.

Many scholars hold different views regarding the uses of environmental technology and systems in the house and its effect on energy consumption and the thermal mass. For example, Mandilaras et al. (2013) claimed that using different building materials could help to reduce energy consumption without changing the use of the air conditioning. Almumar et al. (2018) agreed with (Mandilaras et al.) and explained that the different building materials have different thermal mass capabilities that could help to reduce the amount of conditioning to cool a space. On the other hand, Butters (2015), Foruzanmehr and Nicol (2008) and Taleb and Sharples (2011) argued that the air conditioning, as one of the most popular environmental technologies nowadays, is the highest energy consuming device in the house regardless of what building materials are used. The argument (Butters, Foruzanmehr and Nicol, Taleb and Sharples), might lack understanding of how the thermal mass of the different building materials could affect the amount of the conditioning required in a space. However, using technology that consumes large amounts of energy will not really help the Saudi Vision 2030 reach their goals of reducing energy consumption, especially in the housing sector (Alwetaishi and Balabel, 2016, Vision2030.gov.sa, 2016). Thus, it might be recommended to use other environmental solutions such as the new passive ventilation systems to meet the aim of reducing electricity consumption and to have higher quality indoor air.

Jeddah contemporary houses could use passive ventilation systems in two ways. The first way is by reusing the traditional passive ventilation elements inspired from Jeddah traditional houses such as the windcatcher, Mashrabiyyah (wood lattice screens) or courtyard. This could be by modifying and tuning the passive ventilation elements and their functions, but it is essential to take into consideration that using these elements is highly expected to affect the spatial organization of the house. Moreover, Abdulkareem (2016), Ford et al. (2010), Mirhosseiniardakani (2016), Kamal (2012) describe how using these elements could help to reduce the conditioning load in the residential building and to provide thermal comfort to its residents.

The other way is by using new passive ventilation systems, such as providing the building with a double façade, natural ventilation, slap cooling, fan or evaporative cooling (Ahmed et al., 2014, Saranti, 2006, Short et al., 2004). However, the new passive ventilation systems could be applied to the contemporary houses, but they might have a minor impact on the spatial organization. Unfortunately, the researchers to date have tended to focus on using passive ventilation systems to provide thermal comfort for the building users and reduce energy consumption rather than focusing on if the passive systems could also lead to improving the spatial organization, particularly defragmenting the family meeting room to enhance the family social interaction.

Previous studies were conducted on the traditional buildings in Jeddah, but these studies mostly described the different spatial organization of the buildings or were history oriented to the social life of the house residents. Regrettably, most of the studies focus on reflecting the social life of the residents in the house without questioning if changing the technology could help to achieve their goal. However, according to Foruzanmehr and Nicol (2008) utilising the traditional solutions were not major subjects for current researchers. Therefore, most of the researchers described how the houses were designed, the different space’s use and geometrics, what the traditional elements were and their different functions, such as (Alharbi, 1989, El-Shorbagy, 2010a) and others. Furthermore, Müller and Reichmann (2015), Suvanajata (2001) and others discussed the importance of reflecting the different social and cultural values in the space. But they failed to suggest solutions on how to reflect the social and cultural values in the space. Moreover, Bekleyen and Dalkiliccedil (2011) and Al-Jamea (2014) point out that there are a number of social factors that could be reflected by the house residents in the different spaces, but the most important one is privacy. Additionally, Al-Azzawi (1996) and Bekleyen and Dalkiliccedil (2011) defined the residents' social life in the house as the family social interaction in the space and the resident movement between the different spaces. Thus, the family interacting in the different spaces and moving between them to avoid interaction in rooms with higher temperatures could be the way that Jeddah house residents engage with the different spaces in their houses.

In conclusion, the previous studies mainly discuss three areas, which are the architectural design, the resident social interaction and the environmental technology and systems used in the residential buildings. Nevertheless, these studies focus on only linking two of these areas together i.e. either the effect of the building design on the residents social life, the effect of environmental technology and systems on the building design or the residents social life, but they do not link the architectural design, the residents social life and the environmental technology and systems together. In other words, there might not be a comprehensive study that discusses the effect of passive ventilation systems (either traditional or contemporary) on the house design and consequently, on the resident's social interaction.

This thesis will try to discuss how the spatial organization, environmental technology and systems and the residents' social interaction are strongly linked together by studying what impact replacing the air conditioning with passive ventilation systems could have on the spatial organization and the family social interaction. The reason for selecting air conditioning and passive ventilation systems is because it is one of the areas that is rapidly developing. In addition, the house residents depend on the air conditioning to provide them with an acceptable indoor atmosphere especially in Jeddah city that has a harsh climate. Finally, selecting the passive ventilation systems that depend on using a set of architectural elements is because it has an effect on the spatial organization.

1.3. The research scope

The research engages with three main areas, which are the architecture of Jeddah houses, the Jeddah house resident social interaction and the environmental technology and systems, see Figure 1. the architectural area, which discusses how the spatial organization was affected after shifting from using passive ventilation systems in the traditional houses to using active air conditioning in the contemporary houses. Also, how the spatial organization could be affected if the residents accept shifting from using air conditioning to using passive ventilation systems. The second area is the resident's social interaction in the house. This area will discuss how the change of the air conditioning and the passive ventilation systems and its effect on the spatial organization has affected the family social interaction in the house. It will also discuss what the family's needs are within the different spaces to enhance their social gathering. The final area focuses on environmental technology and systems which discusses three issues. Firstly, the use of traditional passive ventilation systems that depends on a number of elements. Secondly, the effect of the air conditioning on the spatial organization. Finally, the possibility of using passive ventilation systems and elements in Jeddah houses.

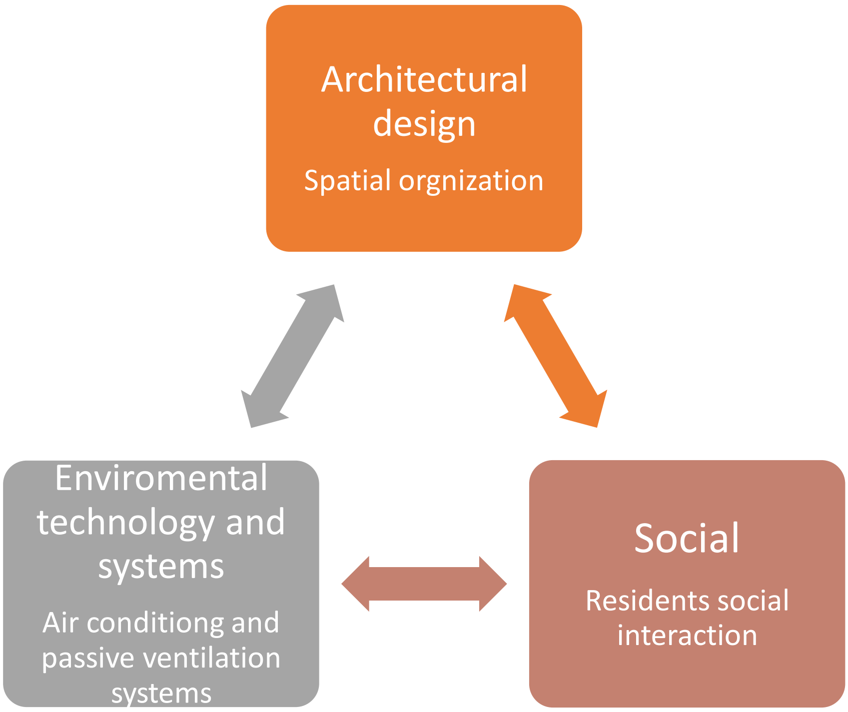


Figure 1 the research areas

Although the three areas are strongly linked together, changing one of them could lead to affecting and changing the other two. For example, Figure 2 shows that changing to air conditioning led to changes in the residents social interaction. Moreover, the improvement in the air conditioning and its effect on the family social interaction affected the spatial organization within the house. Another example is the changes in Jeddah house designs that result from importing designs from other countries since the 1970s. The changes in the designs and the spatial organization affected the resident's way of living in the house and the use of air conditioning in the house. Hence, this research will explore if shifting back to using the passive ventilation elements, in a contemporary way, could improve the spatial organization of

Jeddah houses. Also, it will ask if reintroducing passive ventilation systems could enhance the resident's social interaction, and finally, whether these changes would be acceptable to Jeddah house residents.

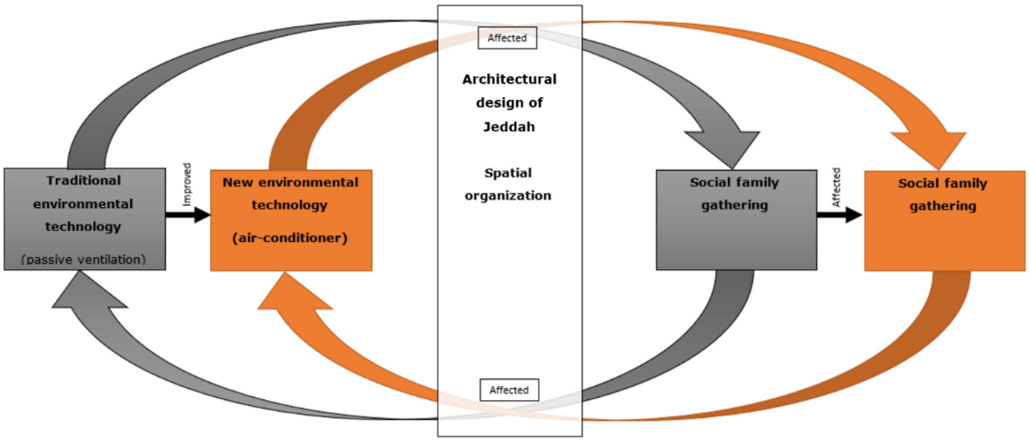


Figure 2 the result of changing one area on the other areas

1.4. Aims and objectives

The aim of the research is to explore how reusing the passive ventilation systems (alone or combined with the air conditioning) could help to affect the spatial organization and improve the house resident's social interaction. In other words, how the spatial organization, the environmental technology or systems and the house resident's social interaction are linked together to have a better dwelling for the house residents in Jeddah. Also, to what extent Jeddah house residents are willing to accept using the passive ventilation systems in their houses. In order to address this broad aim, more specific objectives are listed as follow:

1. Highlighting the changes in residential building spaces over time, since the introduction of the air conditioning.

2. To examine the relation between the architectural design, the environmental technology or systems and the house resident's social interaction.

3. To explore how the reuse of the passive ventilation systems inspired from the traditional houses could affect the spatial organization, the resident's interaction and the power consumption.

1.5. The research questions

1. What changes have taken place in the design of Jeddah residential buildings since becoming dependent on the use of air-conditioning to achieve thermal comfort?
2. How are Jeddah house residents dwelling in the contemporary houses, and how have these changes affected their social interaction within the house?
3. What effect could reusing passive ventilation systems have on the spatial organization, the residents' social interaction and the reduction of energy consumption?
4. To what extent would Jeddah house residents be willing to accept the reintroduction of traditional passive ventilation systems?

1.6 The research contribution

This research made a new and original contribution to the existing knowledge by exploring to what extent there is a link between the architectural design (spatial organization), the house residents' social life (family social interaction) and environmental technology and systems (air conditioning compared with passive ventilation systems) used in the house. Furthermore, it assesses the attitude of Jeddah residents to the potential reintroduction of passive ventilation technologies and the extent to which this could lead to better spatial organisation, improved quality of life and the reduction of power consumption - as well as better reflecting the residents' cultural identities. Finally, it identifies links between the three main research areas with a view to making improvements in residential design not only in Jeddah city, but elsewhere in Saudi Arabia and possibly worldwide.

Chapter 2: the literature review, the link between the three research areas

2.1 Introduction

The research explores how linking the architectural design (spatial organization), the house resident's social life (family social interaction) and the environmental technology and systems used in the house (the air conditioning and the passive ventilation system) could lead to providing Jeddah city house residents with a dwelling that reflects their social needs and consumes less energy. In addition, the research explores how changing any of the research areas could lead to affecting the other two areas. However, although previous studies discuss these areas, they focus on only linking two of these areas together i.e. either the effect of the architectural design on the social life, the effect of the environmental technology and systems on the architectural design or the social life. In addition, the previous studies show different strengths between the different areas. For example, the strongest link could be between the architectural design and the environmental technology and systems and the weakest link could be between the environmental technology and systems and the social life. Unfortunately, there might not be a comprehensive study that links the three research areas together and discusses the effect of changing one of the areas on the others.

The Saudi National Transformation Plan that is called Vision 2030 was announced in May 2016. The Vision 2030 has a lot of goals, one of these goals is to increase residential ownership from 48% in 2016 to 64% by the year 2030. Therefore, the Saudi government provides its citizens with either pre-built houses or non-profit loans to be used for building new houses. Another goal is to reduce the dependency on oil revenues and to increase the development of non-oil revenues (Vision2030.gov.sa, 2016) . As a result, one of the directives that the government is acting on is to reduce energy consumption, to enhance the sector of renewable energy, and to use it in a wider range of the government and private sector projects. Another directive is to improve energy saving techniques in all life sectors, especially in residential buildings (Alwetaishi and Balabel, 2016). Jeddah residential building energy consumption 17.6 MWh per dwelling (Electricity & Cogeneration Regulatory Authority, 2020). Moreover, up to 80% of the energy used in the house's area can be attributed to air conditioning (Vision2030.gov.sa, 2016). To a high extent, most of the plans discussed in the vision 2030 focus on the quantity and quality of the building, but they do not discuss the quality of living in the building. In other words, they focus on linking the architectural design with the technology that helps to reduce energy consumption, but they do not consider the house residents' social life needs within the house.

At first it might be important to define what a house is from the scholar's point of view and what the different house residents' understanding of a house are. In general, Cooper (1974) defined the house as the physical fabric that surrounds its resident. However, in order for the resident to adopt this physical fabric, they could furnish it in their preferred way, hang pictures on its walls and others. In other words, the house residents could reflect their image of themselves on the different spaces in the house. On the other hand, Mallett (2004) and Lawrence (1987), argued (Cooper) and pointed out that a house is not a place that is inhabited by physical things and belongings, but the house spaces must be inhabited by the resident's activities and relationships. In other words, the house is a reflection of the resident's culture and lifestyle. In addition, Dupuis and Thorns (1996), agreed with (Mallett) that a house is a "Source of personal identity and status and a source of personal and familial security". In other words, a house is a place and space where people can retreat and relax (Moore, 1984).

Recently, because of the technological and economical changes, the understanding of the house, to some extent, has changed. For example, nowadays, the house could include traditional functional spaces such as a dining room or a living room and could have new functional spaces such as an office, playroom or a reading room. Although this new function could affect the spatial organization and the resident's understanding of the different spaces, they might reflect the resident's lifestyle and needs. For example, it could change the understanding of a house from a gathering of spaces to relax in and interact with the family to a gathering of functional spaces to relax, interact with the family and work (Mallett, 2004). Interestingly, adding new functions to the house, to a high extent, might not change the understanding of dwelling in the house. Because these new functions, nowadays, are part of the experience of something that the residents are doing in the house and dwelling could be defined as the way the resident reflects their way of living in the house (Heidegger, 1971, Lawrence, 1987).

Besides the scholar's different view of what a house is, Al-Jamea (2014), Lawrence (1987) highlighted what the house is from the house resident's point of view. In general, a house is a "shelter, hearth, privacy, roots and abode" that reflects different principles such as privacy, social needs, cultural values, quality of life, adaptability, safety, security, participation, and accessibility. Therefore, a house from the house resident's point of view could be a shelter that reflects the resident's way of living in it and reflects their social needs such as the need to have private spaces.

In general, the house must be a number of functional spaces that provide shelter for its residents but also the way of organising the different functional spaces and the technology used in the different spaces should reflect the resident's social needs.

After defining what a house is from the different scholar's point of view, it might be important to highlight what the house resident's preferences for living in the house are. A number of scholars discussed the house resident's preferences for the house that they want to live in. Many different preferences showed up but there were three main preferences that most of the scholars agreed on. The first house residents preference for selecting a residential building is its design, specifically how the house reflects the house resident's culture and the way of living in the house i.e. how they dwell in the house (Opoku and Abdul-Muhmin, 2010). Furthermore, Kauko (2006) points out that the house design for most of the house residents is more important than the location of the house and quality of the neighbourhood. Finally, although each house resident from different cultures has different needs, different building designs are required to reflect the different needs (Al-Momani, 2000, Jabareen, 2005, Sirgy et al., 2005). Consequently, importing designs from different cultures to live in might cause the house resident to make some changes to the building to adopt their way of living and engaging with the residential building. Unfortunately, these scholars, to some extent, failed to give an explanation of how to reflect the house resident's culture on the house design.

The second preference for selecting a residential building is the building size. According to Danko et al. (1990), the cost of buying or constructing the house and its size could be the main factors that control the house resident's preferences when selecting a residential building to live in. Moreover, Bhatti and Church (2004) agreed with (Danko et al.) and explained that the house residents prefer to have bigger houses in order to have the flexibility for redesigning the spatial organization. However, although the house residents prefer to have a bigger building size, building regulation and cost might be the main limitations that control the house resident's selection of building size.

The third resident preference for selecting a residential building is the quality of the neighbourhood and availability of services (Kauko, 2006, Wachs et al., 1993, Wang and Li, 2006). Besides that, Kaynak and Stevenson (1982) Spetic et al. (2005) added that the building materials and the technology in the house that helps to reduce energy consumption are important to some of the house residents.

This chapter will explore the link between the three research areas (architectural, social and environmental technology and systems) through exploring the previous studies relating to providing a dwelling for the house residents. This chapter will be divided into four sections. The first section will explore the link between architectural design and the house resident's social life. The second section will explore the link between environmental technology and systems and architectural design. The third section will explore the link between environmental technology and systems and the house resident's social life. Finally, is the conclusion section.

2.2 The link between architectural design and social life

The house design should reflect the house residents' physical and social needs and how the residents engage with the different spaces. The physical and social needs of the house residents in Saudi Arabia are derived from religious and cultural requirements. These requirements inform the spatial organization of the traditional house (Alharbi, 1989). Alafghani (1992) points out that the influence of religion and culture on the spatial organization in Saudi Arabia could be categorised into three categories.

- The relation with neighbours: in the Islamic religion the neighbours have a number of rights such as maintaining their privacy. Therefore, the design of the traditional houses have a number of solutions such as not having the main entrances or the different openings facing each other. Another example is the use of the Mashrabiyyah that allows the residents to have an outdoor view without being seen.
- The family kinship: one of the most essential expectations in Islam is to look after your family and relatives. Such as looking after the parents, brothers, sisters, sons and daughters. Therefore, the traditional houses usually contain an extended family. According to Akbar (1998) and Salagoor (1990), each floor in the traditional house is assigned for one of the house owner brothers or sons. As a result, the family is interacting and gathering for longer periods of time. Consequently, the family living room is the biggest room in the house. In addition, there are other areas for the family to interact in such as the courtyard and roof.

  Moreover, it is the responsibility of the sons to take care of their parents and one of the sons must live with them or ask them to live with him. In addition, the parents, in some cases, prefer to move between their sons. Thus, in the traditional houses there is normally a prepared bedroom for the parents on the ground floor. This room is located next to the entrance of the house. Thus, the house residents are looking after the parents every time they enter or leave the house.

- The house resident privacy: the Saudi community is known for its requirement of high levels of privacy. The privacy could be reflected in the residential building in many ways such as orienting the house indoor towards a central courtyard to provide privacy to the house residents. Another example is having different privacy zones in the house that control the movement of family and non-family users between the different spaces.

Jeddah city has a unique traditional architectural style which is called the Higazy style (Bagader, 2014). The houses were designed based on the residents needs with the available building materials and environmental systems (Akbar, 1998, El-Shorbagy, 2010b). According to Al-Lyaly (1990), Akbar (1998), the different Higazy houses have a similar spatial organization that helps the residents and their visitors know what public spaces they can use and which private spaces they cannot use. However, after the introduction of the new residential building types, the house resident's social interaction in Jeddah houses has been negatively affected and, nowadays, the family no longer gather and meet regularly (Akbar, 1998, Jeddah Mishwarah Social Society, 2012). This section will show how the architectural design is associated with the house resident's needs.

A considerable amount of literature has been published on exploring how architectural design is associated with the house resident's social life, but this literature did not consider if the change in the environmental technology or systems could be one of the reasons that affect both the spatial organization and the resident’s social life. Table 1 shows a number of studies exploring the link between the architectural design and the house resident’s social life which has been identified in different databases for engineering, architecture and the built environment, and will be discussed in this section.

Nowadays, the contemporary residential building is a production process that results in a tangible product that contains a number of different functional spaces (Heidegger, 1971, Lea, 1994). Unfortunately, this product provides the residents with functional spaces, mainly for shelter, but does not provide the residents with a dwelling space. In other words, this production process cares about providing a high number of buildings without questioning the quality of using and living in these buildings. This might be because of the high demand for the residential building by the citizens. Another reason could be that the construction sector is facing a great improvement and change in the technology used in constructing the buildings that results in affecting the spatial organization of the building. In addition to this, the noticeable improvement of the technology used day to day could affect the house resident’s social life.

Heidegger (1971) describes the residential buildings as spaces that the residents can dwell in, while he describes the dwelling as a way of thinking and engaging with the space. Also, Mallett (2004) defined home as the place where its residents can control their living space and how they spend time in it and express their way of living in it without any limitations. Therefore, if the buildings were not designed to reflect the resident's way of thinking within the space, then these buildings will provide the residents with their minimum need, which is different functional spaces only. As a result, the house resident might not be relaxed in the space. Moreover, Rapoport (1969) agreed with (Heidegger) and added that there is a difference between providing the house residents with their basic natural need for shelter that they might live in, and a dwelling that provides them with their basic needs to engage with the space. As a result, the residents may live in these buildings but not dwell in them. Unfortunately, the previous scholars did not specifically highlight if engaging with the space could be by providing a specific spatial organization or specific elements in the building or how the resident's needs could be reflected in different spaces. This might be because the different residents have different needs or ways of engaging with the space.

The spatial organization could be one of the factors that differentiate between living in the house and dwelling in the house. Because the spatial organization could be a way of reflecting how the house residents interact and move between the different spaces. Thus, living in the house could be defined as having a number of spaces with different functions that provide the house residents with their needs, but without considering how these spaces are organized or how the residents move between the different spaces. On the other hand, dwelling could be defined as a form of thinking and a way of engaging with the spaces and reflecting the house resident's natural way of living and moving in the spaces (Cooper, 1974, Heidegger, 1971, Mallett, 2004). In other words, dwelling in the house could be by reflecting the house resident's pattern of using these spaces and how they organize the space.

Rapoport (1969), Steadman (2006) highlighted a specific way of engaging with the space which is by reflecting the body movement in the space and between the different spaces. To clarify the differences between a house and a dwelling, Krier (2008) gave an example of a residential building that looks like a church, this building gives the basic needs to its residents, which are providing them with shelter and spaces to live in, but it does not really reflect the resident's pattern in a dwelling, how the different spaces are organized in the house nor does it give them the need to engage with the different spaces. From the previous example, it might be clear that having different spaces could provide the residents with their basic need which is having a shelter, but organizing the spaces for the residents to engage with them could provide them with a dwelling (Lea, 1994).

Chermayeff and Alexander (1963) point out that the contemporary residential building provides its residents with three main functions which are security, ceremony and privacy. However, these three functions could affect the internal and external spatial organization. Therefore, the contemporary residential building might not be a dwelling building because it loses the clarity of its internal and external organization. Although the security, ceremony and privacy are some of the house resident's needs, (Chermayeff and Alexander) to some extent, failed to clarify how the three functions affected the residential building's spatial organization and prevented them from being dwellings.

Banham (1984) highlighted a reason that led to changing the internal and external spatial organization in the contemporary residential building which is the new building materials and technology used in the building. For example, the thick walls were replaced with thin walls which led to having more internal space see Figure 3. Al-Kodmany (1999) agreed with (Banham) and added that it was not only the building technology that could change the indoor space, but other technologies could also affect the indoor space, such as the use of air conditioning. For example, not having a courtyard led to changing the residential building from being indoor oriented to being outdoors oriented. In addition, the interior layout was affected by the different room functions and furniture that led to limiting the use of the space. On the other hand, Mandilaras et al. (2013) argue that the technology could be one reason why the spatial organization is affected but stressed that the change in the house resident’s lifestyle is the main reason for the spatial organization and the different room functions being affected. However, the building materials could be one of the elements that have some effect on the dwelling and its spatial organization because the building materials and the other technology could be adapted to provide the house resident with their needs. On the other hand, the change in lifestyle could be the main factor that affects the spatial organization because it has changed the house resident’s needs and way of engaging with the space. The argument shows that the spatial organization, the building technology, and the house resident’s social life are strongly linked together and if one of them is changed, it will affect the other two.

Figure 3 traditional building with thick walls (right), contemporary building with thin walls (left) (Author,2018)

From the previous discussion, dwelling does not mean to have houses that have similar designs throughout the different time periods because dwelling is linking the way the resident engages with the space itself. Consequently, because the lifestyle of the house resident is changing; for example, it is possible nowadays to work from home and not go to the office (Mandilaras et al., 2013). the new houses might have different designs, new room functions and different spatial organization than the old ones. Dupuis and Thorns (1996) interview findings show that, although the elderly residents insist on living in houses that have a similar design to traditional houses, they think that the new generation will be more open to living in houses with different designs because of their modern way of living. Le Corbusier (1965) points out that it is acceptable to create spaces with different functions, but it is important that these spaces hold meaning to the resident. Therefore, having contemporary residential buildings with new room functions and different spatial organization can still be dwellings because it provides users with spaces that reflect their way of thinking. Interestingly, Cooper (1974) agreed with (Mandilaras et al.) and indicated that the house is a reflection of the self and the pattern of living. Therefore, this pattern should not reflect the way that the house resident was living with their family but should reflect the house resident's current way of living. Also, Krier (2008) emphasizes that "the house is not an architectural design of the past but of who we are". Consequently, contemporary houses must not be a copy of the traditional houses.

On the other hand, Lawson (2001), Sidawi (2008) and Suvanajata (2001) argued (Cooper) and (Krier) and agreed that the house resident's experience of using the space is one of the most important factors because the house resident needs to engage with the space and reflect their social life. They also stated that engaging with the space could be by reflecting the house resident’s experience of using the space, reflecting the social way of living in the space and having an acceptable spatial organisation. In other words, the house resident has previous experience of how to engage with the different spaces that could be a cultural legacy and it might not be easy to change them. Additionally, Lawson (2001) points out that the house resident could reflect their experience of using the space in two ways. The first is by reflecting their cultural identity such as how the family socially interacts in the house. The second is by reflecting their personal identity such as the room colour. This explains (Dupuis and Thorns) outcome of how the residents prefer to live in houses that have a traditional design. In addition, the residents might apply some changes to the house design to adopt their new way of living. Lawson (2001) point could lead us to believe that the resident’s way of engaging with the space and reflecting their identity on the space are two sides of the same coin. However, (Lawson, Sidawi, Suvanajata) point of view to some extent might not be acceptable nowadays because the house resident’s way of engaging with the different spaces has changed. In addition, Jeddah house residents are more interested in living in western design houses that do not reflect their way of engaging with the space.

The house resident’s family social interaction affects how the different spaces need to be organized in the house. Although Heidegger (1971) defined the dwelling as a gathering of spaces that the house resident’s engage with, Lawson (2001) defined space, not as the area surrounding us only, but also the objects that the space might determine “how far we can move, how much we can see and hear and how can it affect our mood”. In addition, Suvanajata (2001) added that the house resident's social interaction could affect how the different spaces are linked together. On the other hand, Serageldin (1979) point out that the space can be defined by the different materials, levels or surrounding it with elements such as walls. Unfortunately, (Serageldin) definition mainly focused on the tangible elements of the space and showed a lack of understanding of how the space could have intangible elements that are linked with the resident's social life and experience of using the different spaces. Therefore, the house resident's social interaction could be one of the main factors that affect how the spaces are organized and how the residents can gather and move between the different spaces. For example, in Jeddah city if a non-family member wants to move in the house, they know, by default, that they are allowed to move in the public zone only (see section 5.3.1.2 The spatial organization and the social life for more details).

Alexander et al. (1977), Al wafi (2006) stressed how the spatial organization is important and how it could affect the social interaction of the building users and stated the following: "No social group - whether a family, a work group, or a school group - can survive without constant informal contact among its members." In other words, downgrading the different functions of the common room, the location and the geometries of the common room are important to increase the chances of resident interaction. Moreover, three different scenarios show how the location of the common room (the spatial organization) could affect the house resident's social interaction (the social life).

The first scenario is having the common room at the end of a corridor and the house residents need to make a special effort to reach this room. Unfortunately, because of the resident's need to make the extra effort to reach this room, residents are unlikely to gather in the common room and use it informally and spontaneously because the resident might prefer to enter their private room, especially if it is nearer than the common room. (see Figure 4).

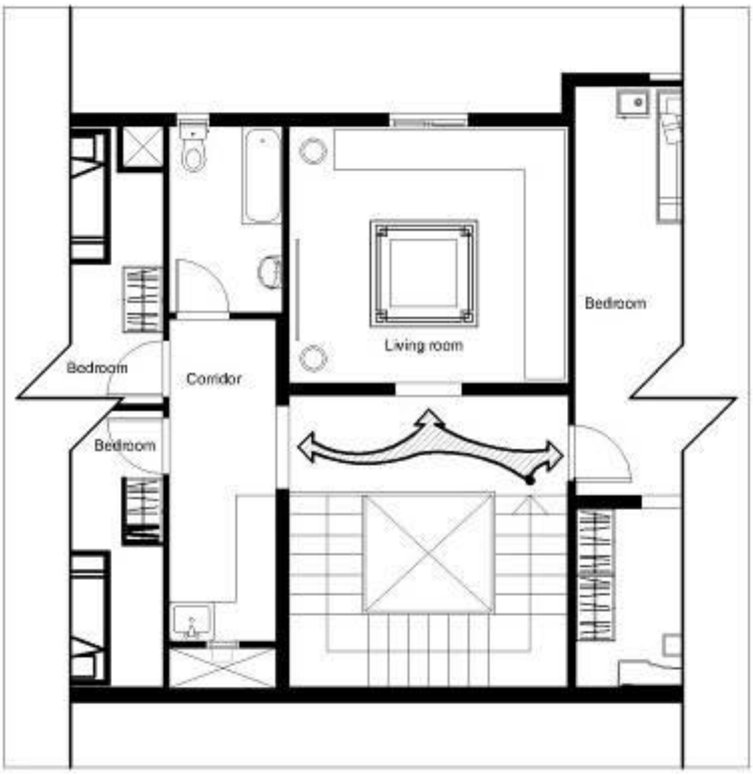


Figure 4 first scenario (Author, 2019)

The second scenario is locating the common room in the corridor or at the centre of the house i.e. the house residents must pass the common room to reach their private rooms. Although this scenario has better chances for the house residents to interact more than in the first scenario, forcing the residents to move through the common room could be uncomfortable and might affect the privacy of the common room and private rooms users (see Figure 5). In addition, in this scenario, the common room could limit the house residents movement if there were visitors in the common room.

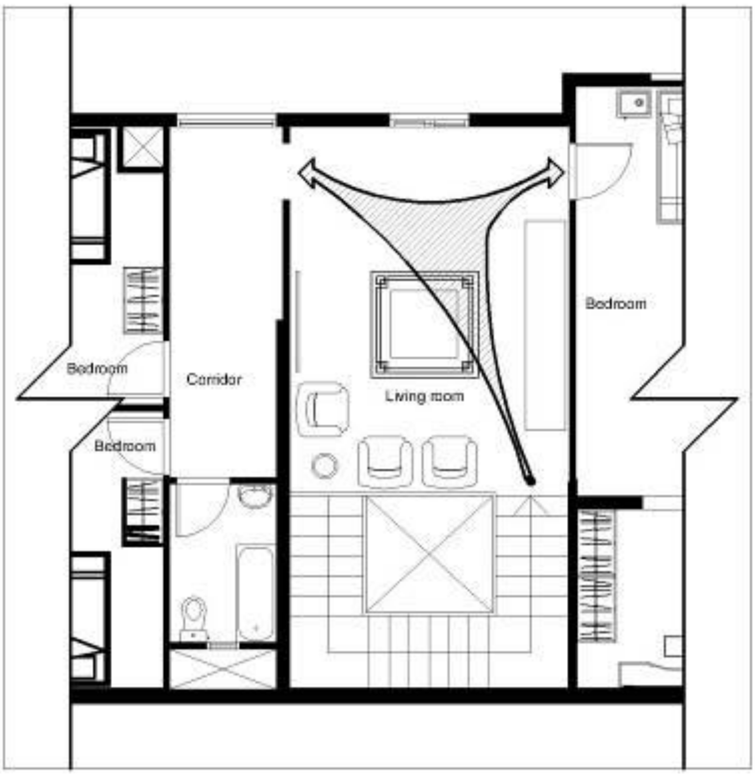


Figure 5 second scenario (Author, 2019)

The third scenario is locating the common room beside the corridor to give the house residents the chance to view the common room and the opportunity to either view what is happening inside the common room or to enter the common room (see Figure 6). In general, the three different scenarios show how the spatial organization could affect the house resident's social interaction.

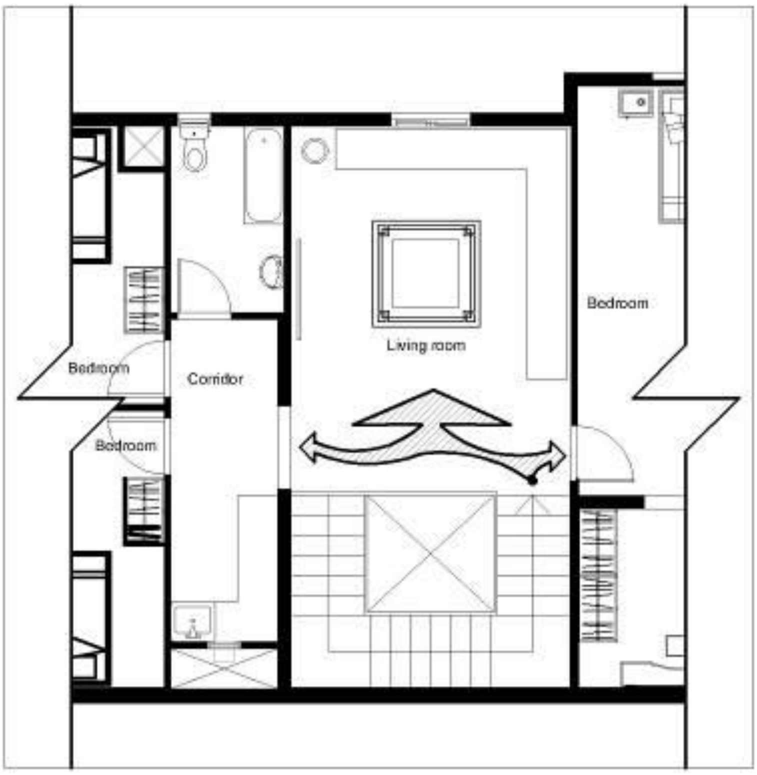


Figure 6 third scenario (Author, 2019)

The room function can reflect the resident's social activities in the room and can affect the spatial organization of the house. Different spaces have specific functions such as the dining room or the bedroom. On the other hand, one space can have different functions such as, in Jeddah houses, the multi-function room that could be used as a family sitting room, a visitor room or a dining room (Al wafi, 2006). However, according to Morris and Winter (1977), the room size could reflect the room function, yet different factors could affect the room size such as the building size, building materials and others. Therefore, the room size might not be the main criteria when reflecting the room function. On the other hand, Lawson (2001) argued (Morris and Winter) and highlighted that the furniture could be the main factor that controls the space function; for example, a space with dining furniture cannot be used as a family room.

The different architectural elements could have control over the spatial organization. According to Fadan (1977), distributing the traditional architectural elements in the contemporary house could help the house resident to engage much better with the space and to reflect their experience of using it. On the other hand, Serageldin (1979) argued that and pointed out that understanding the resident's behaviour and their use of the space could be much more important than providing the residents with the traditional architectural elements in it because the residents could live and engage with the space without the architectural elements. Moreover, Serageldin (1979) agreed that the body movement and its experience of using the space are more important than the architectural elements used within it. The key problem with this explanation is that it totally disregards the effect of the different architectural elements on the space and their function such as the courtyard. Moreover, in Jeddah residential buildings, the traditional and the contemporary buildings have similar private zones, but the contemporary buildings are not organized and functional in the same way as the traditional ones mainly because they do not have the architectural elements that have the power to control the spatial organization. Also, other scholars claim that the architectural elements could be used as symbolic references in the space. The main weakness of this claim is that the symbolic element could provide un-functional architectural elements that could, to a high extent, increase the cost of the building. Moreover, different cultures might have similar elements that have different uses, geometries, needs and value (Rapoport, 1969). Therefore, they may not be the best way of representing the social life of its residents. Krier (2008) stressed the importance of using architectural elements in the space and suggested that the traditional architectural elements could be used in contemporary houses, but they must be tuned to match with the contemporary building style.

Author	Title	Aim	Method	Finding
Al Wafi, 2006	The Development of the Domestic Interior in Makkah, Saudi Arabia: From the Traditional to the Modern Way of Living	the main objective is to identify the type of internal space that would provide for the domestic needs of different-sized families in Makkah (newly married, small family, and big family... etc) in a way that is commensurate with Arabic Muslim value systems	Mixed method (qualitative, quantitative)	Although Makkah houses share a lot of similarities feather with other traditional houses in other Arabic cities, Makkah houses have different spatial organization than the other cities. The new technology and modern materials can be used to reflect the traditional houses in a modern way. The room distribution could affect the way the residents can meet in the house in three different scenarios.
Al-Kodmany, 1999	Residential visual privacy: Traditional and modern architecture and urban design	The aim of the study is to examine residential visual privacy in two middle-class neighbourhoods in Damascus, one, based on its architecture and urban design.	Questionnaire targeting women only.	the urban designers need to understand and incorporate core values of the culture in which they are working, in order to meet the needs of a city's residents. The house residents prefer houses that provide them with privacy. The house residents are making changes and adding elements to the houses to maintain their privacy. Spaces that provide less privacy for the house resident are used less.
Dupuis and Thorns, 1996	Meanings of home for older homeowners	The meaning of home has been the subject of much recent debate. The paper explores this debate by using empirical data.	Interviews with a series of homeowners	One reason for moving between the houses is that they cannot adopt living in houses that are not similar in design to their houses. The house reflects the family history and the society around them. The house reflects the house resident culture and social life. Even though, the house meaning can be changed between the different generations, but it will still reflect the house resident culture and social life
Krier, 2008	The architectural tuning of settlements	How the traditional design could be reflected in modern building by tuning the architect elements	Case study	The house is a peace from now and not from the past “the house is not an architectural design of the past but of who we are”.
Mallett, 2004	Understanding home: a critical review of the literature	The aim of this paper is to bring together and examine the dominant and recurring ideas about home represented in the literature	Critical review of the literature	Home is a place but it is also a space inhabited by family, people, things and belongings – a familiar, if not comfortable space where particular activities and relationships are lived. Household designs, furnishings and technologies constrain or facilitate cultural and historical modes of relating between the people who share these spaces.

Mandilaras et al, 2013	Experimental thermal characterization of a Mediterranean residential building with PCM gypsum board walls	The aim is to examine the influence of Phase Change Materials (PCM) in the wall's thermal response in different rooms.	Experimenting two case study	Using the PCM on the building walls had increase on the time of transferring the heat of approximately 100 min during late spring, early summer and autumn. The thermal technology could not be the reason of affecting the spatial organization but the change in the house resident's lifestyle is the main reason that affects the spatial organization and the different room functions. The spatial organization and function is changed because of the change in the resident lifestyle.
Opoku and Abdul-muhmin, 2010	Housing preferences and attribute importance among low-income consumers in Saudi Arabia	This study examines the housing preferences of low-income consumers in Saudi Arabia, with specific emphasis on their preferences for alternative dwelling types and tenure options, factors influencing their housing decisions, and how these vary across socio-demographic sub-segments of this population segment	A structured self-administered survey	The financial considerations, private living space, and aesthetic aspects of the house rank as the top 3 important factors in the low-income consumers' housing decisions. The 3 least important factors are exterior space, street location, and proximity to relatives. The latter is a particularly interesting result, given the strong social and familial bonds in Saudi culture. On socio-demographic differences, only for importance interior layout, private living space, aesthetics, and exterior space do we find significant gender differences (females consider them more important than males).
Serageldin, 1979	Culture: a dimension in design	The aim of the research is to establish a better understanding of the intellectual development of man and human society thus revealing the structure of the design activity	Critical review of the literature	The setting of the different spaces and their function influence and possibly change the social relation of the residents. The space can be defined by the different materials, levels or surrounding it with elements such as walls. Understanding the house resident's behaviour and their use of the space could be much more important than providing the residents with the traditional architectural elements of the space.
Steadman, 2006	Why are most buildings rectangular?	The paper offers evidence to show that the geometry of the majority of buildings is predominantly rectangular, and asks why this should be	Literature review	The shape of the space affects its use. Engaging with the space is by reflecting the body movement in the space.

Suvanajata, 2001	Relations in architectural space designs and effects in space of the traditional Thai houses and temples	To investigates the relation of intelligibility of space known by architects in the design process and the one that exists in the architectural reality known by the residents of the buildings	Case studies	Four dimensions shows how the architectural space is the interaction between concepts and design and reality which are the structural, experience, functional and architectural elements. The house resident needs to reflect them selfies and way of moving in the house The resident social interaction could affect how the different spaces are linked together

Table 1 summary of identified empirical studies that link the spatial organization with the resident’s social life

2.3 The link between environmental technology and system and the building design

The previous section discusses how the dwelling could be a result of linking the spatial organization with the resident's way of engaging with the spaces, but the technology in general and the environmental technology and systems in particular used in the house was not a concern in the discussion of the dwelling. Interestingly, Hirsch and Silverstone (2003) point out that using different technologies in the space can affect the house resident's experience in engaging with the space. Accordingly, the technology is as important as the spatial organization and the need for a social life to provide a dwelling. This thesis will focus on the environmental technology used, in particular the air conditioning such as the window type, split and central unit. In addition it will also focus on the environmental systems, in particular the passive ventilation solutions that depend on a specific set of elements.

This section will be divided into two subsections. The first subsection will show what passive ventilation features were used in Jeddah houses. The second subsection will discuss the literature that links the effect of technology, in particular, the environmental technology and systems with the architectural design, in particular, the spatial organization. Table 2 summarises a number of studies which explore the link between the architectural design and the environmental technology and systems which had been identified in different databases for engineering, architecture and the built environment, and will be discuss in this section.

2.3.1 The passive ventilation system in Jeddah houses

The passive ventilation systems in a traditional residential building in the Middle East cities such as Jeddah mainly depend on a set of elements, which to a high extent, work together, such as the opening size, its location and the building materials. However, the three main passive elements are the Mashrabiyyah, the windcatcher and the courtyard.

2.3.1.1 The Mashrabiyyah and openings

The Mashrabiyyah is the element covers the biggest opening facing the street. It is one of the architectural elements that are still used nowadays. According to Salagoor (1990), the Mashrabiyyah was a way to show the wealth of the house owner. Moreover, it is usually made of wood, and it contains shutters that are called Rawashine to control the light and air flow coming from outside in, as shown in Figure 7 (Akbar, 1998, El-Shorbagy, 2010b, Salagoor, 1990). In addition, the Mashrabiyyah provides privacy for the house residents because it allows the house residents to view the outdoors without being seen (Al-Kodmany, 1999). In Jeddah traditional buildings, the biggest opening covered with the Mashrabiyyah is located in the Northern or Western sides to allow the best airflow and natural lighting because the incoming winds from these sides are cooler and carry less dust. Thus, the common rooms in Jeddah traditional residential buildings are located on the Northern or Western sides behind the Mashrabiyyah.

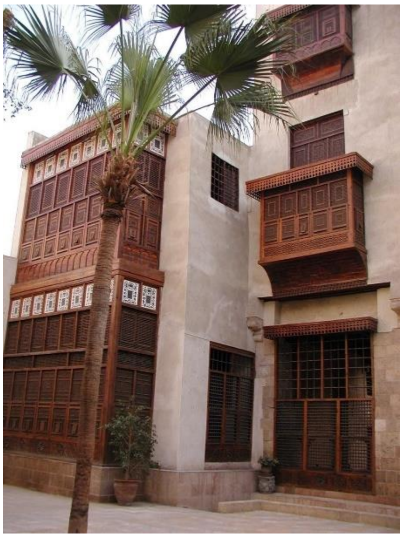


Figure 7 Mashrabiyyah (egyptianways.com, 2018)

Besides outdoor openings, having an indoor opening between the different rooms could help to create better indoor airflow (see section 5.3.1.3). Figure 8 illustrates that the window size and distribution in the space also help to intake the airflow into the building and through the different rooms (Abdulkareem, 2016, Ahmed et al., 2014, El-Shorbagy, 2010a). On the other hand, Figure 5 shows that having small windows distributed on one side of the room also affects the incoming airflow. Moreover, Kamal (2014), added that the window size and distribution would not only provide the spaces with optimal airflow but would provide them with natural lighting. This could be another element that helps to reduce energy consumption in the house.

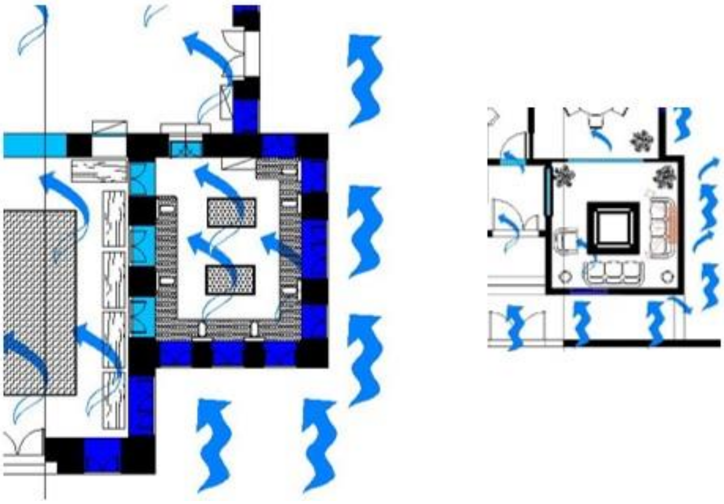


Figure 8 airflow in the visitor's room (similar scale), traditional house (left side) and contemporary house (right side) (Author, 2018)

2.3.1.2 Windcatcher

El-Shorbagy (2010a), Montazeri (2011) defined the windcatcher as a passive ventilation element that facilitates the effective use of natural ventilation in a building in order to increase the ventilation rates. As illustrated in Figure 9 the windcatcher is usually the highest element in the house elevation to intake the air through it from the higher level to the lower level (Ford et al., 2010). According to El-Shorbagy (2010a) the windcatcher's main opening is on the top of it. In addition, there are other openings in the rooms that have views to it to allow the airflow in. The windcatcher is usually located in the sides of the house to provide the different rooms with the airflow, particularly the rooms that do not have proper incoming airflow. Thus, the rooms that face toward the windcatcher are the daily used rooms such as the bedrooms or the corridors.

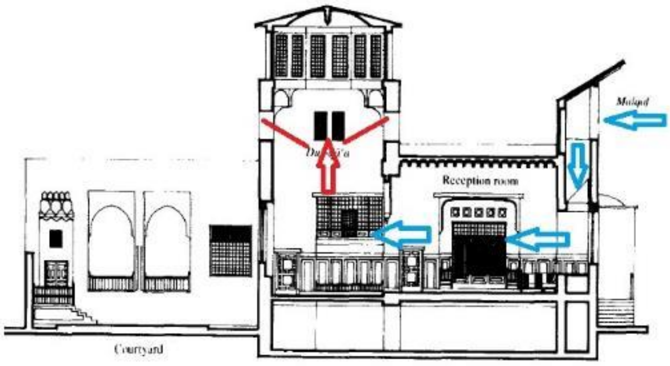


Figure 9 windcatcher (El-Shorbagy, 2010a)

However, Al-Kodmany (1999) points out that, although the windcatcher has a lot of benefits on the residential building's spatial organization, in the contemporary houses, the windcatcher might not be acceptable nowadays because of the building regulations, the small building sites and the cost of the building. On the other hand, Krier (2015) argued (Al-Kodmany) and highlighted that the architectural elements could be tuned and used in a contemporary way. To a high extent, if the elements were tuned and provided but in smaller shapes or sizes, it is expected they would be less efficient. Instead of tuning the windcatcher, some of the contemporary residential buildings are combining the concept of the windcatcher with the staircase. Moreover, for these elements to be more efficient, some mechanical parts could be added to them, such as adding a fan or shutters.

2.3.1.3 The courtyard

The courtyard can be one of the essential spaces in a traditional house. It is usually located in the middle of the house as shown in Figure 10 (El-Shorbagy, 2010b, Zein Alabidin, 2010). Interestingly, there were no standards for the sizes and number of courtyards in a house, but it depended on the needs of the house residents. Usually, house residents prefer to have the windows look into the courtyard rather than a view of the street.

According to Abdulkareem (2016), El-Shorbagy (2010a), this might be because of the hot climate and to maintain the family privacy. However, the courtyard is commonly used as a ventilation element to provide cooled air and channels it down into the interior of the building (El-Shorbagy, 2010a).

Figure 10 courtyard (Zein Alabidin, 2010)

After the economic changes in the 1970s in the Kingdom of Saudi Arabia, the contemporary house designs, to a high extent, adopted fashionable western models. Moreover, besides adopting the western designs and because of the massive increase in temperatures over the last decade (Almazroui et al., 2013), the residents totally dependent on air conditioning that provides the different spaces in the house with similar thermal conditions but consumes up to 80% of the energy used in the house (Vision2030.gov.sa, 2016). The change to using air conditioning affected the house's spatial organization and some of the room functions by not allowing any space for the passive ventilation elements.

With the admission of a new housing type, new building regulations, changes to the real estate ownership regulations, changes in lifestyle and the developing technology, most of the house residents might not be aware of how the architectural design and elements and the air conditioning they are using could affect the quality of living in the house (Susilawati and Al Surf, 2011). This might be because the residents are not really worried about what air conditioning units are available in the house while constructing or buying a new house, but they are strongly worried about other factors such as the financial considerations, the privacy, living space, the number of rooms, the location of the house and the neighbourhood (Al-Momani, 2000, Opoku and Abdul-Muhmin, 2010). On the other hand, although the resident might be aware of how the architectural design, elements and air conditioning could affect the quality of living in the house, they do not really have alternative systems to allow them to design the houses as they want. This might be because of the high cost of designing and constructing a bespoke house or that the time required to design and build a bespoke house takes longer than buying a prebuilt house.

2.3.2 the literature review

According to Banham (1984) using the different new technology adds a new layer to the residential buildings. In addition, Müller and Reichmann (2015) added that the technology is one of the architectural design shells. However, this layer might not be well adapted and might affect and change the building design and the space function. As a result, Lea (1994) points out that the 20th century design buildings have failed to meet the real needs of their residents.

Different technologies were found to meet the different resident needs in different times (Basalla, 1988). Therefore, there might be one type of technology such as environmental technology but provided to the house residents in different air conditioning solutions (Akbar, 2020). However, each solution might have a different effect on the resident experience in the space and also on the spatial organization because every solution requires different setups. Thus, it might be expected that the different environmental technology and systems will affect the resident's experience in using the space, but if the environmental technology and system reflects the resident's needs in the house, it is not expected that it will affect the dwelling. In other words, air conditioning or the passive ventilation system might improve and affect the spatial organization and the resident's social life, but still, the concept of having a dwelling might remain the same. Krier (2008), Mandilaras et al. (2013) indicated an explanation for that which is, the house is a reflection of the residents. Therefore, the residents should be aware of how to adopt the different air conditioning or passive ventilation system in the space to reflect their way of engaging with the house.

On the other hand, Mandilaras et al. (2013) argued that and claimed that the technology could be adapted to meet the resident's social life and there might not be a need to have any effect on the spatial organization. The claim of (Mandilaras et al.) might not reflect what is happening nowadays in Jeddah residential buildings because the use of air conditioning affected the spatial organization of the residential building and consequently the residents social interaction. Another reason is that the passive ventilation system, which was used in traditional Jeddah houses, required a set of elements that are no longer used because of the use of air conditioning.

Air conditioning consumes up to 80% of the residential building's energy (Taleb and Sharples, 2011). Unfortunately, because of the harsh climate in the Middle East, most of the 20th century buildings are dependent on air conditioning (Abdulkareem, 2016). Regrettably, if the air conditioning goes off, it is highly expected that buildings very quickly become unoccupied (Foruzanmehr and Nicol, 2008). This might be because the residential building is designed to depend on air conditioning only without engaging other ventilation systems such as the passive ventilation system.

Although the temperature is rising through time especially in urban areas (Almazroui et al., 2013), two types of passive ventilation systems and elements could be used and vary in their results. The first type is the passive ventilation systems that depend on different elements such as the windcatcher or courtyard. Although this type depends on the outdoor weather and it is effective for part of the year, mainly in spring and winter especially in hot and arid areas, it affects the spatial organization and the resident's social interaction. The other type is the new passive ventilation technology which could be a mechanical system that could be used without depending on any of the traditional architectural elements such as evaporative cooling that does not require adding new elements (Ahmed et al., 2014). Although these passive systems could provide acceptable indoor thermal results, they do not have any effect on the spatial organization. Consequently, the solutions that (Ahmed et al.) highlighted could lead to a defect between the spatial organization and the resident social interaction because it can be added to any building design regardless of whether the design reflects the resident’s needs. In addition, Florides et al. (2002) mentioned other low energy cooling solutions such as the slap cooling which depends on having cold air tube or chilled water tube through the ceiling slab to cool it and then the slab radiate the colonies to the different spaces. One of the slap cooling advantages is that it reduces the need for mechanical cooling. On the other hand, its performance depends on the level of overnight ambient air temperature and provides sensible cooling only. Consequently, it might not be possible to totally depend on the slap cooling system in hot arid areas. Another low energy cooling solution is the evaporative cooling system that converts hot air into a cool breeze using evaporation water (Goetzler et al., 2014). This might be one of the best solutions in arid areas like Saudi Arabia. The evaporative coolers could be combined with most types of air conditioning (Florides et al., 2002). However, the slap cooling and the evaporative coolers could be added to the residential building but will not have much effect on the spatial organization. In addition, (Ahmed et al., Florides et al., Goetzler et al.) did not clarify if using the different passive ventilation systems they mention have any effect on the building design.

A number of scholars agreed that designing a house that considers how to benefit from the surrounding environmental conditions could reduce energy consumption from between 30% to 50%, which could help to meet the Saudi Vision 2030 objectives. Besides reducing the energy consumption, Feist et al. (2005) point out that using passive ventilation could provide the indoor environment with better air quality and the residents with thermal comfort. Moreover, Morrissey et al. (2011) explored how orienting the building could affect energy consumption and one of their findings is that building orientation is an important factor that could reduce energy consumption by 30%. In more detail, (Morrissey et al.) experiment shows the effect of orienting the building elevations and openings facing toward the incoming airflow and having less openings on the sunny elevations could reduce the incoming heat. In addition, understanding how the incoming air might flow between the different rooms could help in distributing the internal rooms to benefit from the expected incoming airflow. Besides this, Aldawoud (2013) agreed with (Morrissey et al.) and added that from his experiment finding the shading solutions and building materials will have a more positive effect on the power consumption alongside the orientation and the windows size and distribution. Moreover, Alaidroos and Krarti (2015) and Taleb (2014) simulated how adding different shading solutions could help to reduce the energy consumption as well as combining the different air conditioning and passive ventilation systems, the simulation showed that the energy consumption could be reduced 23.6%.

Feist et al. (2005), Karava et al. (2012) added that besides the building orientation, using passive ventilation systems or combining them with the air conditioning could result in using less energy in the house. By the same token, Bajwa et al. (1990) found out from their experiment that the use of air conditioning and the passive ventilation system should be interchangeable in order to have better power saving results. On the other hand, Ratti et al. (2005) was concerned, from his observation, that the passive system could lead to consuming more energy if, for example, the openings were randomly distributed on the elevation and in addition, if the building materials used in the different passive ventilation solutions were low in quality. To a high extent, (Ratti et al.) concern might be obvious because if the openings were of low quality materials, were large and facing the sun , it is highly expected that more heat would be created indoors. Therefore, the opening distribution, size and materials must be adjusted to profit from the surrounding environmental elements and to allow proper indoor airflow.

Al-Azzawi (1996), points out that the indoor thermal comfort solutions affect the house design and the family pattern of using the different spaces. Indeed, more recently, using air conditioning could affect the spatial organization of Jeddah contemporary houses because it is the main environmental technology used in Jeddah contemporary houses. Moreover, not having passive ventilation elements has led to affecting the spatial organization. For example, depending on the air conditioning for ventilating and cooling the house led to changing the need to direct the building toward the Northern or Western sides, the need to have big windows, the need to have indoor openings between the different rooms and the need to have functional passive ventilation elements such as the windcatcher. This could be because the air conditioning could provide all of the indoor spaces with an acceptable thermal heat. Another explanation could be that the using air conditioning helped to avoid the outdoor climate changes. Unfortunately, Babsail and Al-Qawasmi (2014) draw attention to the fact that the designers are ignoring the environmental conditions while designing the buildings. One possible explanation for that could be that the designers and the house residents prefer to depend on air conditioning to solve the indoor thermal problems. Consequently, this has led to changing the residential building design and the functions of the different areas (Banham, 1984). On the other hand, the designers could use other passive ventilation systems that do not depend on elements and could be combined with the air conditioning.

Traditionally, Jeddah residential buildings were attached without any buffer area between the buildings. Therefore, the residential buildings were inward oriented to provide shade in the courtyard and a social private area for the family to interact in. Besides the social advantages of these solutions, there are environmental advantages such as minimising the façades facing the sun in order to reduce the thermal heat stored in the building (Alwetaishi and Balabel, 2016). On the other hand, contemporary residential buildings are outwardly oriented (Alharbi, 1989, Al-Kodmany, 1999). Unfortunately, this might be because Jeddah new building regulations do not allow the attachment of residential buildings from all sides but allow them to be attached from one side only (either the back or one of the sides) (Jeddah Municipality, 2018). Thus, the area facing the sun is bigger and more thermal heat is generated and stored in the residential building. Correspondingly, the setback led to reducing the amount of sunshade on the street and on the buildings. In addition, having the setbacks led to reducing the built area and dispensing of some of the architectural elements or rooms. As a result, the quality of the incoming airflow from the windows located in the setback was negatively affected (Chermayeff and Alexander, 1963) and there is a need to use air conditioning. Because, mainly, the buffer between the two buildings would not be smaller than four meters. Consequently, this affects the quality of the airflow.

In Jeddah residential buildings, three main factors could help to reduce dependency on air conditioning if they were considered in the design of the house. The first factor is to direct the building toward the incoming airflow (Butters, 2015, Ghaemmaghami and Mahmoudi, 2005). Usually, the best incoming airflow in Jeddah is from the Northern or Western side. The second factor is to have an acceptable window size, use high quality materials and to distribute the windows toward the incoming airflow (Bekleyen and Dalkiliccedil, 2011). Finally, the internal spatial organization, building layout and the building height could help to generate indoor airflow if they were aligned together (Abdulkareem, 2016, Bekleyen and Dalkiliccedil, 2011). Although these researchers focused on how to design a house that considers the environmental conditions, they did not link how the different designs could affect the social interaction of the house residents.

Interestingly, Short et al. (2004) suggested using the double façade elevation as a passive downdraft cooling solution. (Short et al.) suggestion could be seen as a contemporary solution that has a similar concept as the Mashrabiyyah. Also, using the double façade could influence and help to improve the spatial organization. In addition, although (Short et al.) did not mention any social effect of the double façade, it is expected to provide the house residents with a higher privacy level in the rooms behind the double façade. Furthermore, Taleb (2014) and Morrissey et al. (2011) agreed that to have an acceptable indoor thermal temperature, is not enough to depend on one passive ventilation system, but it is important to use more than one system in one building. In other words, not all of the passive ventilation elements and systems give the same results. Therefore, it is necessary to have a set of elements and systems to meet the required goal of providing the house with the thermal level needed and to reduce power consumption. Regrettably, although there is an agreement that using the passive ventilation elements could affect the spatial organization, there is a lack of information on how using the passive ventilation elements could affect the spatial organization.

Besides designing the residential building to utilize the local climate characteristics and using the different elements, Taleb (2014) and Kwon et al. (2013) agreed that the building materials is one of the important factors that affects the thermal performance of the building. In more detail, it is important to use different insulation in the walls, ceiling and floors to reserve the indoor thermal level. To a high extent, this point is important because of the thin walls used nowadays and their materials, to some extent, have low thermal performance. Also, Taleb (2014) stressed on using the isolation materials because, from the experiment he conducted, the different isolation solutions could reduce the indoor thermal heat from leaking outdoors. However, the main source of leaking the indoor thermal temperature is through the windows. Therefore, the windows must be distributed in an effective way with high quality materials.

Alwetaishi and Balabel (2016) claim that using small windows might help to reduce the incoming heat. Moreover, Taleb (2014) added that the materials used in the windows and their quality is the main reason that leads the indoor coolness or outdoor heat to filtrate through the window. In addition, Alaidroos and Krarti (2015) pointed out that it is important to shade the windows to have less solar heat. Moreover, (Alwetaishi and Balabel) did not discuss if the window distribution in the space has any impact on the incoming airflow. In addition, not highlighting the importance of the indoor opening could lead to negatively affecting the incoming natural air and its flow through the house. On the other hand, Abdulkareem (2016) highlighted that not only the window size could affect the incoming air flow but also its distribution in the space.

Author	Title	Aim	Method	Finding
Ahmed et al, 2014	Selection of suitable passive cooling strategy for a subtropical climate	The main aim of this study is to find a procedure to identify that cooling strategy for any hot and humid subtropical climate	Simulation in different cities	The procedure of selecting an appropriate passive cooling strategy has been developed for the residences and buildings in a hot and humid subtropical climate. It would be applicable for all buildings with internal heat gains of a hot and humid subtropical climate and will encourage the inhabitants to design the building considering their local climatic conditions.
Alaidroos and Krarti, 2015	Optimal design of residential building envelope systems in the Kingdom of Saudi Arabia	The aim is to improve the energy performance of residential buildings in the Kingdom of Saudi Arabia (KSA) through optimizing the building envelope elements	Simulation	In door elements such as walls and opening, can help in controlling the indoor temperatures without the need of mechanical systems. The simulation results showed that window shading and glazing properties have a great impact on reducing solar heat gains to the buildings in hot climates. Among the shading alternatives, the electrochromic glazing offered the best energy performance. Nonetheless, optimum size of exterior shading, such as overhangs and side fins, is a key shading strategy to reduce cooling energy especially during summer season.
Aldawoud, 2013	Conventional fixed shading devices in comparison to an electrochromic glazing system in hot, dry climate	The aim of this analysis is to provide architects and designers with general guidance and appropriate design strategies for different window treatments and shading techniques during early design stages in hot, dry climates.	modelled using Design Builder software	Both exterior shading devices and electrochromic glazing reduce the amount of solar heat gain that is admitted into a building. The different glazing materials have significant impact on the amount of solera heat inside the building The building type, interior spaces, location and local climatic condition, the windows orientation, windows size, and the optimal size and location of shading devices are all major factors that have a great impact on the amount of solar heat gain let into the building.
Alshaikh and Roaf, 2016	Designing comfortable, low carbon, homes in Dammam, Saudi Arabia: The roles of buildings and behaviours	The present paper explores the thermal performance and comfort levels of seventeen air-conditioned homes monitored during the summer of 2013 in Dammam	Observation of 17 case study	It is clear in this study that the orientation of the dwelling plays a massive part of the dwelling's energy consumption. The internal layout and room arrangements is fundamentally affecting the heat distribution within the spaces in the home.
Alshenaifi and Sharples, 2019	A parametric analysis of the influence of wind speed and direction on the thermal	The aim is to investigate the relationship between local wind speed and direction and the performance of the	Case study in Saudi Arabia	The passive downdraught evaporative cooling cannot provide cooling all time and mechanical cooling must be used. The wind direction and speed are the main factors that affect the performance of the (PDEC). As a result, the opening location and distribution must be facing the incoming wind.

	comfort performance of a Passive Downdraught Evaporative Cooling (PDEC) system – field measurements from a Saudi Arabian library	passive downdraught evaporative cooling towers		It was apparent from the finding that higher wind speeds had a negative impact on the performance of the towers.
Bajwa, 1990	The potential of the evaporative cooling techniques in the gulf region of the kingdom of Saudi Arabia	The aim is to identify comfort enhancement potential of evaporative cooling through wind tower by the supply of cooled air into the rooms directly from air outlets or indirectly through the ducts	Experiment on an existing building in Saudi Arabia	Evaporative cooling reduces the operation time of the air-conditioning system significantly during the overheated period of the maritime-desert climate. The performance of the combining system would be much better if ON-OFF switches were to be automatically controlled by the outdoor Relative Humidity Probe and wind direction sensor.
Huhhes ei al, 2012	The development of commercial wind towers for natural ventilation: A review	The purpose of this study is to evaluate the development of wind tower devices and their integration into buildings, thus providing a comprehensive review of current and potential wind tower development.	literature review	The traditional solutions in vernacular architecture can be adopted or integrated with new technology to make them compatible with modern requirements. Reducing the windcatcher height will help to reduce the construction cost without affecting the performance. The review further highlighted the different cooling techniques which can be integrated with wind tower systems to improve its ventilation and thermal performance.
Karava et al, 2012	Experimental study of the thermal performance of a large institutional building with mixed-mode cooling and hybrid ventilation	The paper investigates mixed-mode cooling strategies using a full-scale experimental set-up in an institutional building with motorized façade openings integrated with an atrium and high levels of exposed thermal mass	Experiment	The results show that the hybrid ventilation system operates around 30% of the time during the cooling season (April October) and free cooling can cover a significant part of the cooling requirements. More specifically, during a period of three months, the total free cooling is estimated to be about 6500 kWh, i.e. 30% of the total cooling load for the atrium and corridors estimated to be approximately 20,500 kWh
Kwon et al, 2013	Energy saving potential of a hybrid ventilation system	The aim of the study was to propose a hybrid ventilation system to	Quantitative indicators using heat	polycarbonate-based heat storage material has a longer heat discharge time compared to heat storage time, and a reduced ventilation heating load by over 37%.

	integrated with heat storage material	reduce indoor heating and cooling loads owing to ventilation by using the heat storage and discharge effects of some heat storage materials	storage time, heat discharge time, heat storage material efficiency and reduction of ventilation loads were used to measure the energy saving performance of the system	The combination between the different cooling and ventilation solutions must work alternatively.
Morrissey et al, 2011	Affordable passive solar design in a temperate climate: An experiment in residential building orientation	The aim of the study is to identify building characteristics that made houses more flexible to orientation change to reduce the power consumption	examined 81 standard volume build house designs in detail, including assessing them for adaptability to orientation change	Orienting the house has a different effect on the power consumption. The houses that have the best result of reducing the power consumption are the smaller houses, less than $250m^2$.
Taleb, 2014	Using passive cooling strategies to improve thermal performance and reduce energy consumption of residential buildings in UAE buildings	The aim of this paper is to test the usefulness of applying selected passive cooling strategies to improve thermal performance and to reduce energy consumption of residential buildings in hot arid climate settings, namely, Dubai, United Arab Emirates.	Simulation of a real case building was selected, and eight passive cooling strategies were considered.	The energy was reduced due to harnessing of natural ventilation and the minimising of heat gain in line with applying good shading devices alongside the use of double glazing. Total annual energy consumption could be reduced by 23.6% in a situation where the building used passive cooling strategies.

Table 2 summary of identified empirical studies that link the environmental technology and system with the spatial organization

In conclusion, this section shows the passive ventilation systems used in traditional residential buildings in Jeddah city and how they impact on the spatial organization. In addition, this section also shows that a lot of scholars are considering the link between the air conditioning and the passive ventilation systems in more technical ways. Furthermore, it considers how the air conditioning can be incorporated with the spatial organization of the residential building without applying many changes to the contemporary buildings that differ from the traditional residential buildings. In other words, the different studies did not focus on changing the spatial organization of the contemporary house, but to leave it as it is and to incorporate air conditioning with the current contemporary designs. Moreover, the literature in this path has more technical details that are aiming to provide any residential building with the proper air conditioning or passive ventilation systems without considering the social life of the house resident.

2.4 The link between environmental technology and systems and the family social interaction

The different environmental technology and systems (mechanical or non-mechanical) must be provided in every building. However, the environmental technology and systems used in the residential buildings varies based on the time of the construction of the building and the available technology. For example, in Jeddah traditional buildings, the passive ventilation system was mainly non-mechanical because it was dependent on a number of architectural elements such as the courtyard, the Manwaar, wall thickness and others (Banham, 1984). Moreover, besides the environmental function of these elements, they have social functions, such as providing different spaces for the family to interact in (El-Shorbagy, 2010b). For example, The fireplace was the main spot of the house for heating and for gathering the family, but when it was replaced with heaters this place lost its environment and social functions and was no longer required in the design except to be used as a symbolic element (Banham, 1984). A local example from Jeddah houses could be the family meeting room that has a big opening and used the Mashrabiyyah to allow airflow, after using air conditioning this space became smaller, the opening size became smaller and the family had fewer meetings in this space because the air conditioning provided all of the rooms with similar thermal conditions.

Rapoport (1969) points out that the air conditioning should not affect the function and social uses of the space, but it could change the image of the space to a more contemporary image. In addition, Selwyn (2003) added that there is different air conditioning that the resident could select from them. In other words, it is the resident's decision to select, from the different alternatives, the proper environmental technology or system that suits them. On the other hand, Chermayeff and Alexander (1963) argued that and pointed out that the house residents cannot link the space function with its contemporary image because of the different technology used in it, and additionally because of the new presentation of the space. Although the air conditioning technology could provide the resident with different alternatives, it is expected to affect the social use of the different spaces because it affects the spatial organization of the building. Moreover, it is expected to add new functions and space. Therefore, the successful architectural design of the house must reflect how the house residents are dwelling on the house and use appropriate air conditioning or passive systems (Abu-Gaueh, 1995). In addition, it is important to benefit from the outdoor surrounding environmental conditions to reduce the power consumption.

Al-Jamea (2014) points out nine principles that must be implemented in the design of contemporary Saudi houses to move towards social and cultural sustainable houses which are: privacy, social needs, cultural values, quality of life, adaptability, safety, security, participation, and accessibility. Interestingly, to a high extent, all these principles could be easily applied if the spatial organization reflects the way that the residents engage with the different spaces. However, Al-Jamea (2014) explained the social needs as the need to have a space that reflects the family needs in the house such as having private gathering spaces. Unfortunately, (Al-Jamea) explanation lacks information about what the house residents might require from their gathering space such as its location and the geometries of the space, and in addition, what environmental technology is required to meet the goal of having social and cultural sustainable houses.

Al-Jamea (2014) described the cultural value needs as providing traditional elements in the space that reflect the culture of the resident s. However, the different architectural elements have different functions such as environmental, social or other functions. Unfortunately, (Al-Jamea) did not mention if these elements should be functional or could be symbolic elements. Abu-Gaueh (1995), argued that the social needs do not require any architectural elements since, based on (Abu-Gaueh) definition, the social needs are the family's way of using the house, such as how they move in the house and where they meet. In other words, how they dwell in the house. To some extent, (Abu-Gaueh) argument might not be adequate because the different architectural elements could affect the spatial organization and the way that the residents engage and move in the house.

The architectural elements and their different functions are important in reflecting the house resident's image on the house. Suvanajata (2001) points out four dimensions that must be applied while designing the house, which are the spatial organization, the resident experience of using the space, the elements in the space and the space function. However, the spatial organization could be the feature that contains the architectural elements and the space function. The dimensions, (Suvanajata) pointed out, could help to reflect the social life of the space user and give them a sense of belonging. Furthermore, Lawson (2001) and Sidawi (2008) agreed with (Suvanajata) and added that the social dimension is one of the most important dimensions that must be reflected in the house. Lawson (2001) and Sidawi (2008) extended the social dimension and divided it into; family social interaction together and family social interaction with others. This could be a way of reflecting the family's need for the different levels of privacy in the house and the need to have public, semi-public and private areas in the house. On the other hand, Bagader (2016) stressed that not providing the traditional architectural elements, that have environmental and social functions, in the house and replacing them with new technology could lead to losing the social family interaction in the house.

The theory of (Al-Jamea) and the arguments that follow this theory mainly focussed on the different social needs of the house residents and the building that contains these needs. Unfortunately, although many scholars agreed that the different environmental technology and systems generally affected the social lives, the argument did not show any clear link between the different air conditioning and passive system and the house resident's social life in the residential building. This might be because the effects of the air conditioning and passive system are more visible on the spatial organization than on the house resident's social life.

The house resident's movement in the house could be a way of explaining the resident's engagement and dwelling within the different spaces and could be affected by many factors. Suvanajata (2001) mentioned one of these factors which is the different technology used in the house. Also, Abu-Gaueh (1995) mentioned another factor that required the resident to move between the different spaces which is to maintain the resident's privacy. On the other hand, Al-Azzawi (1996) and Bekleyen and Dalkiliccedil (2011) argue that the environmental conditions are the main reasons that led the family to move and interact in different spaces in the house. In other words, the house residents are moving between the different spaces to shelter from the sun, take advantage of better airflow and an acceptable indoor temperature. Thus, the family behaviour in the traditional houses is to change their meeting room based on the thermal conditions, i.e. they spend the day in the family living room to enjoying the cold airflow, but at night when the room temperature becomes higher because of the wall radiation, they prefer to meet or even sleep on the terrace or the roof to enjoy a better thermal condition (Abdulkareem, 2016).

Therefore, the family has two movements throughout one day in the residential building which are vertical and horizontal movements (Al-Azzawi, 1996, Bekleyen and Dalkiliccedil, 2011). To a high extent, the scholars agreed that the movement in the residential building is mainly because of where shade and a better indoor temperature can be found, especially in the traditional buildings. However, the need for shading and having better thermal comfort does not reduce the importance of the resident's need for privacy. Yet, the traditional architectural elements provide the house residents with both the environmental and social functions for the resident in their house. It also enhances the house residents need to move between the different spaces at different times of the day. On the other hand, shifting to use air conditioning led to affecting the house resident's need to move between the different spaces (Lawson, 2001). Regrettably, the air conditioning has changed the need for the environmental function of the different architectural elements. Consequently, the architectural elements were dispensed with, and the spatial organization was affected. As a result, the family interaction and movement between the different spaces in the residential building changed.

Using different technology in the house led to having rooms with a specific function, such as the dining room, reception room, and bedrooms. In addition, new room functions emerge, such as the playroom, office, the kitchenette and the laundry room. Moreover, these rooms could be used throughout the day irrespective of the different thermal conditions, mainly because of the use of air conditioning and also because, it is hard to move the different gadgets and furniture between the rooms (Bekleyen and Dalkiliccedil, 2011, Lawson, 2001). Consequently, the family interaction and movement between the rooms is because of the room function and not the need to meet the family members or to avoid the outdoor environmental conditions.

In addition, the resident's horizontal and vertical movement between the different spaces was affected because in the contemporary houses the different floors had specific functions; for example, the ground floor was mainly for the visitors and the second floor was for the family's daily use. Interestingly Chermayeff and Alexander (1963) mention that more than one function could be provided in one room but with different zones; for example, the living room might have a zone for seating, reading and dining. Having a multi-function room could help the family members to interact in one space if the multi-function room was in the public or semi-public zone, but if the multi-function room was in one of the private rooms, it is highly expected that it will negatively affect the family's social interaction.

In conclusion, most studies in this field clearly failed to link the family social interaction with the different environmental technology and systems, but the link between the two areas was through the spatial organization of the house (see Table 3). It might be clear from the literature that the houses depending on air conditioning have an advantage of solving the harsh environmental conditions and have more indoor temperature control. In contrast, it could affect the family social interaction within one space. This could be because, previously, the family members interacted in one room to avoid the thermal conditions, but with the air conditioner, all the rooms have similar thermal conditions.

Author	Title	Aim	Method	Finding
Abu-Gaueh, 1995	Privacy as the basis of architectural planning in the Islamic culture of Saudi Arabia	This paper aims to explain the concept of boundary and its use in the cultural context of Saudi Arabia	A literature review	The first main finding is that physical partitions are the primary mechanisms which people in Saudi Arabia use to nonverbally communicate their concern about privacy to outsiders. Second main finding is that residents of human spaces in this country make their choices regarding territorial behaviour based on their strong adherence to the Islamic religion and on their sense of self identity. The social needs are the family's way of using the house, such as how they move in the house and where they meet
Al-Jamea, 2014	Towards social and cultural sustainability in the designs of contemporary Saudi houses	This paper highlights the absence of social and cultural sustainability implementation in the design of contemporary Saudi houses, and it explores its effects on satisfying the users.	A literature review	Nine principles must be implemented in the designs of contemporary Saudi houses towards social and cultural sustainability which are privacy, social needs, cultural values, quality of life, adaptability, safety, security, accessibility, and participation. The cultural value needs as providing traditional elements in the space that reflect the culture of the house residents
Al-Lyaly, 1990	The traditional house of Jeddah: a study of the interaction between climate, form and living patterns	The hypothesis behind the study was that the use of space in the traditional house was closely related to, if not dominated by, a need to maximise thermal comfort.	Interviews and thermal measurements	The climate played a role in the morphology of the city and the form of the house. The use of the space in the traditional house was dominated by a need to maximise thermal comfort.
Bekleyen and Dalkiliccedil	The influence of climate and privacy on indigenous courtyard houses in Diyarbakır, Turkey	This article explores the effects of climate and privacy measures on the characteristics of indigenous courtyard houses in Diyarbakır	The study sample consisted of fifty historical courtyard houses in Diyarbakır	The house residents have different movements in the house and around the courtyard in different seasons. Another finding is that privacy measures had an important role in the space organization of the houses.
Sidawi, 2008	Incorporating lifestyle in the design of affordable	This research argues that there is a need to build concrete knowledge about people's lifestyles and to incorporate it in the design of affordable housing.	A literature review	The implementation of resident lifestyle in the initial design concept would prevent some of the harmful consequences to take place during the property lifecycle such as possible waste of time and effort of the owner/ resident who would like to adapt the building in regards to his/her lifestyle. The satisfaction of the resident would be best achieved through the participation of the property's resident/'s, the owner/client and the neighbours with the architect in the design process.

Suvanajata, 2001	Relations in architectural space designs and effects in space of the traditional Thai houses and temples	The aim is to investigates the relation of intelligibility of space known by architects in the design process and the one that exists in the architectural reality known by the users of the buildings	case studies	That architectural space is the interaction between concepts in design and reality of use and built objects. A building is the link between the concept design and the real resident need can be applied in four dimensions, structural, experiential, functional and architectural element dimensions which form different relations in different pieces of architecture in different socio-cultural contexts.

Table 3 summary of identified studies that link the environmental technology and system with the family social interaction

2.5 Conclusion

Many of the scholars gave an architectural definition of the residential building which is a gathering of spaces that provide its resident with their needs such as a private space and a secure shelter. However, other scholars linked the architectural aspect with the house resident's social aspect and defined the residential building as a gathering of spaces that reflects its resident's way of thinking and engagement with the different spaces. However, because the technology is a layer that can be added to the building and because the technology is flexible enough to be adopted based on the building conditions and the resident's needs, it was not a real concern for the scholars. Nevertheless, if the technology used in the house is changed, it is highly accepted that the architectural design of the house (in particular the spatial organization) and the social life of the house residents (in particular the family social interaction) will be affected.

The literature shows a strong link between the cause and effect of the spatial organization and the house residents' social gathering (see Table 1). Also, it shows a strong link between the cause and effect of the air conditioning or passive system used in the house and the spatial organization (see Table 2). The literature shows that a lot of scholars are considering the link between the different environment technology and systems and the spatial organization in more technical ways. Furthermore, because of the high flexibility of the air conditioning and passive system, the focus of the scholar is mainly on how to integrate air conditioning or the passive system with the different spatial organization. Therefore, the traditional environmental elements were not a concern because they could be easily replaced with new air conditioning technology. As a result, the residential building has become more technical.

Interestingly, one of the literature limitations is having a weak link between the cause and effect between the air conditioning or the passive system used in the house and the house resident's social interaction (see Table 3). In other words, there is a limitation when discussing how a house as a technical space is connected to a house as a social space.

Chapter 3: the literature review, designing a thermal comfort residential building

3.1 Introduction

The previous chapter discussed the link between the spatial organization, house resident's social interaction and the air conditioning and passive systems and how they can affect the dwelling. In addition, how focusing on the resident's physical needs such as the room size and numbers are more important than the social needs and the selection of the technical issues which are the type of air conditioning or passive system. This chapter will focus on how benefiting from the surrounding environmental issues and the building's thermal mass could help to design a residential building that provides thermal comfort for its residents and help on reducing power consumption.

Tap et al. (2011) defined human thermal comfort as the state of mind that expresses satisfaction with the surrounding environment. Konya (2013) defines human comfort as how to keep the body's internal temperature within a certain range regardless of the external environment. Moreover, the resident's thermal comfort in buildings is affected by the transfer of heat between the outdoor and indoor temperature that can be transferred by conduction, convection, radiation, and evaporative heat loss. In other words, the thermal comfort of the resident in the house is affected by the thermal mass that is defined as the material's ability, in different surfaces, to transfer and/or store heat and coolness (Balaras, 1996). Abdulkareem (2016), Tap et al. (2011) added that the relative humidity of the ambient air, the air movement pattern and its velocity, radiant heat exchange, the metabolic rate of a person, the person's clothing and in addition the resident's pattern of moving in the house are other factors that could affect the resident's thermal comfort .

This chapter will begin by describing Jeddah's microclimate such as the wind speed, humidity and others. Then go on to look at how the passive design of a building such as the building orientation, windows, shading, courtyard and windcatcher will help to benefit from the night cooling and the thermal mass of the building to provide thermal comfort to its residents. Finally, it will explain how having thermal control could affect the house residents movement.

3.2 Jeddah microclimate

Saudi Arabia specifically and the Middle East in general are known as an air conditioning dependent society (Alshaikh and Roaf, 2016). Because they depend on air conditioning solutions to provide indoor thermal comfort conditions because the outdoor temperature reaches 45°C Unfortunately, depending only on air conditioning led to consuming a high amount of power that could account for 80% of the power used in a residential building (Vision2030.gov.sa, 2016). In addition, it will lead to an increase in the running cost of living in the building and not reaching the Saudi vision 2030. Likewise, it led to losing reflecting the resident's social need in the building.

The passive ventilation systems could reduce the power consumption in a building by using a non-energy solution to reduce the peak cooling load. Also, it could provide the indoor atmosphere with balanced heating and cooling conditions (Kamal, 2012). Besides that, the passive ventilation systems provide the physiological effect on the building residents by providing fresh, cool indoor air (Jomehzadeh et al., 2017).

According to Alwetaishi et al. (2018), there is a strong correlation between microclimate permeants and thermal comfort. Therefore, for the passive system to be effective, understanding the microclimate of Jeddah will help to provide better passive solutions because the passive solutions mainly depend on the outdoor environmental conditions. Jeddah is located at 21.71°N, 39.18E° in the western region of the Kingdom of Saudi Arabia. Jeddah is surrounded by the Red Sea from the west side and with a series of mountains from the east side and the north and south sides are relatively flat, rising eastward gradually from sea level to an elevation of about 12 meters.

3.2.1 Wind speed

In Jeddah city, the North and North-West winds are characterised by light to normal speed for most of the year. Therefore, most of Jeddah's buildings are oriented toward the North or North-West. On the other hand, the South winds are normally more active during the summer and winter and its characteristics are humid, sandy and warmer than the North and North-West wind. Finally, the hottest and driest winds are the Eastern winds that are normally active in June (Salagoor, 1990).

3.2.2 Humidity

The humidity is generally high most of the year because of Jeddah's geographic location next to the Red Sea. Humidity reaches its highest levels in summer due to the high temperature of seawater and humidity is lower in winter due to the impact of the average air mass associated with high pressure.

3.2.3 Air temperature

According to Almazroui et al. (2012), AlSarmi and Washington (2011), the outdoor heat nowadays is much higher than the outdoor heat over the last two centuries i.e. in the last two decades the heat in Jeddah has risen by nearly 8°C . In the 21st century, Saudi Arabia, especially Jeddah city, has experienced a higher temperature, on 22nd June 2010, Jeddah measured a record-breaking temperature of 52°C (Almazroui et al., 2014), when in the summer time the temperature usually rises to 45°C (Salagoor, 1990). The air temperature significantly decreases from day to night, equal to about 15 to 20°C (Abdulkareem, 2016). The difference in the temperature between day and night could help to benefit from the night cool by store coolness at night to be radiated in the daytime to help to provide thermal comfort. On the other hand, in winter the temperature is usually 25 to 27°C.

3.2.4 Rainfall

The average annual rainfall is around 40-80 mm (Almazroui et al., 2012). Although rainfall is rare in Jeddah and occurs as sudden showers, Jeddah might have torrential bursts of rain lasting for three to five hours a day (Salagoor, 1990).

3.3 Passive building design

While designing a building, it is important to bear in mind that "One of the most important purposes of buildings is to provide comfort for users, regardless of the type of building" (Alwetaishi et al., 2018). In other words, it is important while designing to consider providing comfort zones for the building user while the comfort zone is the range of conditions in which thermal comfort is experienced. The comfort zone, the user thermal comfort and the power consumption depend on the air temperature, surrounding surfaces, the humidity of the air, air movement in the building and wind speed around the building, windows to wall ratio and windows glazing type and shading (AlAnzi et al., 2009, Konya, 2013). Furthermore, Konya (2013) mentioned that the solar heat could be transferred from/to the building in four ways which are the direct short-wave radiation from the sun, diffused short-wave radiation from the sky, short-wave radiation from the surrounding buildings and long-wave radiation from the heated ground and nearby objects.

To have a low energy building, in the designing processes, it is important for the stakeholders to define the building envelope, surfaces, materials, the system that will be used in the building and how they work together (Torcellini et al., 1999). This is because the walls and roof slabs, slaps thickness, used materials and shading solutions have different capacities to transfer, store and radiate heat (Almumar et al., 2018). Additionally, Torcellini et al. (1999) highlighted a number of aspects to ensure that the building is a low energy building such as considering benefiting from the outdoor environmental conditions such as the orientation of the building, benefiting from the windows by applying the right widows to wall ratio and to select the proper HVAC design. However, Torcellini et al. (1999) stressed that after considering the different aspects while designing the building, it is highly important to simulate the building thermal performance and energy consumption. Because it is much easier to evaluate the building performance and to apply changes in the building design, the passive system used, the building materials and others before constructing it. Torcellini et al. (1999) applied this strategy on a commercial building and the simulation results show that the power consumption could be reduced by 70%. However, the actual energy performance after constructing the building shows a reduction in power consumption of 63%. The reason for the difference in the power reduction between the simulation and the actual building is because of a change in some of the building materials during construction such as the window frames. Applying these steps on a residential building might be costly and time consuming.

It is not always necessary to install a complex active system to provide the house residents with thermal comfort, but achieving both thermal comfort and low energy consumption could be attained simply with the existence of a high-performance dwelling envelope, orienting the house, with acceptable sized openings and outdoor solar shading (Alshaikh and Roaf, 2016, Goetzler et al., 2014). In addition, combining passive systems with the air conditioning that require understanding of the air movement in the house and around it (Goetzler et al., 2014). The following subsections discuss the passive design aspects that are inspired by traditional Jeddah houses that can be applied to Jeddah contemporary houses.

3.3.1 Building 0rientation

Orienting the residential building and having its main and longer elevation toward the incoming wind flow and the smaller solar radiation side, massively decreases the power consumption and increases the indoor thermal comfort (Goetzler et al., 2014). This is because the building mass observes less heat and the incoming winds which are highly expected to cool down the surfaces. Alshaikh and Roaf (2016) observed 17 houses in the Eastern region of Saudi Arabia to explore their thermal performance and comfort levels during the summer of 2013. (Alshaikh and Roaf) found out that the houses that were oriented toward the North North-East consume around 90 kWh/m2 energy per annum. A possible explanation could be that the North-Northeast elevations are facing cooler winds because the winds are coming mainly from the Arabian Gulf. On the other hand, the houses that were oriented toward other sides consume between 118 kWh/m2 to a maximum of 206 kWh/m2 per annum. Certainly, other factors such as the building materials and insulation affect the power consumption because they have different capabilities to store and radiate heat (Alwetaishi et al., 2018).

3.3.2 Windows

The windows could be the weakest interaction point that transfers a massive amount of heat between the indoor and outdoor areas. This is because of the specifications of the windows' materials. Therefore, the building that has a high glazing ratio in their elevation is expected to observe high solar heat. In other words, "The larger the window area is in the façade, the more intense the energy demand for cooling is in the dwellings" (Alshaikh and Roaf, 2016). Konya (2013) agreed with (Alshaikh and Roaf) and added that the windows' distribution on the elevation also affects the amount of incoming solar heat. Furthermore, although the location of the windows, their size and materials could lead to losing indoor heat or coolness, it is an element that provides ventilation to the indoor atmosphere (Alwetaishi et al., 2018).

It is important to understand how to distribute the windows in the different elevations with the proper size to reduce the solar heat and to create indoor ventilation. For example, in Jeddah traditional houses, the biggest openings were located on the North and North-West elevation facing the cold incoming winds. On the other hand, to create indoor airflow, the smallest windows were on the Southern elevation to exhaust the indoor air. In addition, shading the windows and using different glazing materials affect positively or negatively the windows' heat transfer performance. (will be discussed later in this chapter).

3.3.3 Shading

The solar shading is one of the most effective and cheapest ways to reduce the indoor heat and to increase the resident's thermal comfort (Aldawoud, 2013, Almumar et al., 2018). On the other hand, Hashemi (2018) claims that shading on its own is less effective in reducing the heat transferees, but shading should be used with other strategies to achieve better thermal comfort results.

Solar shading has different solutions and can be provided either internally or externally. For example, shading from trees could reduce ambient thermal temperatures in outdoor walls by 2.5^{o}C to 2.5^{o}C (Kamal, 2012). Indeed, there is a need to examine the effect of the internal and external shading effect on the building. Thus, a simulation conducted by (Hashemi, 2018) shows that the external shading is 30% more effective than internal shading. Moreover, Goetzler et al. (2014) point out that, although shading is one of the high performance strategies to reduce observation of solar heat, the shading devices should not cover the sunlight and the view from the windows. Figure 11 and Figure 15 show different shading solutions for the opening and courtyard such as sunshades and window louvres. The Mashrabiyyah is one of the shading devices that was used traditionally to control the incoming airflow and sun lighting (see section 2.3.1.1 The Mashrabiyyah and openings for more details).

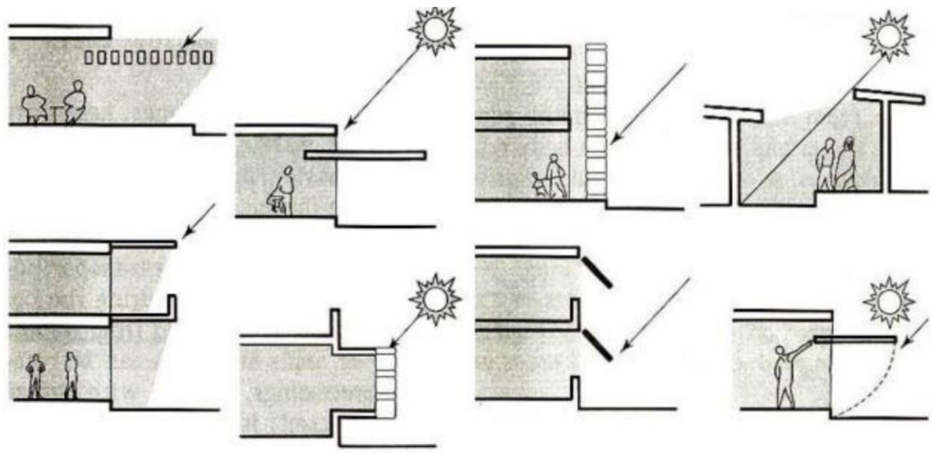


Figure 11 different shading solutions FOR openings (Kamal, 2012)

Besides the need for shading solutions on the elevations and openings, Aldawoud (2013), Tzempelikos et al. (2010) simulate how the different glazing types could help to reduce the incoming heat through the windows. (Tzempelikos et al.) used different glazing types in the simulation which are single, double, and triple glazing. The results show that the indoor temperature could be less than the outdoor temperature by 8 to 10°C based on the glazing type. Moreover, adding shading observes up to 20% of the solar heat besides the glazing type. Aldawoud (2013) suggested using electrochromic glazing which is a glazing material instead of using shading devices or elements. (Aldawoud) has simulated different alternatives of shading which are not using any shading solution or device on the building, using shading devices on the opening, using the electrochromic glazing and using both the shading device and electrochromic glazing to experiment with their effect on the amount of solar heat observed in the building. The results from using shading devices show a reduction in the incoming solar heat by nearly 34% in winter and 32% in summer. Moreover, better results occur when simulating the effect of using the electrochromic glazing on the windows to reduce the incoming solar heat. The reduction was nearly 48% in winter and 53% in summer.

However, using the electrochromic glazing material might negatively affect the incoming natural lighting, sun glare and outdoor view and might be a high-cost element.

3.3.4 The courtyard

The courtyard on its own might not provide the house residents with the required thermal comfort because as (Etzion, 1990) found that "In summer, most of the time the courtyard is warmer than the ambient air temperature near the house, day and night. In a few cases, the temperature differences between the ambient air and the air inside the courtyard were as high as 7°C." In addition, Al-Hemiddi and Al-Saud (2001) Dunham (1961) agreed with (Etzion) and added that to improve the thermal performance of the courtyard, different elements must be added to it such as a water fountain or shading.

The size of the courtyard and its height and width are major factors that affect the courtyard environmental performance. Abdulkareem (2016) describes the mechanism of the courtyard thermal performance in four cycles:

The night cycle: At night-time, the courtyard surfaces such as the floor and the surrounding walls are the main source of heat because they gain heat from the daytime. Consequently, at night, they are much hotter than the sky (Sharif et al., 2010). Accordingly, the heat exchanges between the courtyard surfaces and the environment surrounding it in two ways which are convective heat transfer and radiant heat exchange (Abdulkareem, 2016). The convective heat transfer happens because the sky’s cold air has a high density. Thereby, the heat transfers when the courtyard surfaces contact the cold air (Dunham, 1961). As a result, the surfaces start to observe coolness and radiant heat (see Figure 12). Givoni (1998) named the process of the heat transfer as thermosyphonic convection, which mainly depends on the difference in temperature between the received air from the sky and the courtyard surfaces. Meanwhile, the rooms facing the courtyard reached their peak, while the courtyard is getting cooler. Once more, due to this thermal variation between the indoor environment and the outdoor space, convective heat exchange happens through the building surfaces, and air currents are created. The heat exchange result is that the indoor thermal discomfort is significantly mitigated.

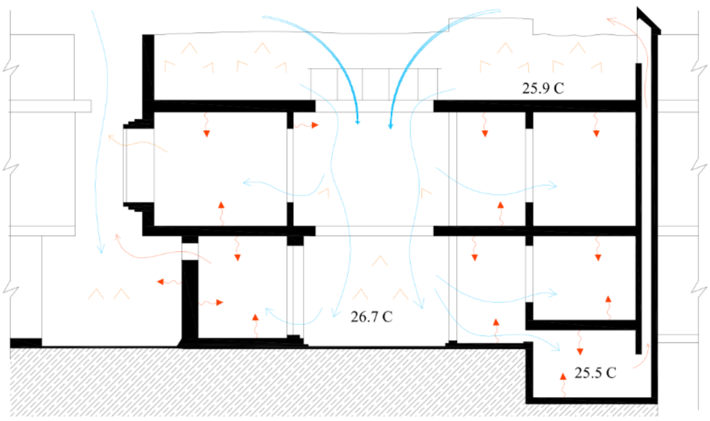


Figure 12 the night cycle (Abdulkareem, 2016)

The early morning cycle: At this time, the air temperature in the courtyard is either similar or comparatively higher than indoors. Figure 13 shows that the solar radiation is low because the solar elevation angle is low and most of the courtyard is shaded (Heidari, 2000). In addition, the temperature between the indoor and the courtyard are similar because the building mass was cooled from the previous night. In other words, the heat exchange between the indoor and outdoor space is at its minimum.

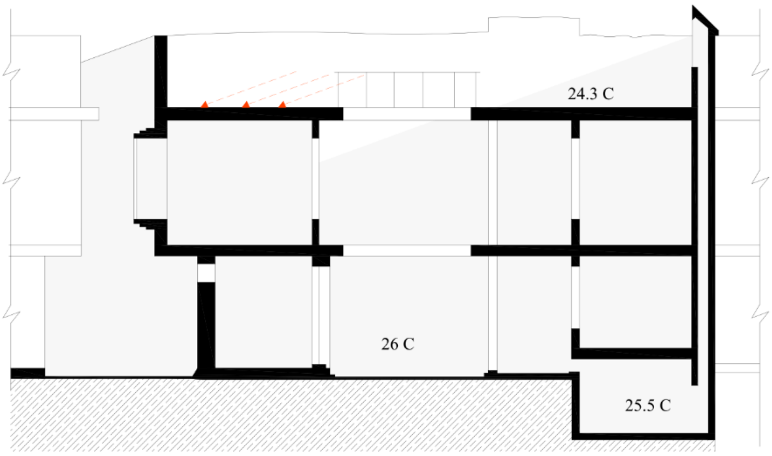


Figure 13 early morning cycle (Abdulkareem, 2016)

The noon cycle: As soon as the sunrises, the sun rays start to face the courtyard surface and the courtyard surface starts to receive large amounts of solar radiation (see Figure 14). The thermal mass of the surfaces starts to lower the ambient air temperature through convective heat exchange. Unfortunately, because of the air temperature and the courtyard materials' capacity for storing heat, this process might not last for a long time and it will stop as soon as the building mass becomes hotter. Hence, the use of the different insulation materials is important to extend the time of the heat exchange and to store less heat. Accordingly, the hot air flows up due to its lighter density and cooler air is drawn into the courtyard from those rooms' openings (Moore et al., 1993). Sharif et al. (2010) recommended shading the courtyard to reduce the sun rays and to create more shade on the courtyard (see Figure 15). As a result, the courtyard surface will observe less solar heat.

Figure 14 noon cycle (Abdulkareem, 2016)

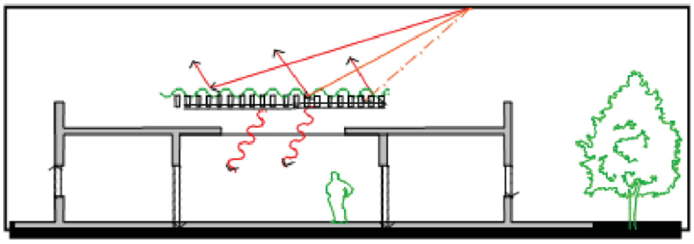


Figure 15 shading the courtyard (Sharif et al., 2010)

The afternoon cycle: at this time most of the rooms surrounding the courtyard have lost their coolness. As a result, there is a need to use other alternatives to cool the rooms such as the air conditioning or windcatcher to provide their residents with their thermal comfort (see Figure 16). On the other hand, Sharif et al. (2010) claim that there is no need to use any supporting air conditioning to have indoor thermal comfort. The claim of (Sharif et al.) might be acceptable because their analysis is based on a country (Libya) that has a less harsh climate than the climate in Saudi Arabia. In other words, the need to depend on different passive solutions to provide indoor thermal comfort depends on the different outdoor environmental conditions of each building.

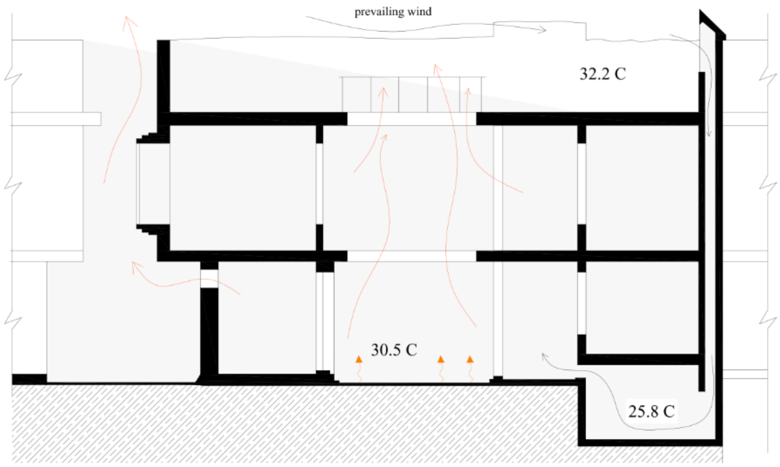


Figure 16 afternoon cycle (Abdulkareem, 2016)

3.3.5 the windcatcher

The idea of using the windcatcher is to move the air from a high pressure to a low-pressure zone. The different pressures between the zones arise from the different air temperatures, mainly between the indoor and outdoor temperatures (Goetzler et al., 2014). In a hot area such as in Jeddah, the windcatcher is more effective at daytime because it provides cooler air into the building (Mazouz and Torkia, 2014). A possible explanation is that the windcatcher surfaces are cooler than the other indoor surfaces because, traditionally, there was a water fountain in the bottom of the windcatcher and, recently, because of having different evaporative cooling solutions (El-Shorbagy, 2010b, Ford et al., 2010, Mirhosseiniardakani, 2016). As a result, the pressure of the outdoor air sucked in is changed through the windcatcher. In more detail, if the internal air pressure is higher than the outdoor air pressure i.e. the indoor is hotter than the outdoor, the outdoor air will be driven from the top of the windcatcher into the building. Consequently, the indoor hot air will move out through the windows (see Figure 17). On the other hand, if the indoor is cooler than the outdoor, the airflow will be reversed. Interestingly, although it might be obvious that the effectiveness of the windcatcher depends on the wind speed, (Mazouz and Torkia, 2014) experiment shows that the windcatcher performance is not hugely affected by the wind speed. In other words, even if the wind speed is low, the windcatcher will provide the indoor with cold air because of the difference in the air pressure between the indoor and outdoor spaces. Mirhosseiniardakani (2016) agreed with (Mazouz and Torkia) and provided an explanation as to why the low wind speed won't affect the performance of the windcatcher. Mirhosseiniardakani (2016) explains that the wind loses its heat by means of convection and radiation when it touches the windcatcher surfaces because the thermal mass of the windcatcher surfaces are cold. As a result, the wind will be cold and will drive into the building. Furthermore, Ford et al. (2010) suggested adding supporting elements such as water sprinklers to cool the incoming air and the windcatcher surfaces in order to increase the airflow (see Figure 18). Adding the water sprinklers will also help to humidify the incoming airflow.

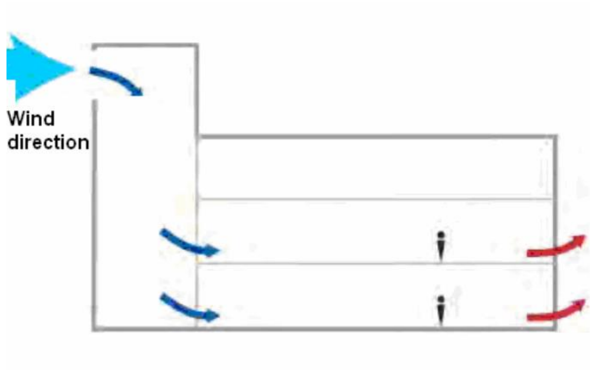


Figure 17 air movement in the windcatcher (Goetzler et al., 2014)

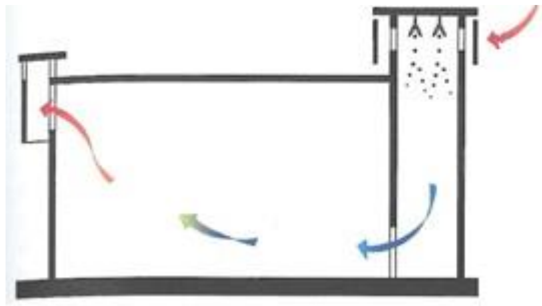


Figure 18 adding water spray to the windcatcher (adopted by author)

Figure 18 shows that there can be two windcatchers, one to intake the cold air and the other to exhaust the hot air. In addition, Jomehzadeh et al. (2017) point out that to make use of the changing wind direction it could help to have a windcatcher with more than one opening. In more detail, as Figure 19 shows some of the openings could be used to intake the outdoor winds and others could be used to exhaust the indoor heat out.

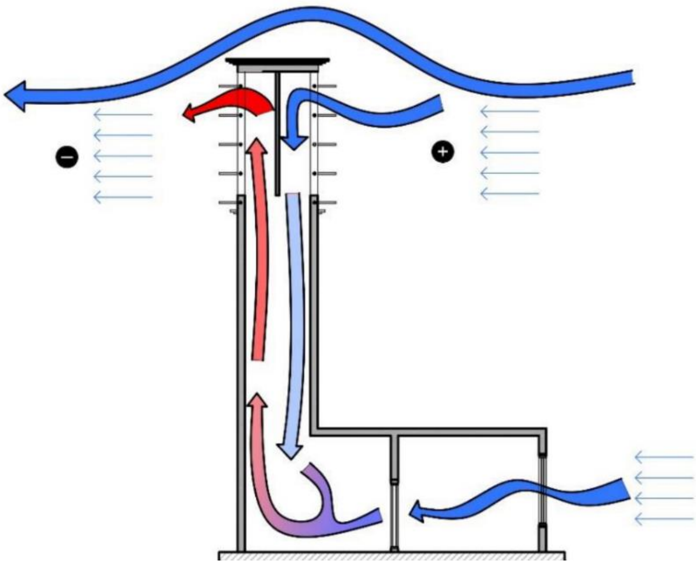


Figure 19 two opening windcatcher (Mirhosseiniardakani, 2016)

3.4 Thermal comfort and its effect on the house resident movement

Abdulkareem (2016), Al-Lyaly (1990), agreed on describing the family pattern of moving and using the different spaces in the house. (Al-Lyaly, 1990), found out that the residents are mostly moving between the different spaces horizontally and vertically to maintain thermal comfort of the body. In more detail, in summer, the residents spend their late evening in the terrace and sleep in the bedrooms on the higher levels or the roof. A possible explanation for staying on the upper levels is to benefit from the cold wind and its ability to quickly cool down the indoor temperature. Another possible explanation as Sharif et al. (2010) highlights, is to avoid the heat radiation from the building surfaces and floor in the lower floors. The thermal mass in the upper floor in a traditional house is less than the lower floor because usually, the upper floor walls are thinner than the lower floors that have nearly 90cm thickness (AboZade, 2012, Almumar et al., 2018). Fascinatingly, the beds used for sleeping and sheets are stored in a special room to acquire coolness from the cold air movement (Abdulkareem, 2016). Moreover, in the early morning, the residents move down from the roof or upper floors to the lower floor to avoid the solar heat generated from the sunrise and to be shaded and in addition, because the building mass was cooled from the previous night and the indoor rooms are thermally comfortable. On the other hand, in winter, the family generally spends most of the day and night on the second or third floor. A possible explanation could be to avoid the extra heat or coolness on the ground floor because, besides the building surface radiation, the ground also converts and transfers heat and coolness to the indoor space besides the other building surfaces. Finally, Al-Lyaly (1990) found out, based on his experiment, that one of the main reasons for the house residents moving between the different spaces is the effect of the air movement and speed in achieving indoor thermal comfort. i.e., in Jeddah, the residents usually spent most of the time in the North or North-West sides to benefit from the cold incoming airflow.

3.5 Conclusion

Although it is important to reflect the house residents' physical and social needs in the dwelling, as discussed in the previous chapter, it is important to provide the house residents with their thermal comfort. Providing thermal comfort for the house residents mainly depends on designing a house that uses outdoor environmental conditions.

To make use of the outdoor environmental conditions, at first, it is important to analyse the outdoor microclimate and the surrounding urban area. Then, to benefit from the analysis of different factors while designing the house. For example, how to orient the house to gain less solar heat, to take advantage of oncoming winds and to also apply different shading solutions. Moreover, understanding the microclimate conditions and the different building materials' thermal mass will help to properly design the different passive ventilation systems in the residential building.

Finally, designing a house that benefits from the outdoor environment and uses the different passive ventilation systems in a city with a harsh climate like Jeddah, might provide the house residents with discomfort for part of the day, such as during the afternoon, or for part of the year, such as in the summer. As a result, it is important to combine different passive systems with air conditioning. On the other hand, it will help to reduce power consumption and to reach the optimal point of thermal comfort faster.

Chapter 4

Methodology

4.1 Introduction

This chapter describes the methodology to pursue the aims and objectives of the study. Firstly, it sets out the research design, explains the justifications for selecting the Mixed Method Research (MMR) design. Following that, the data collection method of this research will be presented. Finally, the chapter will describe the analysis method for each phase of the study.

4.2 Research design

The research design is the path that allows the researcher to achieve their objectives and answer the research questions. It is a structure that helps to address four main issues: which questions to study, which data is relevant to the questions, which data to gather and how to evaluate the results (Philliber et al., 1980). Moreover, it has been argued that the methodology should be considered a philosophical framework starting from the research project, through the theory and ending with the findings (Creswell and Clark, 2017).

This study utilized a mixed methods approach with a multilevel model triangulation design. Triangulation is known as mixing approaches for obtaining two or more viewpoints (different but complementary data) to best understand the subject being studied (Creswell and Clark, 2018, Olsen, 2004). (Creswell and Clark, 2018, Olsen, 2004). Mixing methodologies (e.g. mixing questionnaire data and interview data) is a form of triangulation (Olsen, 2004). Consequently, the researcher has selected a mixed method design to explore the links between the architecture of Jeddah residential buildings (spatial organization), the house resident’s social life (the family’s interaction and gathering) and environmental technology and systems (air conditioning and the different passive ventilation systems).

The main reason for using this design in the current study was to combine the distinctive strengths of quantitative methods, such as the large sample size and the ability to generalize findings, with those of qualitative approaches, which provide in-depth and detailed accounts of the subject of interest (Al-Saati, 2013, Creswell and Clark, 2018, Patton, 1990). This robust design fitted with the aim and objectives of this research. According to Tashakkori et al. (1998), this method of "multilevel research" is utilized to address different levels within a system. Studying the links between the three research areas requires a deep understanding of what changes occurred in Jeddah residential buildings and the residents' social interaction after changing the passive ventilation system to using air conditioning; Understanding the effects of air conditioning on the form and function of residential buildings in Jeddah; Exploring how reusing the passive ventilation and its elements could reduce power consumption, enhance the residents interaction and affect the spatial organization. The findings from each approach (phases) were merged together into one overall interpretation to add to the current knowledge about the link between the three research areas. This study included one quantitative part, a questionnaire study and two qualitative parts, an observation, and an interview study (Figure 20). An explanation for the justification of the chosen design will be discussed in the next section.

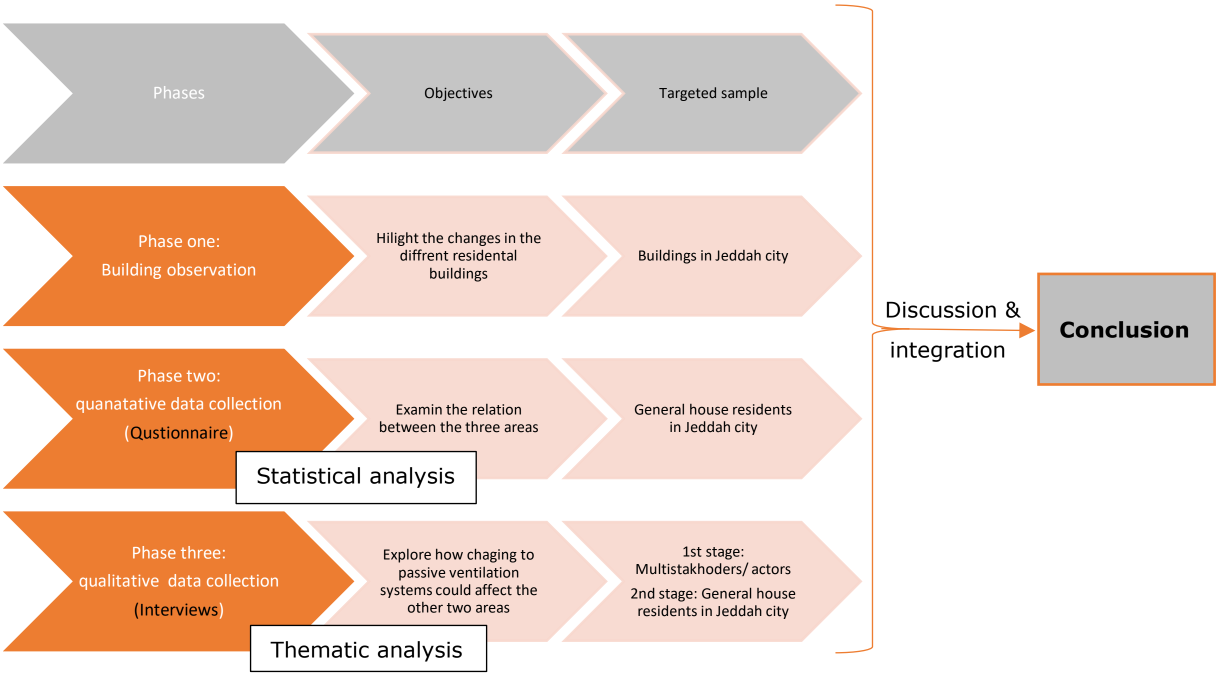


Figure 20 process of data collection and analysis for this study

4.2.1 Justification for the chosen research design

One of the main concepts of the mixed method design quality is the identification of the reasons for combining qualitative and quantitative methods within a study (Tashakkori and Teddlie, 2010). This enabled the reader to understand the importance of employing an MMR methodology to gain findings (Caracelli and Riggin, 1994). Cohen et al. (2018) argue that research design is controlled by the notion of 'fitness for purpose and that there is no single blueprint for planning research'. The justification for MMR is highlighted by Morse (2005), who indicated that the rationale underpinning MMR is to achieve different but complementary data on the same issue to best conceptualize and explore the research questions. All research methods have drawbacks, and the use of a design with more than one method tends to average out the number of errors associated with individual methods (Teddlie and Tashakkori, 2009).

Considering the MMR typology suggested by Creswell and Clark (2018) and Johnson and Onwuegbuzie (2004), MMR can show many different strategies for integrating data. For this study, a sequential mixed methods approach with a multilevel model triangulation design was used, after evaluating the feasibility of a mixed approach to data collection. A particular justification for using sequential MMR for this study was that each phase depends on the previous phase of the study. For instance, the first observation study informed the quantitative phases of the research. Integrating the observation methods helped to reveal any important variables that could emerge to inform the content of the questionnaire which was used in the quantitative phase. From the literature review (Chapter 2 and 3) no existing specific questionnaire exploring the link between the three research areas was identified that captured this concept. Only a few questionnaires were identified that link two-research areas (either social and architect or technology and architect). Thus, it was important to develop a new instrument that fitted the research context which allowed understanding of the links between the three research areas. This was based on the elucidated variables that emerged from the observation phase findings in addition to the adapted items from previous studies. Finally, based on the participants’ responses on the quantitative phase, the qualitative phase used to fulfil the objectives of knowing if reusing the passive ventilation systems inspired from Jeddah traditional houses could affect Jeddah contemporary houses’ spatial organization and the family interaction in the house. It also sought to find out if the residents accepted the use of the passive ventilation systems through combining or replacing them with air conditioning.

4.3 Research ethics

Ethical approval was obtained from the Faculty of Engineering Ethics Committee at the University of Nottingham. All ethical considerations were considered which included the ethical approval process, informed consent, data protection and confidentiality and emotional distress.

4.4 Phase one : Observation of Jeddah building typology

This phase aimed to understand if the changes in Jeddah residential building resulted from using air conditioning instead of the passive ventilation system. These changes included the effect of the spatial organization and the different private zones that reflect the social interaction on the house. Importantly, this phase serves the subsequent phase of the quantitative data collection as a data baseline guidance and to elucidate any variables that could be included in the questionnaire.

Observation is a data source used by researchers to understand and explore a social phenomenon, community or culture or event (Holloway and Galvin, 2017) and is commonly used in the exploratory phase (Robson and McCartan, 2016). The researcher visited Jeddah city from 17th of November 2016 to the 29th of November 2016 to visit and observe the different buildings in Jeddah city. However, it was not possible to access all the rooms in the houses to observe the building and social interaction due to the participants' privacy and cultural issues. Thus, the observation in this study intended to analyse and to have a wider understanding of the non-human factors that includes three residential buildings as case studies. The first case study (traditional building) helped to gain a background of the spatial organization of Jeddah's traditional houses, the passive ventilation system and elements used and the different private zones. The second case study focused on the spatial organization of contemporary houses, the type of air conditioning used and the different private zones. The final case study is of a contemporary house where the design is inspired by a traditional house and uses both the passive ventilation system and air conditioning. Figure 21 will show the criteria of selecting the different case studies such as the age of the building and where the documents were sourced.

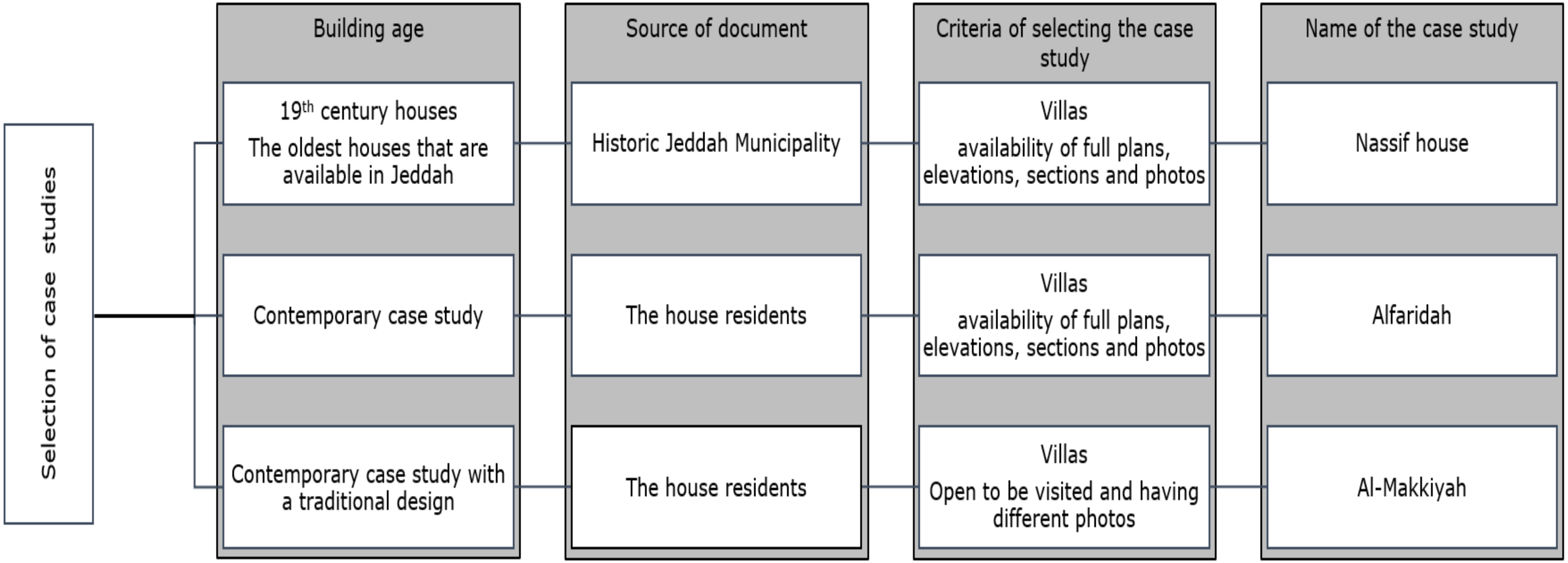


Figure 21 criteria of selecting the case study

Many residential buildings (11 buildings) have been visited to explore the changes in Jeddah residential buildings and if they resulted from using air conditioning instead of the passive ventilation system. The intended aim was to include different buildings varying between traditional and contemporary houses. However, not all the documents were available or could be accessed such as plans, sections, and elevation. The researcher managed to have full documents and comprehensive information for one building from different eras. This section will provide a brief background regarding these buildings and the sources of data that will be discussed in more detail in chapter 5:

4.4.1 Traditional building

This traditional case study offered a clear background about spatial organization such as the different room functions, room size, location, and others of different traditional houses in Jeddah in addition to the data regarding the passive ventilation system and elements used in Jeddah's traditional residential buildings and how the residents were interacting in the different private zones in the buildings.

Jeddah city centre (Historic Jeddah area) has a number of different traditional houses which have been visited by the researcher. However, the only traditional house that the researcher managed to acquire full drawings for and was able to access was the Nassif house. The documents and data were provided by the municipality of Historic Jeddah and previous studies.

4.4.2 Contemporary building

In the mid-20th century; the house residents had different needs such as building smaller houses. The houses were designed for one family only and not for multi families. Another reason for building smaller houses is that most of Jeddah's residents were fascinated by western cultures. The analysis of the contemporary houses provided a deep understanding of how using air conditioning led to changing the spatial organization of the house such as the different room functions, location, size and others. It also highlighted the effect on the private zones and the house resident's social interaction.

Although there is a high number of contemporary residential buildings in Jeddah city, because of the high privacy of the house residents, it was difficult to observe the houses. However, one of the house residents provided the researcher with full drawings for their house but did not allow the researcher to enter the house to observe different rooms.

4.4.3 Contemporary building with a traditional design

The Al-Angawi house, which is known as Al-Makkiyah was built nearly 25 years ago in Jeddah city. This residential building is an iconic building in Jeddah city because it was designed to reflect the traditional house design of Jeddah, its building materials, spatial organization and the different private zones. In addition, it uses both the passive ventilation system and air conditioning to provide its residents with thermal comfort. The researcher managed to visit Al-Makkiyah and to meet the designer as the house owner was allowing visitors to visit the building and to enter the public and some of the semi-public zones in the house at different times of the year.

To sum up, the observation of Jeddah's different building typology provided a descriptive and comprehensive background regarding the spatial organization, the different passive ventilation systems used or if air conditioning was used, and the private zones in the residential buildings. It also highlighted many important variables to be included in the questionnaire for the second phase.

4.5 Phase two: quantitative method (questionnaire)

The aim of the quantitative phase is to examine the relation between the different research areas by analysing the data statistically. This section provides an overview of the data collection method, development of the instrument, and analysis method used in the quantitative phase. The strength of the quantitative approach lies in its ability to measure and precisely compare the characteristics and concepts that this research had interpreted were issues of importance to participants.

4.5.1 Quantitative data collection

Quantitative data was collected through a cross-sectional questionnaire study to help the researcher analyse the end user's understanding of how air conditioning has changed their family gathering and the spatial organization of the house and to also find out what alternatives the house residents might use instead of using air conditioning such as reusing the passive ventilation systems. Since the passive ventilation system inspired by Jeddah traditional houses is not commonly used nowadays, it was important to understand the house resident's views on the renovation of passive ventilation systems, whether they could affect the spatial organization and resident's social interaction. Thus, and due to the exploratory nature of the study, it was not possible to measure this experimentally or undertake any kind of physical measurements of indoor thermal comfort in the traditional and modern houses.

Although the questionnaires have some drawbacks, such as low response rate, possibly not accurately representing the response of the participants, and a misunderstanding of the questions (Robson and McCartan, 2016), they have several advantages that make them appropriate for this research. They can offer a broad survey of participants' views and a straightforward and simple approach to the study of beliefs, values, motives, attitudes, and, with a high level of standardization (Robson and McCartan, 2016). As indicated previously, there was no existing specific questionnaire that explored the link between the three research areas, thus it was important to develop a new instrument that enabled understanding of the link between the three research areas.

Questionnaires can be administered in several ways, involving self-administration, telephone, post, or online. In this research, the decision was to utilize an online method for the questionnaire. Although the paper-based questionnaires intended to have a higher response rate than the online one, the online method has more advantages that fit the study (Cohen et al., 2018, Robson and McCartan, 2016, Streiner et al., 2015). Firstly, since it would be impossible to access Jeddah house residents through a paper-based questionnaire, the online approach helped to reach or access the widest possible number of the target participants. Additionally, faster and lower data collection costs (Cohen et al., 2018, Streiner et al., 2015).

4.5.2 Participants sampling, recruitment, and research administration

The cross-sectional questionnaire targeted the general participants who were living in villas in Jeddah city. The questionnaire was distributed in an electronic form. It was expected to be released on the 19th of March 2017 to the 2nd of April 2017. However, the distribution of the questionnaire was delayed to the 4th of April 2017 to 4th May 2017 to ensure its validity and reliability which will be discussed in the next section. Participants who were willing to participate indicated this by returning the questionnaire, which had an explanation about the study at the beginning.

A volunteer sampling for questionnaires was utilized in this phase. It is mostly useful when potential participants are dispersed throughout the community or difficult to contact directly (Cohen et al., 2018). Samples are often drawn through advertising, requesting people to volunteer to participate in the study (Bryman, 2015). Jeddah residents were invited to participate through different social media such as Twitter and WhatsApp as the most appropriate methods to access a wider number of participants. The questionnaire was to target at least 150 participants living in Jeddah. There was no formal sample size calculation due to the exploratory nature of the study (Polit and Beck, 2004). However, the collected sample was assigned to Chi-square for goodness of fit to ensure that it represented Jeddah house residents, as will be discussed in chapter 6. The voluntary nature of the sample and potential for participant bias are acknowledged and considered when interpreting the results with caution.

Inclusion criteria:

- General public (resident)
- Living in Jeddah
- Living in a villa
- 50% or more of the questions are completed

Exclusion criteria:

- Living outside Jeddah city
- Living in apartments
- Incomplete questionnaire

4.5.3 Development of the questionnaire

Developing a psychometric tool of high-quality has been described as a valuable approach to capturing human experiences (Widger et al., 2015). Nonetheless, key influencing factors that include the selection process, quality and reliability of items must be considered in developing a robust and valuable tool (Streiner et al., 2015). These aspects will be addressed within the following sections explaining the development of the questionnaire and issues related to the validity and reliability of it.

The questionnaires are an important way to communicate with the general citizens that live in Jeddah and a fast way to collect data (Bryman, 2015). Also, this method can provide trends of the population's point of view by studying samples of them and pointing out the important variables (Creswell, 2013). Therefore, it was important to design the questionnaire carefully in an easy language to minimise social desirability bias (see appendix 1 for the questions). Then it was piloted before distributing it to ensure that it is understandable to the public.

The observational analysis of the three case studies buildings (from the first phase) offers a rich source of data from which items were developed for the questionnaire. Then, the items selection was guided further by adapting items from existing measures in the literature from previous chapters. While utilizing an existing questionnaire might save time and resources (Boynton and Greenhalgh, 2004), a questionnaire that captures the link between three research areas was not readily available nor was one available in the Arabic language.

The questionnaire included 33 preliminary questions. The range and variety of questions produced much useful information about the link between the three research areas. It was divided into four main parts, as follows:

- **General background:** it described the general background of the questionnaire and the house residents', such as the building type, the house residents' age, and others.
- **The second part:** described Jeddah residential buildings' spatial organization. It mainly focused on the most important spaces in the house and the spaces that could be dispensed with. Also, what changes the house residents have applied or intend to apply in their houses and in addition, what reasons led to changing the spatial organization. Moreover, it showed the different relation between the variables that help to answer the research question such as if there, for example, is a relation between making changes in the residential building and the building age and others.
- **The third part**: was the social interaction that highlighted what the most common room that the family interacts in is, what the different activities are that they have in the

different rooms and what the main reasons that affect the family interaction in the house are. In addition, this subsection will examine if there is a relation between the common meeting room and the building age.

- **The fourth part**: described the technology most used in the house. The participants were given three different technologies. The first technology was air conditioning. The second technology was media technology. The final technology was the house appliances. Furthermore, this subsection will examine the relation between the different technology and the building age, the dependency on the technology used and the house residents' age and others.

The aim was to choose an appropriate scale for measuring the Jeddah house resident's responses on different aspects of the three research areas that could provide detailed and reliable responses to the questionnaire. While evaluating approaches to designing response scales, it is important to consider first the kinds of possible responses that can emerge (Blaikie, 2003). The decision was made to choose a nominal scale of measurement as most of the questions included dichotomous (yes or no) answers or a simple check rather than rank ordering. The nominal scale simply donates categories, the data classifies but has no order, thus it is usually considered as frequencies in individual categories, and 'non-parametric' statistics must be used for analysis (Cohen et al., 2018, Blaikie, 2003).

4.5.4 The pilot study

After the initial pool of items for the questionnaire were established in English, they were piloted in January 2017 by two qualified experts (supervisors), and twelve of the general participants (house residents in Jeddah). Feedback was requested regarding items suitability, the questionnaire design usability, logic, accuracy, language, innocence of item construction problems and their understanding of the words used. The aim was to keep the items clear, meaningful, and short as far as possible. The first version of the questionnaire design depended on closed-end questions to cover six different areas which were;

1. The first area aimed to provide the house resident's demographic data.
2. The second area aimed to know the house specifications that the participant lives in.
3. The third area aimed to understand the social life of the residents.
4. The fourth area aimed to understand how the participants use the space.
5. The fifth area aimed to ask what technologies they use in their houses.
6. The final area aimed to compare the social life between the family meeting nowadays and the family meeting in their parents' house.

According to Wang and Groat (2013), if the questions are too broad, there is "no clear guide in deciding what data to collect." On the other hand, if the questions are too narrow, they may "leave out many things that are important to the goals of the study." The first questionnaire piloting outcome identified many major issues and offered the researcher crucial advice about items which were ambiguous, not related, repetitive, or complex. For example, one of the participant's general comments was that it had a lot of questions and it was time-consuming. Another comment was that some of the questions were unclear and it might have misled the participants. As a result, some of the participants preferred a reduced number of questions. Considering the feedback and continuing reflection on the questionnaire, further alterations were made to its wording, layout, and length. All questions were revised and updated and sent back to most of the volunteer participants to review the final version of the questionnaire.

The final version of the questionnaire was piloted by five different participants (three of them were involved in the previous piloting and two were judging the questionnaire for the first time). The final version was given to the same participants two weeks later to ensure the reliability of it and the results were, to a high extent, similar. One suggestion was to add an open-ended question for the participants, to ask them, "What they might do differently if they had the chance to rebuild their residential building?" The reason for adding this question was to give the participants some space to share their personal experience and view. Unfortunately, after distributing the questionnaire, the open-ended question did not provide any useful information because most of the answers were too general and unclear such as, "redesigning the house" or "having bigger rooms" and other general answers.

4.5.5 Validity and reliability of the questionnaire

It is important for the questionnaire to have the highest degree of validity and reliability to ensure the best outcome from it (Bryman, 2015). For the questionnaire to be valid, the outcomes must be reliable, i.e. it gives a stable outcome, if the outcomes are not similar then the questionnaire is not valid (Bryman, 2015). However, the main factor for this research questionnaire to be valid would be the translation to the Arabic language. Consequently, the researcher contacted one of the advisors in the King Abdul-Aziz research centre at King Abdul-Aziz University in Jeddah and requested their support to ensure the questionnaire validity. The support was helpful in ensuring the validity of the questionnaire, especially in ensuring the questionnaire was asking what it was meant to ask. There were moderate changes in the Arabic wording of the questionnaire that could be a result of the different accent. However, the wording was changed to match the nearest accent of Jeddah house users. Moreover, the content of the questionnaire has been reviewed and validated by two experts in the field before the translation process.

The reliability of the questionnaire means that if the questionnaire was distributed at a different time, but with similar conditions such as the same participants, similar living conditions and such it would deliver similar results (Bryman, 2015). As a result, the questionnaire was distributed two times for similar participants but at different times. The results were, to a high extent, similar. Therefore, the questionnaire was distributed to the public on the 4th of April 2017.

4.5.6 Quantitative data analysis

Quantitative data was analysed by utilizing the Statistical Package for Social Sciences (SPSS Version 24.0), and descriptive statistics for frequencies carried out to the data of questionnaire. Creswell and Clark (2017) suggested five main stages of quantitative data analysis. The first stage is the data preparation which includes categorising the data. This stage took place while designing the questions and before collecting the data. In order to enter the data in SPSS, all variables were assigned a specific label and code. The researcher randomly selected many computerized data to ensure the accuracy of the data file (Tabachnick et al., 2007).

The second stage is the initial exploration of the data. In this stage the researcher looked for obvious trends or relations. Following that, is the analysis of the data. The questionnaire collected nominal variables and the analysis does not include comparison between categorical variables. Therefore, following the screening and the inspection of the data, analysis was centred to different Chi-square tests to examine the differences between categorical variables for a single population using SPSS. First, a Chi-square test for goodness of fit was used because it is a statistical hypothesis test that shows how well sample data fit a distribution from a population (Field, 2018). The Chi-square for goodness of fit was used on the participants demographic data such as the participants gender, building type and others to test if the collected sample represent Jeddah house residents. Second, a Chi-square test for independence was used to determine whether there is an association between categorical variables (for example, whether the variables are independent or related). The fourth stage is the representation and display of the data which could be through exploring question by question finding, using tables, figures, and others. Finally, is discussing the data as will explain in chapter 6.

4.6 Phase three: the qualitative method (interview)

The aim of the qualitative phase is to explore and to gain a deep understanding of how the reuse of the passive ventilation systems inspired by Jeddah traditional houses could affect the spatial organization, the resident’s interaction and the power consumption. Also, if the house residents accept the use of passive ventilation solutions either by replacing or combining them with the air conditioner. This section will provide an overview of the data collection and analysis method utilized in the qualitative phase. The strength of the qualitative approach based on its ability to investigate participants' views, perceptions and attitudes where it usually emphasises words rather than quantification in the collection and analysis of the data (Bryman, 2015). The purpose of the qualitative data is to understand rather than infer, to clarify the range rather than generalise, and to gain insight and understanding into how people perceive situations rather than make statements about the population (Onwuegbuzie et al., 2009, Krueger, 2014). Moreover, the qualitative data treats context as important (Braun and Clarke, 2013). According to Braun and Clarke (2013) the qualitative findings tend to be more focused and in-depth in nature, whereby a generally small sample of participants can provide extensive detail and rich narratives, thus building on the existing knowledge base.

4.6.1 Qualitative data collection

Usually the most popular data collection methods in the qualitative approach are interviews, focus-groups, and observation (participants, structured, and unstructured). Semi-structured interviews were considered the most suitable method to address the phase aims. The justification for using the interview as a qualitative method rather than other qualitative methods were as follows. Observation is a source of data which is generally used to explore and understand a group or culture of social phenomena (Holloway and Galvin, 2017). However, this method was rejected because of the participants' privacy and anonymity as it was not possible to access their houses. Nevertheless, the researcher had the opportunity to observe the public area of the house where the interview had been conducted, with permission of the participants. This observation was only limited to the interviewee who was moving in and out the public room and across other rooms. A focus-group was also rejected as the participants were general public and group interviewing could limit their discussion and require them to share their privacy, anonymity and confidentiality. On the other hand, the interview could help provide in-depth understanding and answer in more detail the unanswered questions from the questionnaire (Blaikie, 2003, Cohen et al., 2018, Creswell, 2013). An interview is defined as a “professional conversation” (Kavale, 2008), with the aim of getting the participants to talk about their perspectives and experiences, and to capture their language and concepts, in relation to a topic of interest (Braun and Clarke, 2013, Rubin and Rubin, 2011).

Although the interview method has some drawbacks, for example, it is time consuming for both researcher and interviewee, and provides a lack of breadth because of the smaller sample sizes (compared to a qualitative survey study) (Braun and Clarke, 2013, Bryman, 2015), it has many advantages that met this phase aim. Interviews provide a rich and detailed data about individual experiences and ideas, it is fixable, ideal for sensitive issues, and accessible (Braun and Clarke, 2013, Bryman, 2015, Yin, 2014). Also, the interview method can be used to generate an almost perfect sample of the general population as practically everyone can be reached and can respond to this approach more easily (Creswell, 2013).

There are a number of different styles of qualitative interviewing such as narrative, active, and grounded theory approaches (Braun and Clarke, 2013). A grounded theory approach was most suitable for the purposes of conducting this specific prospective study. Charmaz (2006) and, more recently Creswell and Clark (2017), have suggested that interviews involve the primary data source when adopting a grounded theory approach, especially when examining real-life situations in terms of lived experiences, influencing factors and social activities underpin a particular phenomenon. Wimpenny and Gass (2000) indicated that interviews based on grounded theory take on a more open-ended style to generate a broad but rich primary data set. They also highlighted that the posed interview questions undergo a continuous process of refinement, based on findings from the data analysis. Interviews could be conducted through different ways: face-to-face, online or telephone. In this research, face-to-face and Telephone interviews were conducted.

In this study, a total of twenty-three interviews were conducted in the Arabic language where each interview counts as a dwelling. They were divided into two stages that involved one-to-one interviews, utilizing a sim-structured interview approach guided initially by participants' questionnaire feedback and the literature from the first stage. Following the findings from the analysis of the first stage and refinement of the questions, the second stage took place to gain a deeper understanding and to cover the unclear questions from stage one.

4.6.2 Participants sampling, recruitment, and research administration

Participants who live in Jeddah city from different backgrounds (heterogeneous sample) such as, house residents, architects, investors and others were included in this study aiming to obtain data from multiple perspectives and to ensure the inclusion of different voices (Adami and Kiger, 2005). The participants were varied throughout the first and second stage of interview data collection, as will be discussed in the following sections. In order to produce a comprehensive understanding of the research phenomena, the purposive sampling technique provided a rich source of data (Creswell, 2013). Thus, purposive sampling was utilized to select eligible participants that met the objectives of the study.

It has been suggested that there are no definitive limits for the appropriate sample size in qualitative research; the selection of sample and size should be appropriate to answer the research question (Creswell, 2013). Sandelowski (1995) argues that the adequacy of the sample size in qualitative research is relative and should be assessed as to whether it is too small or too large for the intended purposes and the intended qualitative product. A sample size of 10 might be judged too small, conversely, large sample sizes (over 50) might be too large to support claims of having completed detailed data analyses. Charmaz (2006) and Creswell (2013) highlighted that the sample size in the grounded theory cannot be calculated, but when the answers start to be repeated and stretch to the data situation, then the sample size is enough. Accordingly, a sample size of between 20-25 interviews was judged to be appropriate to produce data with an average time of 60 minutes for each interview.

Moreover, the selection of participants for the qualitative study were not meant to be representative of a population, instead the findings from this research are to generalize a theory rather than a population (Bryman, 2015, Cohen et al., 2018, Creswell, 2013). It is the "cogency of theoretical reasoning" rather than statistical criteria (Bryman, 2015). In other words, it is the quality of the theoretical inference that is made from qualitative data that is crucial to the assessment of generalisation. Thus, the findings were interpreted with caution.

Participants who had consented to participate in the interview study were contacted and a convenient time for the participant and place for the interview was scheduled. Participants of this phase of the study were selected for participation differently in each stage of the interviews, but generally they should be within the main eligibility criteria of this study phase:

Inclusion criteria:

- Participants were able to provide consent
- Saudi citizen living in Jeddah city
- House owner

Exclusion criteria:

- Living outside Jeddah city
- House renter or living with a wider family

4.6.3 Stage one of interviews

The first interview stage took place from the 18th of April 2017 to the 29th of April 2017. This stage aimed to interview participants who live in Jeddah city and it targeted eight different actors such as the house residents, architects, investors and contractors (see Figure 22). This stage managed to conduct eleven (10 male and 1 female) face to face interviews. However, some of the actors (urban planning and building permit) withdrew from participating prior to the agreed time of interview because they did not have the Jeddah municipality authorisation to conduct the interviews. The sample included only the house resident and architects. Other actors who participated in this interview stage such as building contractors, academics, investors, and real-estate agencies were included as a house resident actor, as will be discussed in chapter 7. The researcher arranged a convenient date and time to visit participants' houses for the interview.

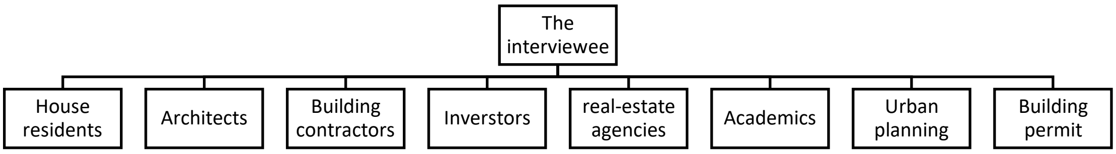


Figure 22 the interviewee categories

Sismondo (2010) mentioned that if different actors were in agreement, they would not be constrained by technology and culture. In other words, if all the actors have a similar goal, the spatial organization will lean with the house residents' social needs and the environmental technology or systems used in the house. However, mostly, in Jeddah city there might not be an agreement between different human actors, for example, using air conditioning or passive ventilation between the house residents and the architects. Consequently, there is a tussle in Jeddah residential buildings between house residents over using air conditioning or passive ventilation.

According to Singh et al. (2009), the architect's responsibility is to provide compatible designs that reflect the client culture and social and physical needs. If the architect can provide such a design, then the house residents can dwell in their house. However, the architect can be one of the visible actors that have control over the house designs. Thus, the reason for having more than one actor is to discuss the research question from different points of view. For example, interviewing the house residents will help to understand where they are gathering in the house. It will also help to understand what their real needs are within the space, how the house residents are interacting in the different rooms, how they are dwelling in these spaces and what stories they have that relate to engaging with the different rooms in their houses.

4.6.3.1 Designing the questions

For the first stage of the interview, questions were designed based on previous phases of the study to spot some of the questionnaire gaps and to ask focused questions and based on the literature review. The questions included in the interview discussion were reviewed and discussed with experts (supervisors) and piloted with some of the volunteers. The researcher earned many benefits from piloting the questions. Firstly, adapting and revising the questions and making them more focused, understandable and clearer. Prior to the actual interview data collection, the intention was to use unstructured interviews with open-ended questions. However, when a pilot interview was conducted, the researcher could not drive the volunteers to focus on a specific area and could not manage the time for asking questions in the different areas. Thus, a semi-structured interview was selected as the investigation aim was clear and focused, which made an unstructured interview inappropriate. Also, the researchers needed the freedom to explore specific avenues painted by the participants, for which structured interviews might have been too restrictive. Consequently, semi-structured interviews provided a systematic method whilst being flexible enough for the researcher to explore aspects raised by participants in more depth if needed.

The questions piloting also provided the researcher with a chance to ask the questions in different ways and also offered an idea of how the participants could respond. Importantly, the researcher was able to practice how to control and facilitate the interview discussion. Additionally, the researcher practiced how to listen and ask without interfering with the participants' response. This helped develop appropriate questions with prompts and props and tested them for suitability of wording and responses.

The final version of the interview questions was divided into the three areas of the research: the architectural design, the social life, and the environmental technology and systems. The social area questions were mainly focused on the house residents' daily activities, the number of family members living in the same house, the preferred family gathering room, the gathering time and comparing the social activity and movement in Jeddah contemporary houses with the way of living in Jeddah traditional houses. Questions relating to the environmental technology and systems enquired about thoughts such as, how the interviewees think that air conditioning has affected their family meeting activities. Finally, in the architectural area, the questions were focused on how the spatial organization and the family social interaction have changed because of the change of using passive ventilation systems to air conditioning from the interviewee's point of view. Importantly, there was no right or wrong answer, but the answers were expected to develop a deeper understanding of how the interviewees judge the influence of passive ventilation or air conditioning on the family social interaction and the spatial organization of the residential houses in Jeddah city.

4.6.4 Stage two of interviews

The second stage took place from the 15th of April 2018 to the 31st of May 2018. Following the data compilation and analysis processes of the first stage, underpinned by grounded theory, they were combined and used to inform any additional data gathering requirements (Duffy et al., 2004). This stage aimed to interview only Jeddah house residents. Twelve interviews, (9 males and 3 females) were conducted in this stage. Based on the first interview stage, accordingly, the objectives of the second stage of the interview were also to know how residents use the different spaces in the house, and what social activities they hold in the different spaces and for how long. In addition, to understand the level of acceptance in reducing the use of air conditioning and the use of passive ventilation systems. The researcher arranged a convenient date and time to visit participants' houses for the interview. In this stage the interviews included both face to face (10) and telephone (2) audio-recorded interviews. This was to include as much as possible a female resident as most of the female participants preferred telephone interviews due to the privacy culture in the Saudi community.

The interview questions of the second stage were also based around the three research areas. However, the first stage interview highlighted some further aspects to explore in more depth. Thus, the questions of this interview stage were refined and adapted and piloted using the same method as the first interview stage. The most important addition to this stage was adding some pictures and figures to the questions to help the participants understand the questions more clearly (see appendix 2). The final version of the second interview questions was also divided into the three research areas with some modifications and additional questions.

The second interview questions helped to acquire more focused and in depth understanding to answer most of the research questions. In the architectural area, the questions discussed the different room locations and the spatial organization between the traditional and the contemporary house. Moreover, in the social area, the questions focused on the family obligation to gather. For example, the first interview question shows the participants a traditional residential building and a contemporary residential building, the researcher explained to the participants some of the differences in the spatial organization and the air conditioning and passive ventilation systems used and asked the interviewees to give their opinion of how the changes affected the family social interaction.

In the environmental technology and systems area, the questions discussed the different air conditioning, passive ventilation systems and elements. While conducting the interviews, showing the participants different passive ventilation elements that have been modified and could be used in the contemporary residential building helped the participants to have a clearer understanding of how the traditional elements could be modified and reused in the contemporary residential building. In addition, it helped the participants to give more concise answers when they were asked to what extent they might accept using the passive ventilation elements and how using the passive ventilation elements could affect the spatial organization and the family social interaction. Finally, the interview questions helped in clarifying why the air conditioner is one of the highest power consumers and how using or combining the passive ventilation could reduce the power consumption.

4.6.5 Qualitative data analysis

This thematic analysis followed guidelines recommended by Creswell and Clark (2017) in order to describe and organise the data in rich detail. Prior to the thematic analysis, all interviews in this study were conducted in the Arabic language, thus, it was important to ensure that the transcript followed a systematic and thorough procedure in translation to the English language. The most popular translation procedure in qualitative research is verbatim transcribing of the original language, content analysis, translation of the emerging categories and concepts by two bilingual translators, back translation, and final agreement on the translation by an expert panel committee (Van Nes et al., 2010, Nikander, 2008, Cruz et al., 2000, Chen and Boore, 2010). Nevertheless, this was relatively difficult to conduct on all the transcriptions in the academic study conducted in the second language because supervisory oversight is essential. However, two transcriptions were selected randomly to undergo the recommended translation process. This process can enhance the quality of the translating process and identify any inconsistencies that may require further clarification (Cruz et al., 2000).

All the interviews transcriptions were analysed thematically following the five main stages suggested by Creswell and Clark (2017). Figure 23 below illustrates the analysis framework that the researcher adapted in analysing the interview. Braun and Clarke (2013) point out that, to a high extent, it is possible to apply changes to the qualitative analysis guidelines in order to have better outcomes from the data. The first stage was preparing the data through transcribing the interviews to text and loading it to a software programme. Following the translation process, a thematic analysis approach was utilised to identify key themes and NVivo software for data management used to assist in data analysis, increase speed and flexibility in coding, retrieving, and linking the data but not to alternate the researcher's intellectual role in analysis. The second stage was the initial exploration of the data which was done by looking for obvious recurrent themes to capture ideas. The third stage was analysing the data. This stage was accomplished by coding the data and grouping and categorised all similar or conceptually related codes were grouped into potential themes. After identifying the initial themes, the researcher developed and refined the themes. Experts involved in this study discussed any issues in relation to the code extraction and in refining the specifics of each theme and offered definitions and a title for each theme. The fourth stage was the representation of the data which was completed by writing an interpretation of the findings. The final stage was the validation of the data. For this research the validation of the qualitative data mainly depended on the translation of the transcript from Arabic to English. Consequently, a random sample of the transcribing and their translation from Arabic to English was selected and reviewed by PhD students fluent in both languages to ensure the validity of the data.

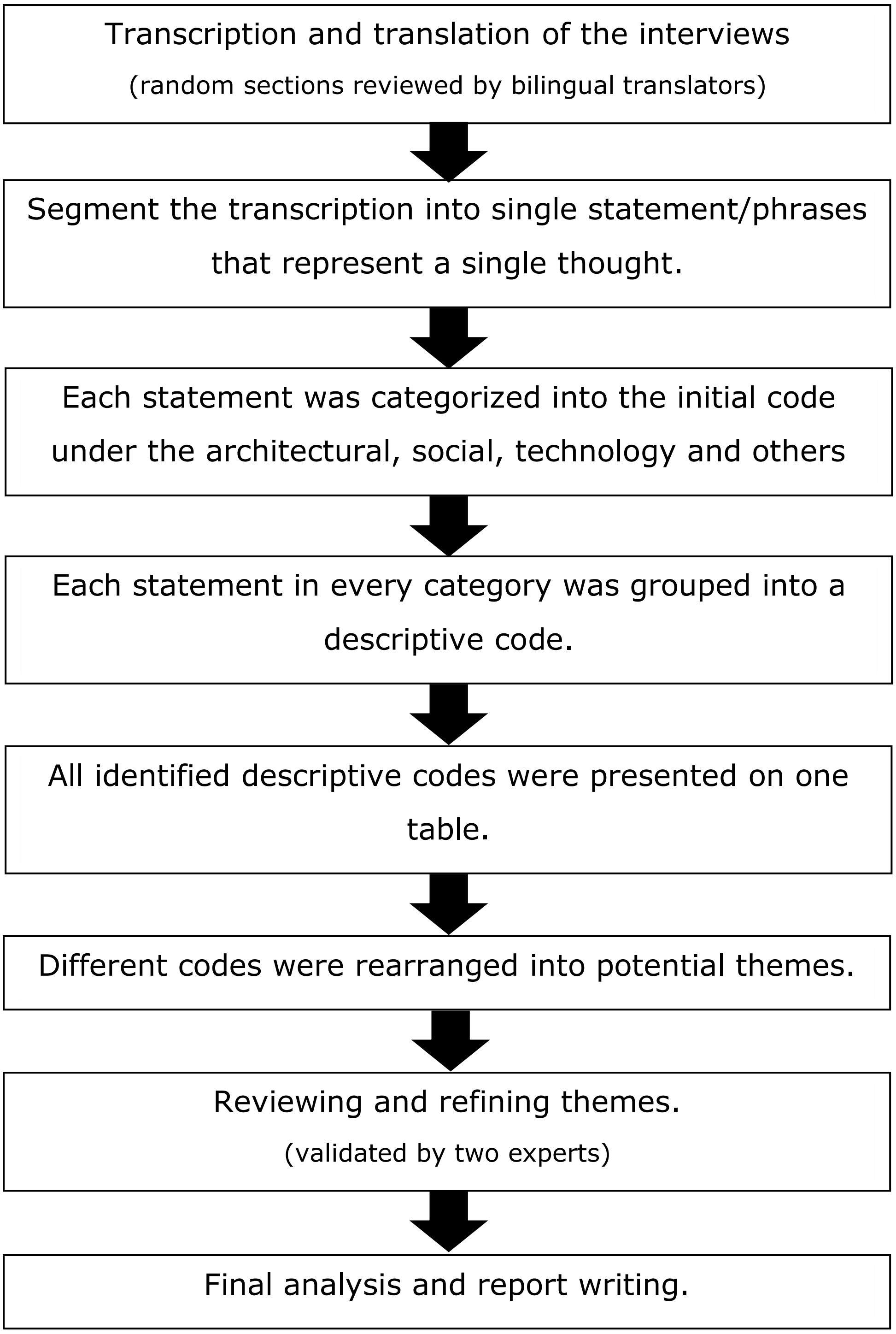


Figure 23 interview analysis framework

4.7 Summary

This chapter described the chosen methodology of this research and the justification for selecting the mixed methods approach with a multilevel model triangulation design. This chapter presented the three phases, observation of Jeddah's building typology, quantitative and qualitative data collection method. The chapter discussed the methods of data collection in all phases and the method of analysis. Quantitative and qualitative data were collected sequentially and were analysed independently. The findings and discussion will be presented in the following chapters.

Chapter 5

Phase one: observation of Jeddah houses typology

5.1 Introduction

The aim of this chapter is to highlight the changes in the residential building spatial organization and the resident's social interaction after introducing air conditioning in different periods of time. In addition, it highlighted many important variables to be included in the questionnaire for the second phase. This chapter is divided into two main themes. The first them is a background of Jeddah city and its urban design. The second them describes Jeddah building typology by exploring three case studies which are the Nassif house that was built in the 19th century, the Alfaridah house which is a contemporary house and the Al-Makkiyah house which was built recently but with a traditional design. The description includes the buildings design, the spatial organization and social life and different environmental technology and systems used in the residential building. The final section will discuss the differences between the three buildings.

5.2 Background of Jeddah city

Jeddah is the second biggest city in the KSA (Daghistani, 1993). Also, it is one of the cities that were built before King Abdul Aziz united the KSA (Salagoor, 1990). Jeddah was the main gate for all Muslims that were aiming to visit the two holy cities (Makkah and Madinah) Jeddah was the main gate for all Muslims that were aiming to visit the two holy cities (Makkah and Madinah) (Daghistani, 1993). As a result, the city had a lot of visitors from all over the world that were transferring their culture and knowledge in different areas to Jeddah citizens such as the building types, use of building materials, technology and other. Consequently, Jeddah became one of the trade hubs of Saudi Arabia.

Figure 24 illustrates how the area of Jeddah city increased from 700KM^2 in 1964 to 2500KM^2 by 2009(Jeddah Municipality, 2018). This increase in the city area is in line with a rapid growth in population. As a result, there was a high demand for residential buildings. In addition, it is expected that the city will further expand because of the Saudi Vision 2030. According to Akbar (1998) and Salagoor (1990), Jeddah city can be divided into two regions. The first region is the city centre, which was surrounded by the Jeddah wall. Nowadays, this area contains most of the traditional buildings and the traditional market. The second region is the new city, which is mainly an expansion of the city outside the Jeddah wall. Figure 24 shows the extensive expansion of the city that required, at first, new transportation solutions.

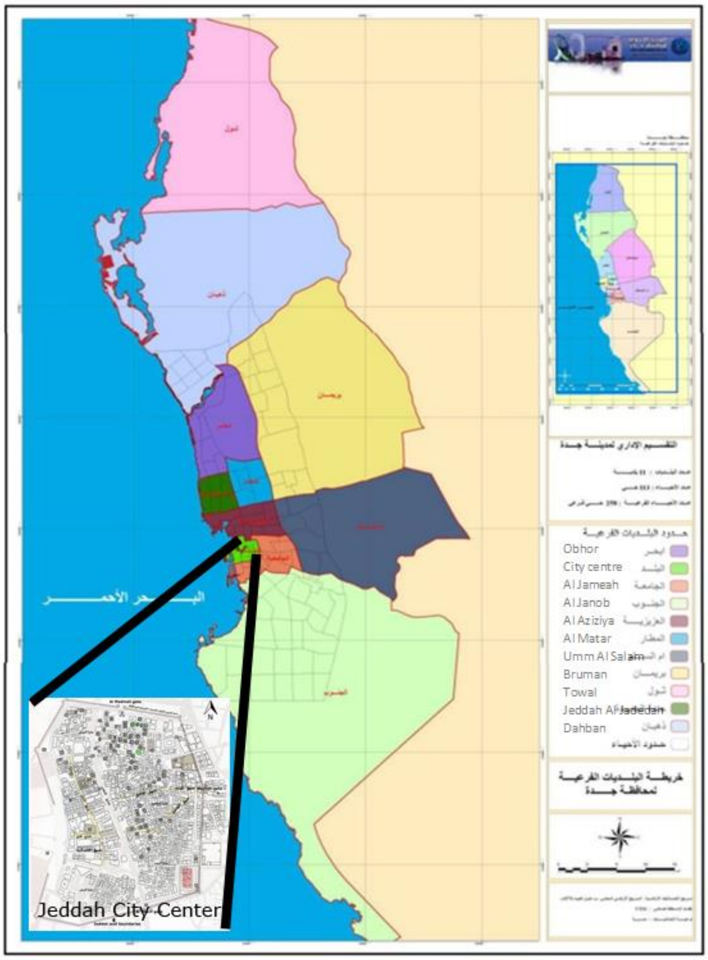


Figure 24 Jeddah city (Jeddah Municipality, 2018)

The Makkah Al-Mokaramah area has a unique architectural typology which is called the Higazy style (Bagader, 2014). This typology has common architectural elements such as using the windcatcher (traditionally called Malqaf and is now known as the Manwaar), the Mashrabiyyah, the Majaz, the courtyard, Dakkah and others as passive ventilation elements to ventilate the house (Al-Lyaly, 1990). These elements have two functions, the first is to provide an acceptable indoor thermal comfort (environmental function) and the second function is to provide private, sociable areas in the house for the family to interact in (sociable function). Interestingly, the Higazy architecture does not share similar architectural elements only, but also, to a high extent, shares a similar spatial organization that reflects the house resident's way of engaging, moving and living in these houses.

Jeddah city had a number of major events from 1930 to the 1970s. These events were the uniting of the Kingdom of Saudi Arabia, the discovery of oil in the Kingdom, the use of electricity for the public and having Jeddah's first masterplan (Alomari, 1993). Besides that, it also started a new industrial era.

Furthermore, in the early 2000s the residential ownership regulation changed for example, it was not possible, before the year 2000 to have different owners of the different apartments in one building, but after changing the ownership regulations, it was possible to have different owners for apartments in the same buildings (Ministry of Housing, 2017). These events might be the main reasons for starting a new era of expanding the city and modernising its houses and the citizens. Unfortunately, because of the lack of local architects at that time and the need for a high number of residential buildings, new building types were imported from different countries (Akbar, 1998, Salagoor, 1990). Yet, copying the building designs, building materials and changing to the use of air conditioning "without the questioning of the suitability" to Jeddah house residents and if it matched with the Jeddah city climate and other sociable values, led to losing the Higazy style and the social life of the house residents. Serageldin (1979) argue that having new building designs such as villas, forced its residents to experience a new way of living, moving and use of different elements such as the furniture in the space. In contrast, this might change the way of dwelling in the house and the residents might feel that they are living in a shelter or different boxes (Heidegger, 1971). Fadan (1977), Lawson (2001), Morris and Winter (1977) agreed that if the residents could not dwell in the house, they would start to reflect their needs within the house in different ways. This might explain why Jeddah house residents began making some changes to the spatial organization, rooms and elements after they began living in the house.

5.2.1 Jeddah urban design

The street's layout in the traditional area of Jeddah city was formed by the buildings surrounding it, see Figure 25. Also, the buildings were built attached together without any setback (Al wafi, 2006, Daghistani, 1993). This might be because, at that time, most of the houses were indoor oriented. The two most visible elements in the façade were the houses' entrances and the Mashrabiyyah. Interestingly, the houses' entrances were not built facing each other to ensure the privacy of each building i.e. even if both doors were accidently opened at the same time, it would be hard to view the neighbouring house, see Figure 25 (Al wafi, 2006). However, having the façade shaping the street edge led to developing and expressing the Jeddah building's identity and aesthetic. This urban solution led to having some environmental outdoor advantages such as, it helped to shade the street from the sunlight, and it created an airflow pressure in the street and between the buildings because of the different street widths. Moreover, because of the dependency on the local environmental technology, not having a setback could provide the residents with better indoor thermal conditions. For example, not having a setback helps to reduce the amount of elevations and building mass that interface with the solar heat which led to reduced storage and exchanging of heat between indoors and outdoors. Furthermore, besides the environmental function of the street layout such as creating shade in the street and an airflow, it had some sociable functions. For example, it provided an outdoor area in front of the houses for the neighbours to meet in, which is called Dakkah.

Figure 25 the building wall forming the street (Alharbi, 1989)

After the discovery of oil and the industrial era started in the KSA in the 1970s, Jeddah city expanded and its population massively increased (Alomari, 1993, General Authority for Statistics, 2019). Consequently, there was a high demand to provide residential buildings as soon as possible. Also, there was a need to link the different expanded areas of the city and to link the city with the suburban areas. To a high extent, cars were the best available solution. As a result, Jeddah's first master plan and the following ones resulted in dividing large plots of land into linear and different size lots on both sides of the streets (Al-Olet, 2003, Daghistani, 1993, Salagoor, 1990). Also, it had wider streets to allow car movement. Unfortunately, the streets were then car oriented and not pedestrian oriented. In addition, the building regulations required having a setback between the different buildings. For example, the residential building must have a 2-meter setback from the side that faces the neighbours and one fifth of the street width for the sides that have a view of the street (Jeddah Municipality, 2018). As a result, the houses' façades were moved from the street boundary to the setbacks and the street edge was shaped by the houses' fences (see Figure 26). The fences' entrances were the primary element that could be viewed from the street as shown in Figure 26 . This could lead to losing the identity of Jeddah houses for the street user. Also, it could lead to negatively affecting the environmental solutions (passive ventilation) that was used in the traditional houses. This urban design led to negatively affecting the shade on the street and the airflow because it had straight and similar street widths. Also, having the setbacks led to having higher numbers of façades interfacing the solar heat. Hughes et al. (2012), point out that the new urban design reduced the wind speed by 10-20%. As a result, the indoor temperature could be higher than the traditional houses that do not have any setbacks. Furthermore, these changes weakened the indoor house resident's social interaction and the outdoor social interaction with the neighbours. In addition, it led to losing the demonstration of the Jeddah house identity and aesthetic in the street. Moreover, using air conditioning such as the window type air conditioner or the air compressors on the different elevations distorted the elevations.

Figure 26 adding of the setback between the street and the building (kinan.com.sa, 2016)

5.3 Typology of the building

“Houses can tell the story of the house users; how they live, what their wealth is and what their culture is” (Alomari, 1993). In other words, the house spatial organization could reflect the family’s social way of living and interacting in the space, their lifestyle and what environmental technology or system is used. Moreover, to have a deeper understanding of the non-human actor boundaries and to answer some of the research questions, it might be important to describe and analyse different cases (Stake, 1995, Yin, 2014), in particular, different residential buildings in Jeddah city built in different time periods. Therefore, after being given a background about Jeddah city and how the urban design affected its streets and the environmental conditions, this section will explore more about the traditional building typology in Jeddah city and the contemporary building typology.

This section will mainly describe three different case studies based on the era of the buildings which are the Nassif house from the 19th century, the Alfaredah contemporary residential building and the Al-Makkiyah house that was built recently but with a traditional design. The case studies were visited by the researcher in April 2017 (see the methodology chapter for more details).

The number of the traditional buildings was limited, many do not have full drawings and cannot be accessed because of either safety reasons or their owners do not allow access to them. Consequently, it was hard to measure and draw the different traditional case studies, take photos or to have any environmental measurements that show the thermal performance of the traditional houses in Jeddah city. However, the municipality of the historic Jeddah area provided the researcher with Nassif house drawing and the researcher could access the building because it is currently used as a museum. But because the Nassif house is still under restoration, it was not possible to access all the different floors.

Moreover, while conducting the interviews, the researcher managed to observe the residential buildings that the participants live in and to make some sketches of the different houses. The researcher was able to acquire a full drawing from one of the interviewees who lives in the Alfaridah housing project and used it as a case study. Unfortunately, although the participant provided the researcher with drawings, they did not allow the researcher to view the different rooms in the house or take any photographs of the house. This is because of the privacy of the house and its residents. Finally, the owner of Al-Makkiyah house was opening his house every Tuesday for the public to visit the house, meet with him to discuss the design of the house and to take photographs of the house.

The description in this section will mainly focus on describing the house designs, explore the spatial organization’s effect on the family social interaction and will explore the passive ventilation and air conditioning used.

5.3.1 The 19th century case study

The 19th century houses or the traditional houses can be found in Jeddah city centre (nowadays it is called Historical Jeddah (Jeddah Municipality, 2018). The urban development of Historical Jeddah did not see many changes besides widening some of the streets to allow car movement. In Historical Jeddah there are a number of traditional residential buildings but unfortunately, most of these buildings are abandoned. However, the most popular houses in the historical area are the Nassif house, the Baschen house, Saloom house and the Norwally house. Moreover, the Nassif house is the only building that the researcher managed to acquire drawings of and some photographs from the historic area municipality by visiting it and from the internet.

5.3.1.1 The building design

The Nassif house was built in 1881 and it is currently one of the oldest buildings in Jeddah (Samir, 2014). The house building area is 900M^2 and its height is nearly 20M (see Figure 27, Figure 28, Figure 29 and Appendix 3 for full drawings). Moreover, the two main building materials were the Mankaby stones which were extracted from Al-Arbaeen Lack and were known for their potential for storing heat and cold. The other main material was the wood that was imported from nearby areas such as Wadi Fatma and was mainly used for the doors and windows (Jcc.gov.sa, 2019).

The house has two main entrances; the public entrance is from the North side of the building and the family entrance is from the West side of the building. The biggest rooms are located on the front side of the house facing the main street and the small rooms are on the side and back of the house. The stairs are located in the centre of the back side of the house. Furthermore, the service rooms are located on the back side of the house.

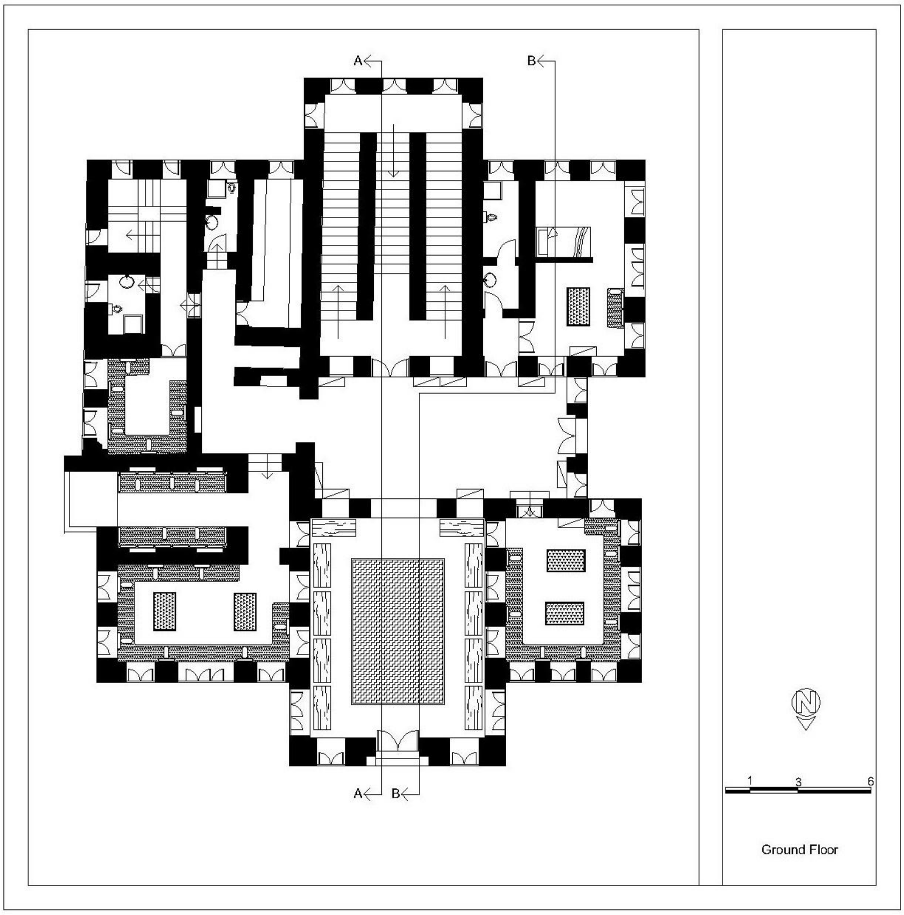


Figure 27 Nassif house ground floor (Author, 2018)

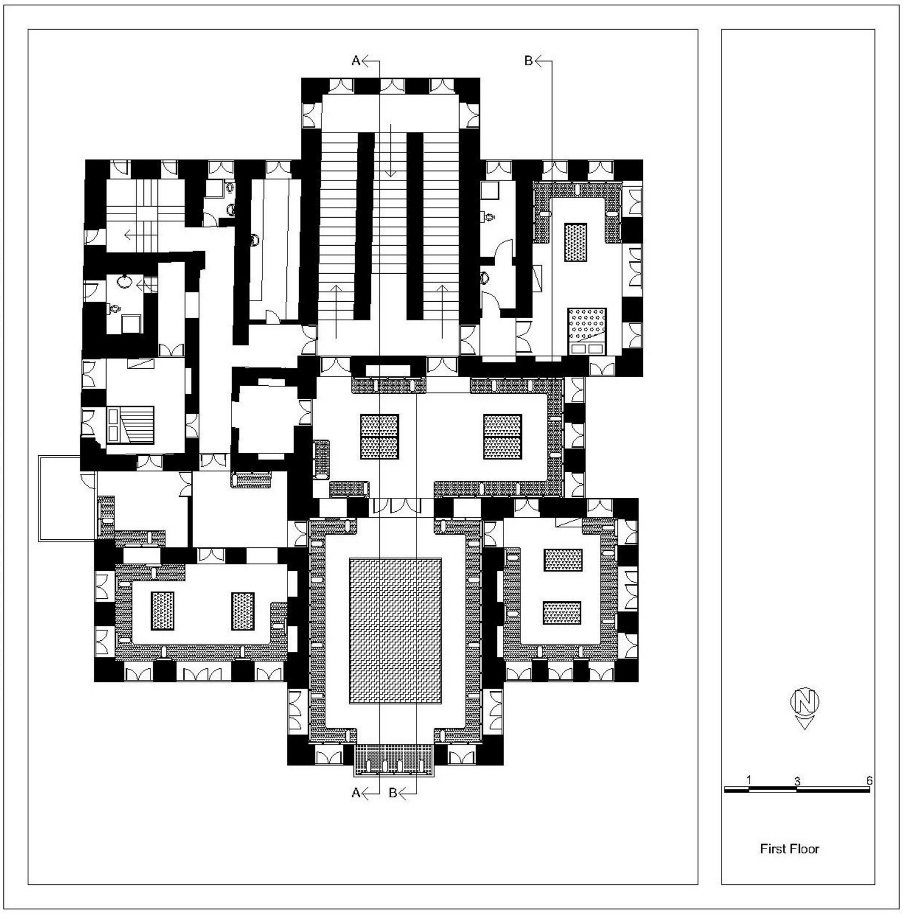


Figure 28 Nassif house first floor (Author, 2018)

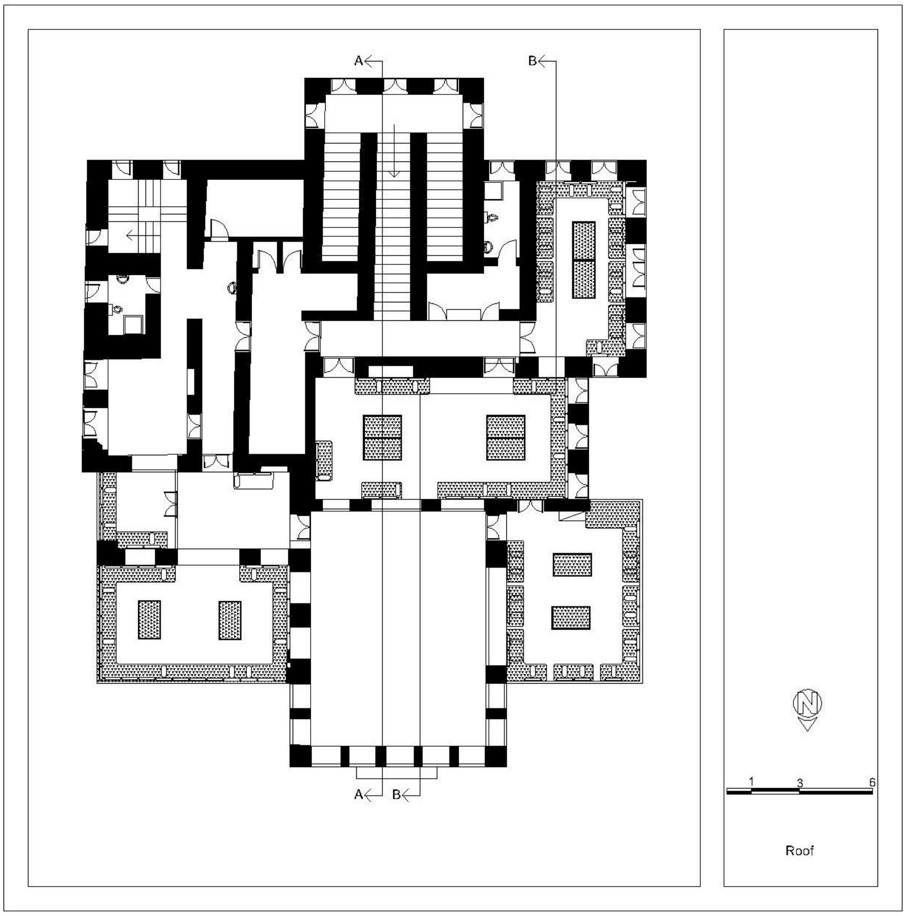


Figure 29 Nassif house roof floor (Author, 2018)

5.3.1.2 The spatial organization and the social life

Jeddah house residents, like any other house resident in the KSA, are known for their high demand for privacy in their houses. Therefore, Figure 30 illustrates the three main private zones in the residential building on the ground floor. The first private zone is the public zone, which is mainly used to meet visitors who are not related to the residents. This zone is usually located on the ground floor and it has a separate entrance. The public zone mainly contains the visitor's room and storage area. Also, in some houses it includes a visitor's bedroom. It might be clear from Figure 30 that the majority area of the ground floor is used for public zones. Figure 30 also shows that there are two entrances from the street. The first entrance is from the main street at the North side of the house. This entrance is directly linked with the public zone and is used by visitors. The second entrance is at the West side of the house. This entrance is the daily used family entrance. Having two entrances is mainly to provide higher privacy levels for the house residents, especially if there are visitors in the house.

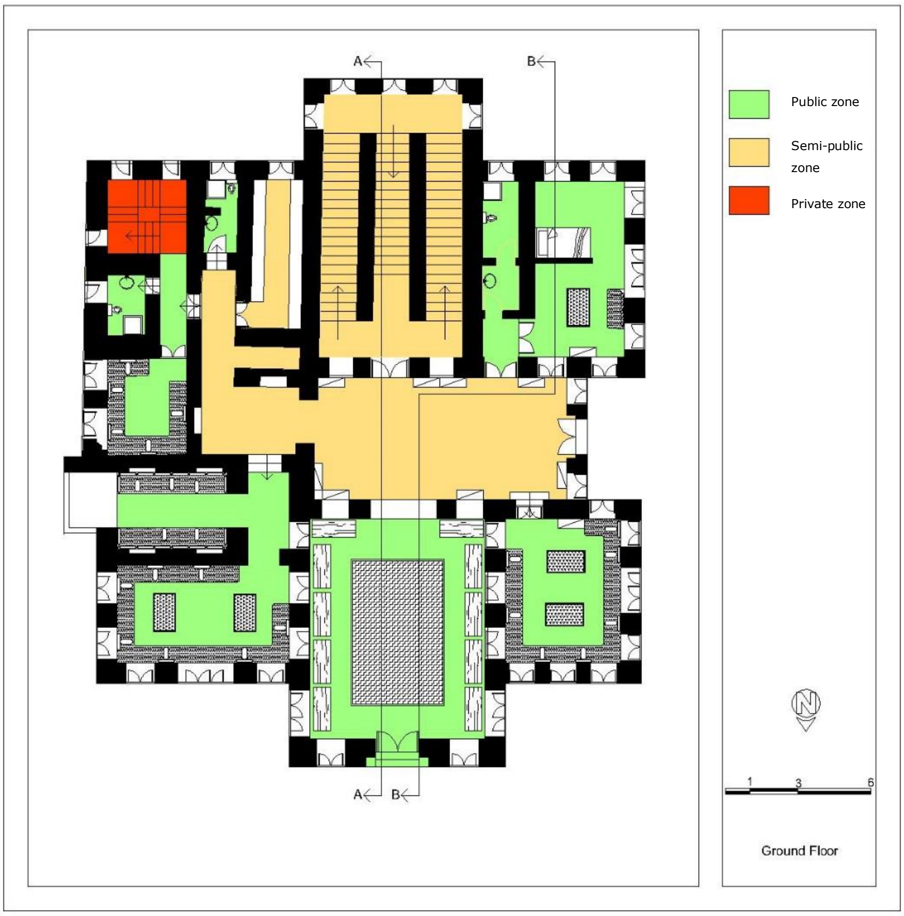


Figure 30 Nassif house, ground floor private zones (Author, 2018)

Figure 31 illustrates the private zones in a typical floor plan for the first to the third floor in the Nassif house. It is clear that these floors do not contain any public zones, but it contains a semi-public and private zone. This might reflect that any non-related visitor is not allowed to enter this level. In addition, it also shows that the different privacy zones are distributed in a hierarchy from the public zone to the private zone.

The semi-public zone mainly contains the multi-function rooms and the service rooms such as the kitchen and bathrooms that are used by the house residents. The multi-function rooms are usually located in the North side of the house for two reasons. The first is a sociable reason, which is to gather the family in the biggest room that has a street view. Also, to allow the house residents to interact with the street through the use of the Mashrabiyyah that allows the residents to see the street without being seen. The second reason is to benefit from the fresh incoming airflow. On the other hand, the service rooms are located in the back side of the house. The multi-function rooms are relatively bigger than the rooms in the private zone. A possible explanation could be that all of the family members are gathering in the multi-function rooms. Another more specific cultural reason is that the males are not allowed to sit beside a female except if they were their mother, sister, wife or daughter. Besides the family social interaction in the multi-function rooms, other activities are done there such as gathering, praying, eating, playing and sleeping.

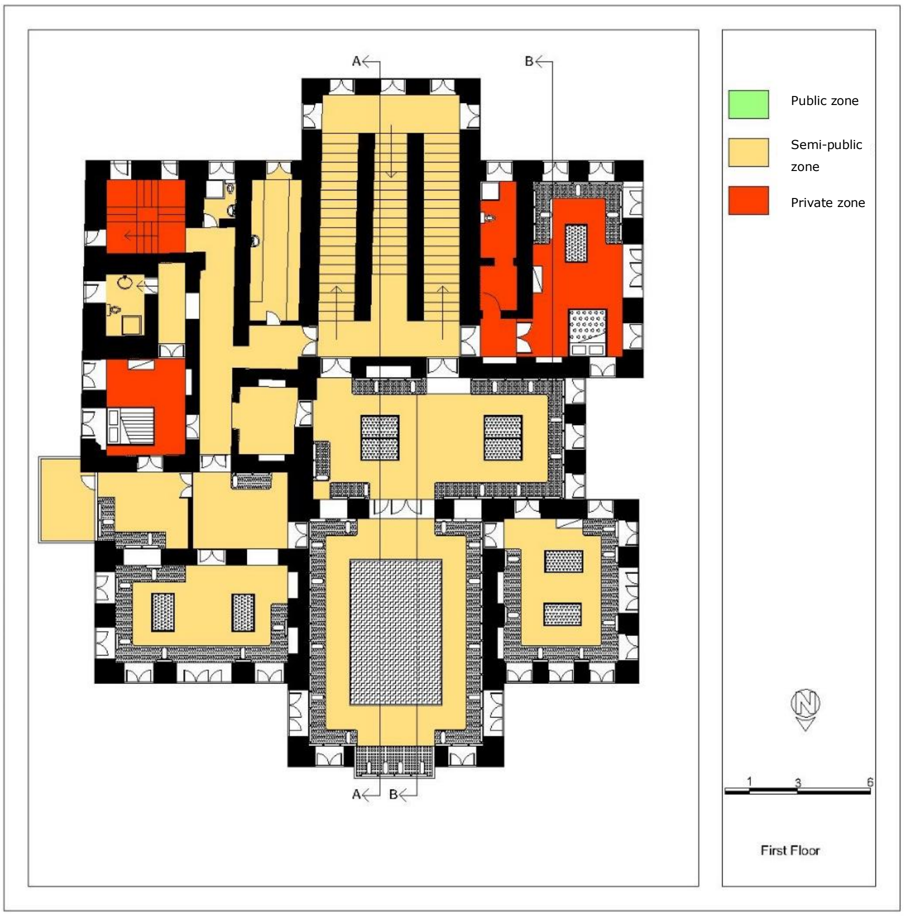


Figure 31 Nassif house, first floor private zones (Author, 2018)

The private zone mainly contains the bedrooms. Figure 31 shows that the location of the bedrooms is mainly in the side elevations and the service rooms are usually in the back or south side of the building. This might be because these elevations do not have a street view which provides the residents with a higher level of privacy. Furthermore, although Akbar (1998), Salagoor (1990) point out that the average number of family members in Jeddah houses was 19 residents, Figure 30, Figure 31 and Figure 32 shows that the number of bedrooms in the different levels are fewer than the number of multi-function rooms. Abdulkareem (2016) clarifies that the bedrooms were generally for the married residents and girls, and the boys were sleeping in the multi-function rooms, the roof or the courtyard in good weather.

Finally, is the roof floor shown in Figure 32. Interestingly, this floor contains the semi-public zone only. Also, Figure 28 shows that the Northern rooms have thinner walls than the other walls. This is to reduce the thermal mass effect and to provide indoor thermal comfort. Finally, this floor contains the courtyard that most of the rooms have a view of. A possible explanation could be that in Jeddah, during the summer, the weather is too hot. Therefore, the house residents might meet in the higher level that has bigger openings and thinner walls to benefit from the airflow to maintain their thermal comfort.

Figure 32 Nassif house, roof floor private zones (Author, 2018)

The section in Figure 33 shows that the public and semi-public zones in the Nassif house are located in the front side of the house, facing the main street. Also, the private zone rooms are located in the back of the house facing the side street or the neighbour. From a social point of view, it might be hard to have the required privacy level in the rooms facing the street. Therefore, the public rooms were located in the nearest area next to the main street (AboZade, 2012). Also, using the Mashrabiyyah on the first floor helped with locating the multi-function rooms facing the street. Interestingly, although the traditional house's different spaces are subdivided, the house residents were more sociable and interacting more than the open plan houses. A possible explanation could be that the house residents are meeting in the same room and moving similarly between the different rooms and levels to avoid the hot weather (see section 3.4 Thermal comfort and its effect on the house resident movement for more details). The next section will describe the passive ventilation system used in the traditional houses and how they affect the spatial organization.

Figure 33 Nassif house, private zone section (Author, 2018)

5.3.1.3 The passive ventilation system and spatial organization

In the 19th century, the environmental technology and system was limited and, unfortunately, most of these solutions were non-mechanical systems (Banham, 1984). Therefore, the main source of ventilation and cooling in the residential building in Jeddah city was passive ventilation (Al-Azzawi, 1996, El-Shorbagy, 2010b). Moreover, Abdulkareem (2016), Hughes et al. (2012), Sharif et al. (2010) agreed that the wind velocity, wind direction and different temperatures between the indoor and outdoor could be the main factors that help to benefit from the natural ventilation. Fortunately, the urban design of historic Jeddah helped to create air pressure between the buildings because of the different street widths and not having straight streets. Also, building without a setback helped to reduce the number of elevations that absorb solar heat. Furthermore, Figure 34, Figure 35 and Figure 36 illustrates different level plans that show the different passive ventilation elements that were used in the Nassif house.

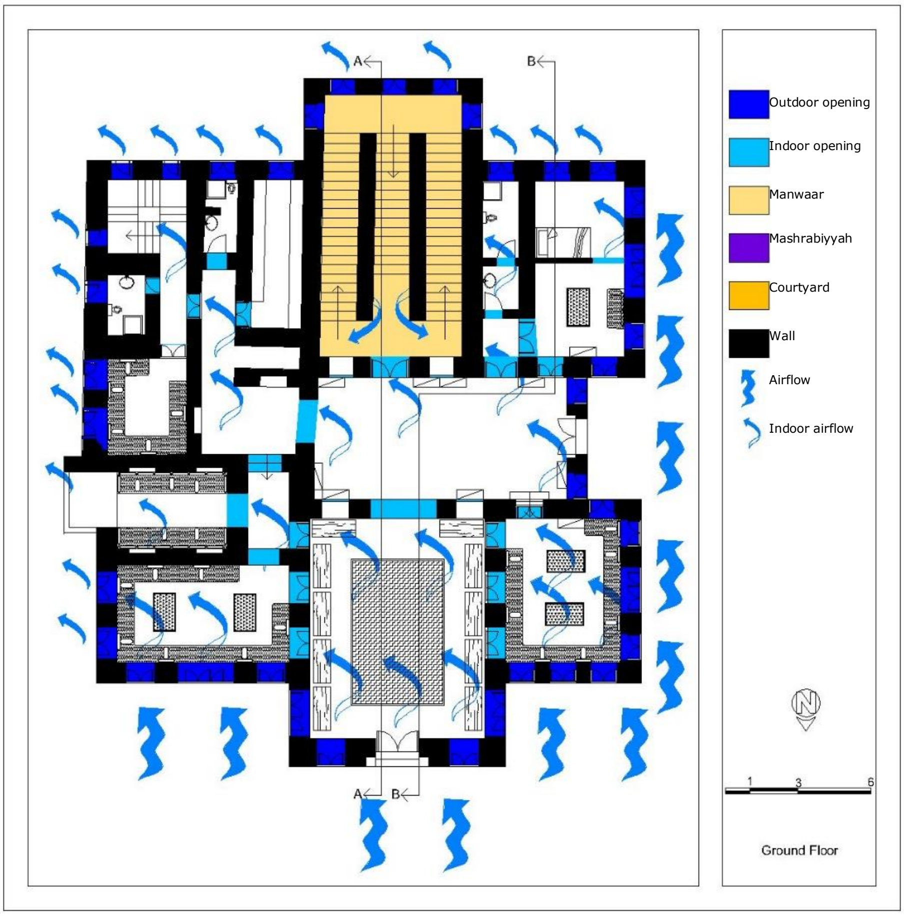


Figure 34 the ground floor environmental elements (Author, 2018)

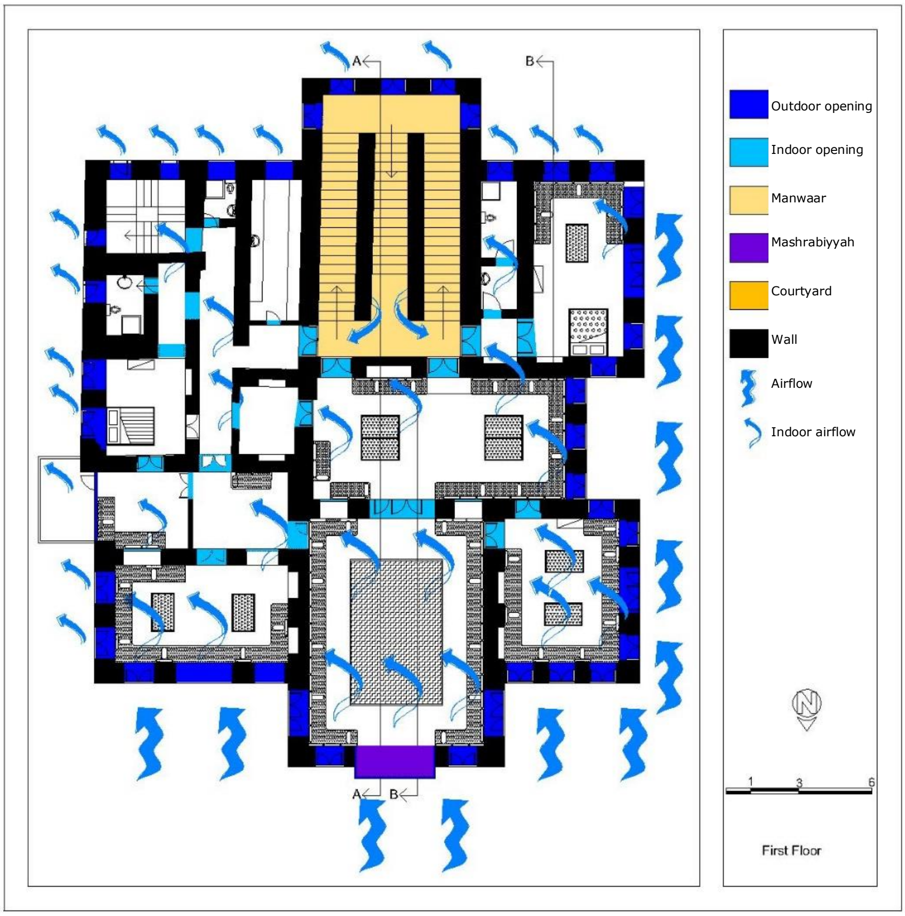


Figure 35 the first floor environmental elements (Author, 2018)

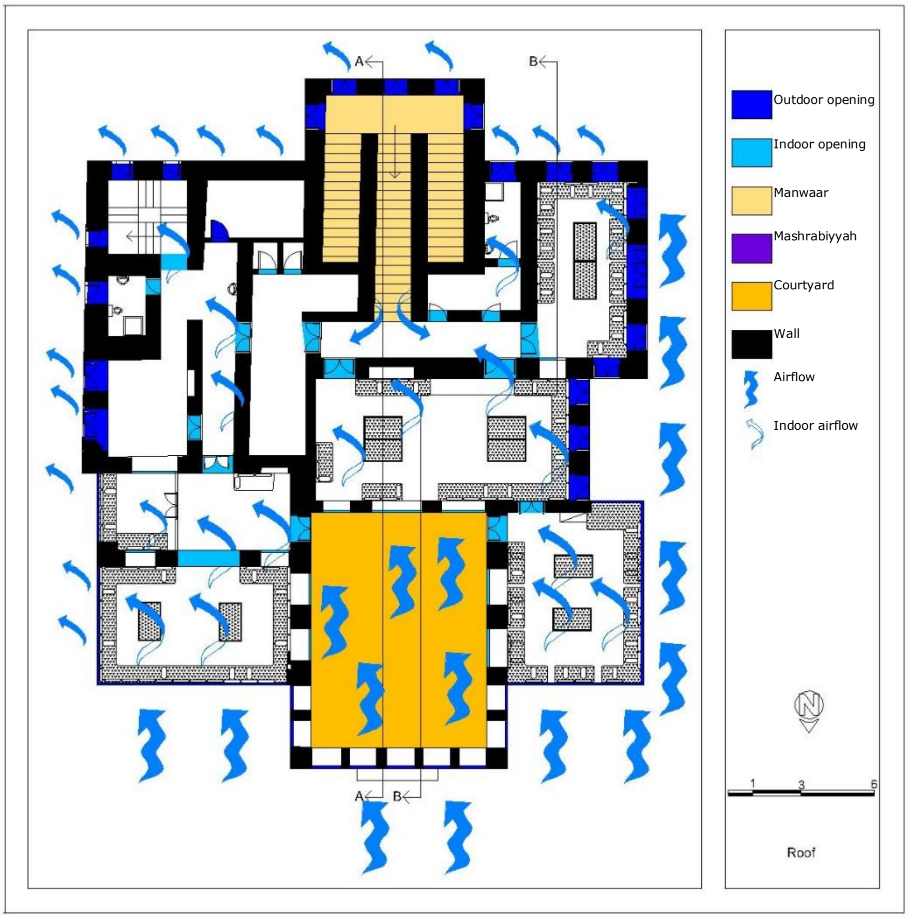


Figure 36 the roof floor environmental elements (Author, 2018)

Mashrabiyyah

According to Abdulkareem (2016) the Mashrabiyyah name comes from the action of shorb (to drink) because, at that time, the house residents put the water pots in front of the Mashrabiyyah. The possible explanation for this is to cool the water pots through having them facing the cold incoming airflow. The environmental function of the Mashrabiyyah is to control the amount of light from the sun and the incoming airflow. Therefore, it must be located in front of the biggest opening in the house facing the cold wind flow. Besides that, it is a shading element that helps to reduce the incoming social heat (Almumar et al., 2018). Interestingly, the water pots help to humidify the incoming airflow to the house, see Figure 37 (Abdulkareem, 2016, El-Shorbagy, 2010b).

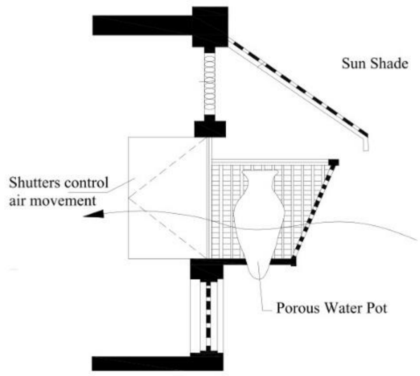


Figure 37 the concept of the Mashrabiyyah (Abdulkareem, 2016)

In Jeddah city, the Mashrabiyyah is normally located in the main elevation that has the biggest openings and facing the best incoming airflow. In order for the Mashrabiyyah to provide the proper airflow for the different spaces, Figure 38 Figure 39 illustrate the opening size behind the Mashrabiyyah that intakes the airflow from outdoors. Also, Figure 39 illustrates the different openings in nearly all of the walls to allow the indoor air circulation. Likewise, Figure 39 shows that the ceiling height in the room is nearly 4M. This is to provide more passive area behind the opening because the passive area behind the opening is double the ceiling height. Architect TSQ pointed out that there is a smaller version of the Mashrabiyyah which is called the Roshan. The Roshan does not have the water pot in front of it, but it has the shutters that control the airflow.

Figure 38 Nassif house main elevation (Author, 2017)

Figure 39 Nassif house multi-function room (Author, 2018)

Besides the environmental function of the Mashrabiyyah, it also has social functions such as, it strengthens the relationship between the indoor residents and the outdoor society. Also, it maintains the family privacy while they are using the multi-function room and their private room. Therefore, as Figure 39 shows, there is a sitting area behind the Mashrabiyyah for the females of the house to sit and enjoy the street view without being seen from the street (El-Shorbagy, 2010b).

Windcatcher

The windcatcher has two different names based on its function. It is traditionally called Malqaf because its main function is to intake the outdoor airflow. However, nowadays it is called the Manwaar because its main function is to provide lighting to the rooms that have a view to it, but it is used to exhaust the bad smells and the hot air generated from the air conditioning compressor. Therefore, because, to a high extent, the Malqaf and Manwaar have similar functions and size, starting from this point and forward the windcatcher will be called the Manwaar. The Manwaar is the highest part of the building because it sucks the outdoor fresh air from the higher level to the lower level as shown in Figure 40 (El-Shorbagy, 2010a). Then, this airflow could be exhausted through the windows or the courtyard. On the other hand, in the lower level, if the outdoor air is cooler than the higher level, the cold air in the lower level can enter the house through the windows and be exhausted through the Manwaar (Singh et al., 2009). In other words, the Manwaar could be used as an air distributor or exhaust based on the outdoor weather conditions (for more details see section 3.3.5 the windcatcher).

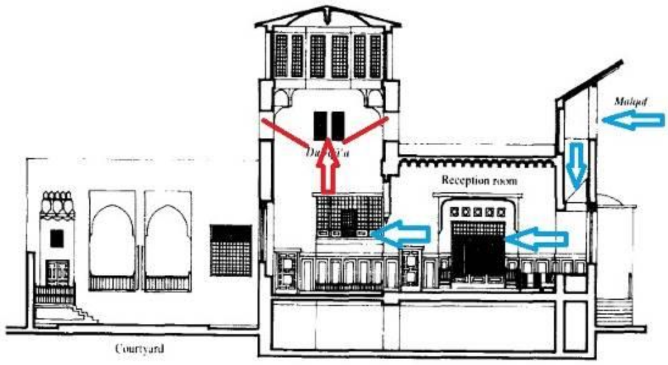


Figure 40 Malqaf (El-Shorbagy, 2010A)

In Jeddah traditional houses, the Manwaar area is approximately a minimum of 2M X 2M and nearly all the daily used rooms have a direct opening toward it. Figure 41 shows that the size of the opening facing the Manwaar is relatively big. Also, the corridors in the house could have a view toward the Manwaar. However, Some of Jeddah's traditional buildings combine the Manwaar with the staircase such as in the Nassif house case study (see Figure 34, Figure 35 and Figure 36). It is clear from the figures that the airflow generated from the Manwaar is distributed to the different levels through big openings and doors.

Figure 41 the Manwaar in Saloom house (Author, 2018)

Furthermore, the section in Figure 42 shows how the airflow comes from the top and is distributed to the different levels. Interestingly, the central space in the house that has fewer outdoor openings is served with the fresh air from the multi-function room and the Manwaar. Therefore, the passive ventilation, at that time, was an effective solution because it provided nearly all the different spaces with cold and fresh air circulation.

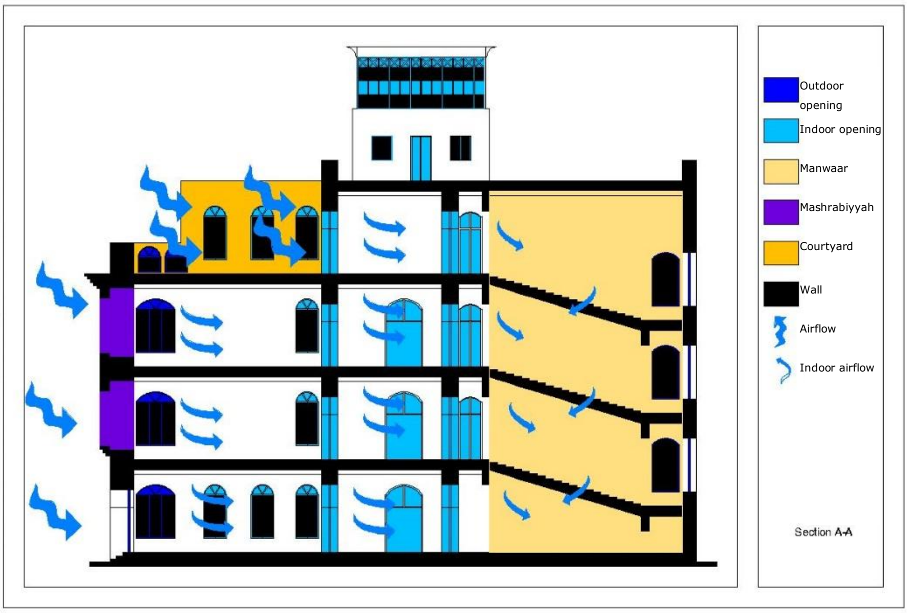


Figure 42 section of the environmental elements and the airflow (Author, 2018)

Walls and Windows

As mentioned previously, one of the main building materials is the Mankaby stone that is known for its high thermal performance (AboZade, 2012). Furthermore, the structure system at that time was using the load bearing walls. Consequently, the wall thicknesses were nearly 90CM. AboZade (2012) mentioned that the back side walls (South, West and East) are slightly thicker than the walls in the front side of Jeddah houses (North, West and East). A possible explanation could be that the back-side walls are observing solar heat for a longer length of time during the day than the front side of the building. Therefore, the walls must be thicker to ensure that it would take longer to store and radiate heat. This can also explain why the number of openings and their size in the back are much smaller as shown in Figure 34, Figure 35, Figure 36 and Figure 42.

Figure 34, Figure 35 and Figure 36 shows that there are two types of opening in the Nassif house that have different locations and sizes. According to Abdulkareem (2016), Ahmed et al. (2014), El-Shorbagy (2010a) having different opening sizes and distribution in the space helps to enhance the airflow in the building.

The first type of openings are the outdoor openings which are located in the house elevation. The outdoor openings are mainly in different sizes i.e. the openings facing the North side are much bigger than the openings in the South side of the house. This is to create a positive air pressure from the North side of the house and a negative pressure to exhaust the airflow from the South side of the house. AboZade (2012) pointed out that the air direction is the main effect on the location of the daily used rooms in the front side of the house. Also, it is the reason that the service rooms are located in the back side of the house. In other words, the passive ventilation solution could have greatly influenced the spatial organization.

The second type of openings are the indoor openings that are located between the different rooms (see Figure 43). The reason for having these openings is to provide the different rooms with airflow, such as the rooms that have fewer outdoor openings located in the centre of the house.

Interestingly, if the opening was a door and there was a need to close it, there is an opening above the door that is opened to maintain the air circulation and in addition, to control the indoor airflow.

Figure 43 indoor opening in Nassif house (Author, 2018)

Courtyard

The courtyard is usually the most social spot in the house and it is usually located in the middle of the house (El-Shorbagy, 2010b, Meir et al., 1995). Besides its social function, Etzion (1990), Fathy et al. (1986) point out that it is one of the most important ventilation elements in the house. This might be because nearly all the semi-public and private rooms have openings toward it (see Figure 44). Interesting to know, there were no standards for the sizes and number of courtyards in a house, but that did depend on the needs of the house residents. Moreover, if the courtyard was on the ground floor, the house entrances should have access to it. Furthermore, the house residents prefer viewing it rather than the street view because it maintains their privacy. Thus, the location of the courtyard, to a high extent, affects the spatial organization of the house. Furthermore, the courtyard is definitely bigger than the Manwaar, but it has similar environmental functions. Additionally, the courtyard could be the most sociable interaction point in the house (Abdulkareem, 2016). Normally, the courtyard has the same height as the building if it is located on the ground floor. In addition, although the courtyard could be located on any floor, starting from its level, its height is similar to the building height. Moreover, the concept of having most of the rooms facing it remain the same.

Figure 44 courtyard in a house in Jeddah (Susie, 2013)

5.3.3 Contemporary case study

In the mid-20th century; the house residents had different needs because the houses were designed for one family only with an average of five residents and not for an extended family that had an average of 19 residents (Salagoor, 1990, General Authority for Statistics, 2019). Thus, the change in the number of house residents, their needs, and the effect on the spatial organization, required a further investigation in the questionnaire phase. In addition, this raised questions about how the change in the number of residents affected their social interaction. Moreover, most of Jeddah's house residents point out other main factors that affect the family needs such as having a smaller building area, the high construction costs and the building regulations that restricts the designers (see section 7.2). Another factor is that most of Jeddah's citizens were fascinated by using air conditioning and were excited by western cultures and building designs. In this period, new residential types appear such as the villa, duplex villas (semi-detached), apartments and roof villas (villas located on the top two floors of the apartment building). One reason for importing these new building types could be that, at that time, there was a lack of local architects. It might be important to know that, Jeddah municipality is approving approximately 8451 permits annually to construct residential buildings (Jeddah Municipality, 2018). However, according to the General Authority for Statistics (2019), 30% of these permits are for villas, which is the focus of this study. Notably, most of the villa permits are for investors in the housing sector. For example, 355 villas are for the Alfaridah project, 135 villas are for the Masharif project and so on. Regrettably, these investors usually have a limited number of designs that they apply to their projects. The difference between the villas is mainly by enlarging some of the rooms or, often, on the elevation building materials (see Figure 45).

Figure 45 different elevations styles for the same villa (kinan.com.sa, 2016)

The designs of the different residential buildings could be divided into two categories. The first category is the self-designed residential building where the house resident had the opportunity to discuss ideas with an architect and then design their own houses. The advantage of this category is that the house residents had full control of the design and could reflect their needs in the design before building the house. On the other hand, the disadvantage of this category is that it is time consuming and its costs are higher.

The second category is the prebuilt residential buildings which were designed and built by an investor. According to Konooze.com (2016), kinan.com.sa (2016) , the investors usually build, in one project, 12 villas of a similar design and the number of the villas of a similar design could increase to 450 villas in one project. The advantage of this category is higher availability, they are cheaper and the residents could move into them much faster. On the other hand, the disadvantage of this category is that these residents do not have any control over the design, and they must accept the designs available in the market. In addition, these designs do not benefit from the outdoor environmental conditions. For example, we can find the same residential building in different locations but one of them is oriented toward the North and the other toward other sides. However, although the house residents can reflect their needs much better in the self-designed houses, the residents, to a high extent, prefer to buy prebuilt houses. One possible reason could be the lack of awareness from the house resident on how to dwell in the house. Moreover, the main difference between the two categories is that the self-design house residents have more opportunities to organise the different spaces based on their needs and wants and have better chances to design the house passively to benefit from the outdoor environment. On the other hand, the prebuilt houses are designed based on the architect's experience that might not reflect the real needs of the residents. Therefore, after purchasing the houses, the residents make some modifications in the spaces to fit their needs.

The next section will describe the house design then how the spatial organization has been changed in the contemporary house and how it could affect the family social interaction. The following section will describe how the air conditioning affected the spatial organization of the house.

5.3.3.1 The building design

The contemporary case-study selected is the Alfaridah house that was built in 2013 in North Jeddah. The built ground floor area is nearly 140M^2, the total built area is nearly 300m^2 and its height is nearly 10M (see Figure 46, Figure 47, Figure 48 and Appendix 4 for full drawings). Moreover, the air conditioning is the solution used in this building to provide thermal comfort for its residents and the main building material is concrete.

The ground floor in Figure 46 shows that the Alfaridah house has two entrances. One entrance has access to the public zone for the visitors and the other entrance has access to the semi-public zone for the house resident's daily use. However, the two entrances do not have access from the street but have access from the setback. Interestingly Figure 46 shows two new room functions that appear on the ground floor which are the dining room and the guard room. Having these new room functions in the contemporary houses, it would need more investigation on what new room functions were added to Jeddah residential buildings and what these new room functions would be dispensed with. In addition, the kitchen was moved from the top floors to the ground floor. The new space functions could reflect the new needs of the house residents.

Figure 47 shows that the first floor has three bedrooms and the family living room which has a similar room size to the bedrooms. Also, the living room is moved from the front of the house to the centre of the house with the staircase. The roof floor in Figure 48 shows that there are new rooms added to the house and that the semi-public zone is the outdoor area.

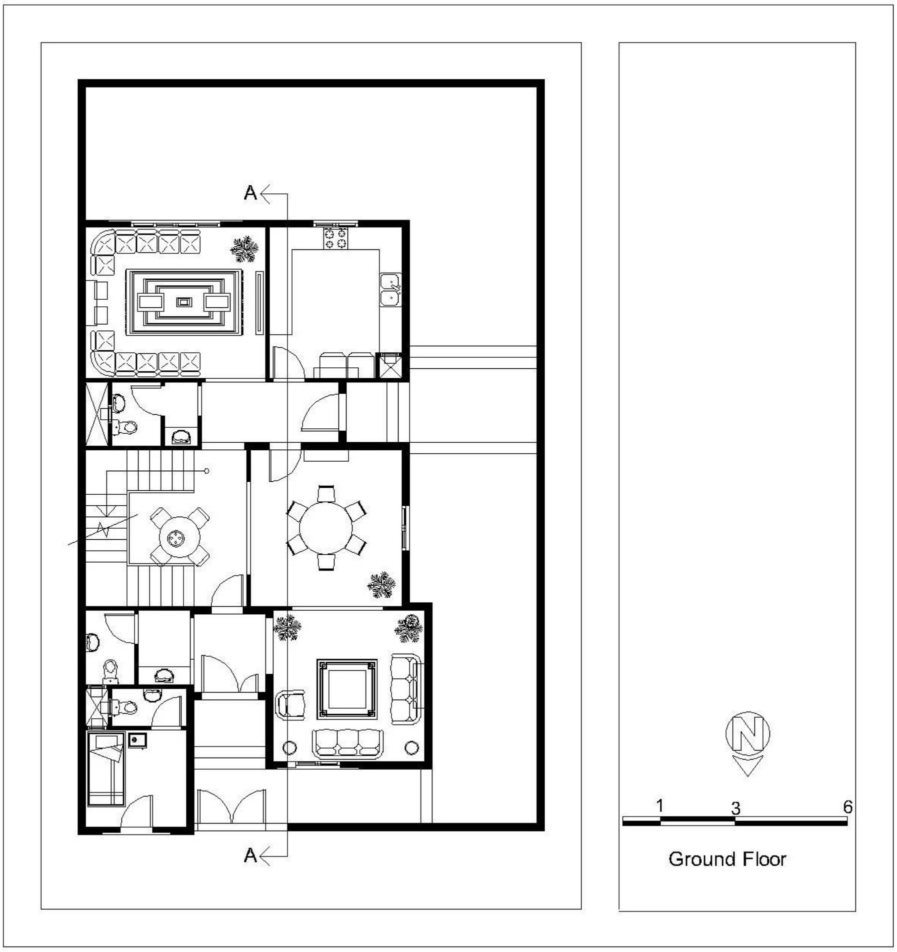


Figure 46 Alfaridah residential building ground floor (Author, 2018)

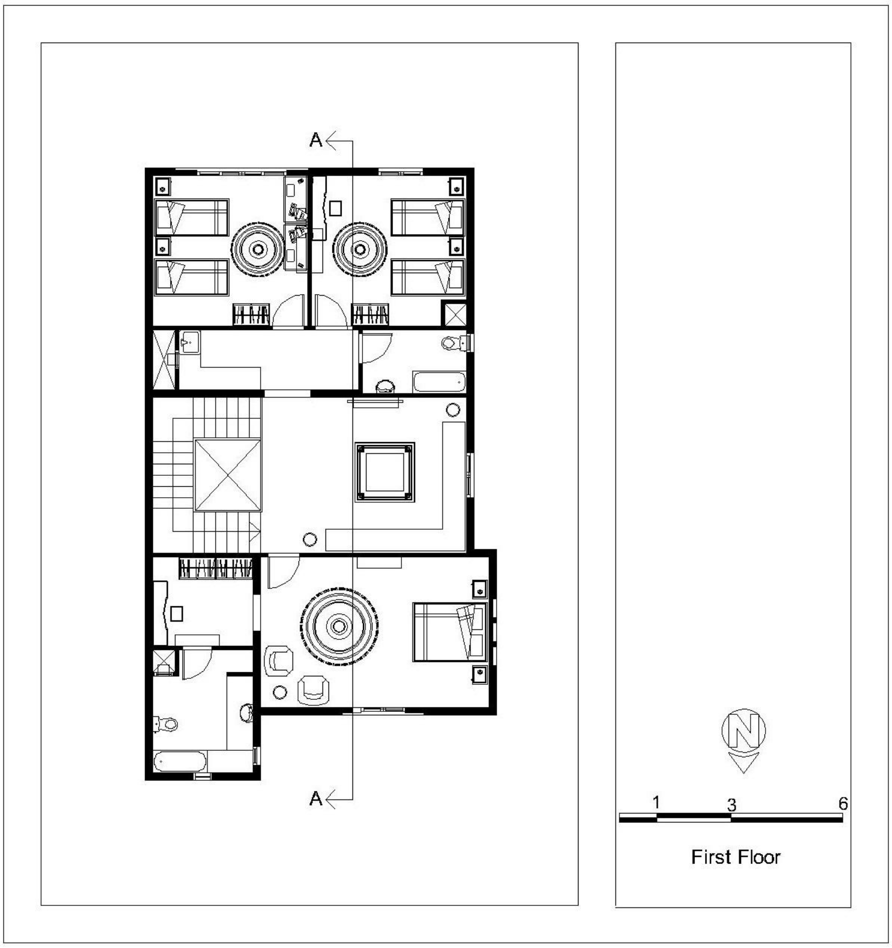


Figure 47 Alfaridah residential building first floor (Author, 2018)

Figure 48 Alfaridah residential building roof floor (Author, 2018)

5.3.3.2 The spatial organization and the social life

Unlike the traditional house, Figure 49 shows that the contemporary house semi-public zone mass is bigger than the public mass in the ground floor. The public zone contains one visitor room that has a view to the front setback and a bathroom. Moreover, the semi-public zone contains the living room and the dining room that have a side or back view and the kitchen. Interestingly, unlike the traditional house, the main kitchen is located on the ground floor and has a view to the side and back setback. Unfortunately, the location and view of the kitchen could be more functional if the family room was located in this space. Also, the bathrooms are not concentrated in the back side of the house but are located in different spots in the house and their openings are toward the Manwaar to exhaust bad odours.

Figure 49 Alfaridah, ground floor private zones (Author, 2018)

Having the setback negatively affected the house resident's interaction with the street users but provided the house residents with a safer outdoor area. Unfortunately, the setback area does not have the required level of privacy for the house residents. As a result, its use is limited to the males and the children of the house. Furthermore, having the female visitor rooms in the semi-public zone could encourage the residents to use it as a family living room besides the one on the first floor. In other words, changing one of the visitor's rooms from the public zone to the semi-public zone could divide the family social interaction and gathering area into two different rooms.

Figure 50 shows the private zones on the first floor of the Alfaridah house. This floor contains mainly two zones which are the semi-public and private zones. Unlike the traditional house, the private zone mass is much bigger than the semi-public zone mass. Remarkably the private zone contains the higher number of bedrooms. This could be because the house contained one family and each resident required a private room. Unfortunately, the family room location moves from facing the street in the main elevation of the house to the centre of the house and the master bedroom has the front, prime location. However, changing the location of the living room could have some social impacts. For example, according to Al wafi (2006), having the living room in the centre of the floor provides less privacy for the house residents. A possible reason is that the living room is no longer a separate room. Also, Al wafi (2006) added that having the living room in this location could change its use into being used as a corridor. In other words, on the first floor the house resident could walk across the living room to their private rooms. This could be because the living room does not have a prime location or because its size, to a high extent, is not big enough to contain all the family members. This might explain why some of the house residents prefer to gather in the female visitor's room on the ground floor.

Figure 50 Alfaridah, first floor private zones (Author, 2018)

In the contemporary case study, the roof floor in Figure 51 shows that the roof has new uses such as the laundry room and the maid room. Moreover, although nearly two thirds of the roof is a semi-public outdoor area, the house residents are not benefitting from it. This might be because the outdoor area in the roof is not outfitted to be used for family social interaction. Another reason is that, to a high extent, the outdoor area in the roof is used for the air conditioner compressors.

Figure 51 Alfaridah roof floor (Author, 2018)

When comparing the section in Figure 33 with the section in Figure 52, it might be clear that there are many similarities in the distribution of the different private zones on the ground floor. For example, the public zone remains in the front side of the house, facing the main street, and the semi-public zones are in the back side of the house. On the other hand, on the first floor, the semi-public zone has moved from the front side and the street view to the central area of the floor with a view of the neighbour. Also, it is surrounded by the private zones from the front and the back side of the house.

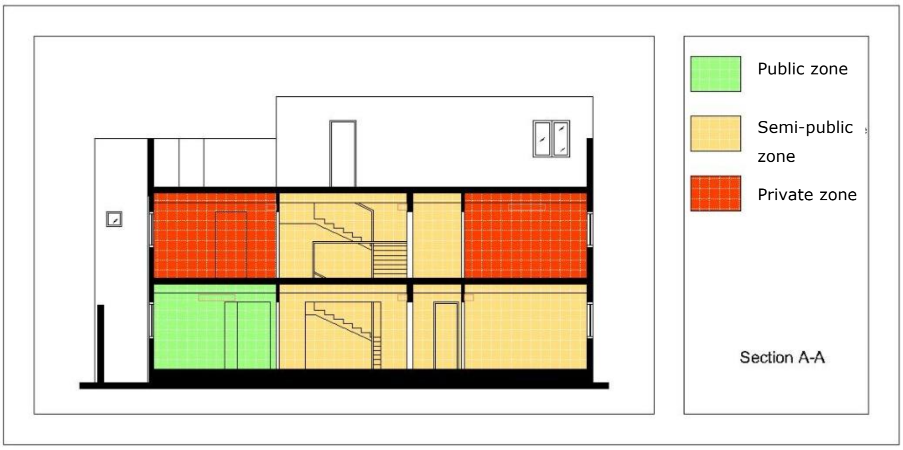


Figure 52 Alfaridah, section (Author, 2018)

In general, the changes in the spatial organization, in particular the different private zones, led to the family social interaction being affected because the gathering area has a lack of privacy, a smaller size and does not have an outdoor view that could provide the indoor residents with their privacy.

5.3.3.3 The air conditioning and the spatial organization

In the 21st century in Jeddah city, air conditioning is the main environmental technology used even though it consumes up to 80% of the power used in the house (Vision2030.gov.sa, 2016). Unfortunately, discarding the use of passive ventilation systems in the contemporary houses, to a high extent, affected the spatial organization of the residential building and the house resident’s family social interaction. Figure 53, Figure 54 and Figure 55 shows that air conditioning is the main solution used to provide the residents with thermal comfort. In addition, the windows and Manwaar are partly used as a means to ventilate the house.

Figure 53 Alfaridah, ground floor environmental elements (Author, 2018)

Figure 54 Alfaridah, first floor environmental elements (Author, 2018)

Figure 55 Alfaridah, roof floor environmental elements (Author, 2018)

Manwaar

In the contemporary houses the use of the Manwaar changed, it is used to provide the different spaces with light and to exhaust the indoor airflow and the bad smells. Also, it is used to locate the air conditioner compressors or as storage. Consequently, although the Manwaar is a requirement from Jeddah municipality, it is considered as a waste area. Therefore, the Manwaar is constructed with the minimum sizes required by the municipality which is nearly 1mX1.5m (Jcc.gov.sa, 2019). This might explain why the size of the Manwaar is massively smaller than the traditional ones as shown in Figure 53. In addition, this explains why the Manwaar is not as functional as it was in the traditional residential buildings. Moreover, this can reflect the lack of the resident's awareness of how to benefit from the Manwaar as a passive ventilation element.

Figure 53, Figure 54 and Figure 55 shows that there are more than one Manwaar in different locations and they might be in different sizes. The rooms that face the Manwaar are, generally, the service rooms such as the kitchen and the bathrooms. This might be a good solution to avoid having the service rooms' opening facing the street or the walk way, especially on the ground floor. On the other hand, this solution led the residents not to prefer having their semi-public or private rooms opening toward it because it does not have a good airflow or view. In addition, because of the bad smells generated from the service rooms and the air conditioner compressors. Consequently, because of not having a proper Manwaar, the spatial organization of the house has changed, and the different rooms have outdoor openings rather than higher privacy indoor openings. In other words, the design of the contemporary house is, mainly, outdoor oriented and not indoor oriented.

Walls and Windows

In this period of time the main building material in Jeddah city is concrete because it has a higher flexibility of providing different construction systems (AboZade, 2012). Even though the concrete is more flexible and stronger than the Mankabi stone, the concrete does not have the same thermal performance as the Mankabi stone. In other words, the concrete itself does not store heat or coldness but it is surrounded with insulation materials that do not filtrate the cooler indoor air out or the outdoor heat in. However, the only way to exchange the heat is through the windows. Consequently, the wall thickness is similar throughout the different sides of the house (see Figure 53, Figure 54 and Figure 55).

Figure 53 and Figure 54 illustrates that there are fewer and smaller outdoor windows than the openings in the traditional house. Also, it shows that the windows are all of a similar size. In other words, the windows in the North side have a similar size to the windows in the South side. Furthermore, the indoor openings in the contemporary houses are also smaller than the openings in traditional houses and are provided in the form of doors only between the different spaces. In other words, the main functions of the indoor openings are to transfer the residents from one room to another and not to rotate the airflow.

Courtyards

It is clear from the two case studies that the average building area nowadays in Jeddah city is smaller than before, they are between 200M^2 and 350M^2 compared with nearly 900M^2. In addition, Jeddah municipality requires having setbacks between the different buildings which is nearly 2M from each side (Jeddah Municipality, 2018). Also, the setbacks between the building and the street need to be one fifth of the street width. As a result, besides the smaller lot area, the built area is smaller. Moreover, because of replacing the passive ventilation system with air conditioning that does not require any space, the courtyard is no longer needed. However, although the setback does not provide a similar level of airflow, shade and privacy to the house residents, it is the optimum alternative to the courtyard.

5.3.4 A contemporary case study with a traditional design

The Al-Makkiyah house was built nearly 25 years ago in Jeddah city. The house owner, Prof. Sami Anqawi aimed to build a residential building that reflects the traditional architecture of Jeddah city and the Makkah area but, to some extent, in a contemporary way.

The Al-Makkiyah house is an example that shows how combining passive ventilation systems with air conditioning could affect the spatial organization and the family social interaction in the house. In more detail, using the different passive ventilation systems and elements affects the spatial organization through indoor orienting the rooms and having direct and indirect indoor views. Also, it affects the size of the windows in the different elevations. Moreover, using passive ventilation in the house affects the social interaction through having different social areas in the house such as the courtyard, the corridor and the room. In addition, providing house residents with strong indoor and outdoor eye contact. Likewise, the Al-Makkiyah house shows how the passive ventilation elements could be modified to be used in a contemporary way such as roofing the courtyard and using different wall types in the roof.

5.3.4.1 The building design

In Al-Makkiyah house, different building materials were used but the finishing materials were the local building materials (see Figure 56). Moreover, the air conditioning is combined with the different passive systems. The ground floor built area is 875m2 and the total built area is 2180m2. Therefore, the

Al-Makkiyah house cannot be an exact model of the other contemporary residential buildings in Jeddah because its building area is nearly triple the regular residential building area in Jeddah city.

The Al-Makkiyah house is designed to be oriented toward the North side in order to face the cold incoming airflow. Figure 56 shows that, unlike the contemporary residential buildings, the elevation has big openings covered with Mashrabiyyah. The reason for having the big openings is to intake as much airflow as possible. Moreover, covering the opening with the Mashrabiyyah is to shade the opening which in turn reduces the solar heat, controls the incoming airflow and sunlight through its shutters. Figure 56 also shows that the elevation mass is not in one level i.e. there is protrusion at the elevation to create shade and shadows in order to reduce the mass facing the sun to reduce exposure to the solar heat. Furthermore, Figure 57 shows that the East elevation has a wavy design to allow as much natural air and sun light into the different rooms in the house as possible.

Figure 56 Al-Makkiyah main elevation (Author, 2017)

Figure 57 Al-Makkiyah side elevation (Author, 2017)

5.3.4.2 The spatial organization and the social life

In the Al-Makkiyah house, the public and semi-public zones are facing the main elevation such as the visitor's room, the living and dining rooms. A possible explanation for having the visitor's room and dining room facing the North main elevation is to have a better airflow and to enjoy the outdoor view. Furthermore, the private rooms such as the bedrooms are located on the side elevations as shown in Figure 57. Professor Anqawi explained that although the bedrooms have a very similar quality of airflow as the public and semi-public rooms in the main elevation, locating them on the side of the houses and far from the street is to reduce the car noise from the street. Besides the location of the rooms, planting the setback also helped to reduce the noise and pollution from the street.

Figure 56 and Figure 57 shows that, although the family living room is facing the street, it is hardly possible for the street user to spot if any of the house residents are behind the Mashrabiyyah. On the other hand, the house residents can enjoy sitting behind the Mashrabiyyah without caring about being seen by the street users. In other words, the house residents can privately connect with the outdoor environment.

5.3.4.3 The environmental technology and systems and the spatial organization

In this case study, different passive ventilation systems were used to ventilate the house but these systems and their elements were modified to be acceptable in the contemporary residential buildings. Moreover, because of the harsh and changeable climate of Jeddah, passive systems were combined with air conditioning.

Manwaar

The Manwaars in this case study are serving the back side of the house to provide them with the required airflow. The

Manwaars have two different heights, Figure 58 shows the high Manwaar and that its main function is to intake the airflow and to provide lighting to the house. Figure 59 shows the low Manwaar and that its function is to exhaust the indoor hot air out.

Figure 58 the high Manwaar (Author, 2017)

Figure 59 the low Manwaar (Author, 2017)

Walls and windows

As mentioned previously, the Al-Makkiyah house were built using new construction systems and building materials but the finishing was with local materials. For example, Figure 56 shows that the wall thickness is nearly 45cm. The reason for having thick walls in a residential building that was built recently is that the walls were built of concrete and then covered with stone. In this case study, using the local stone helped to reflect the local identity of the Higazy building. Additionally, it increases the thermal mass of the building which helps to reduce the need for using air conditioning. In other words, it requires a longer period of time for the heat to be observed and to radiate.

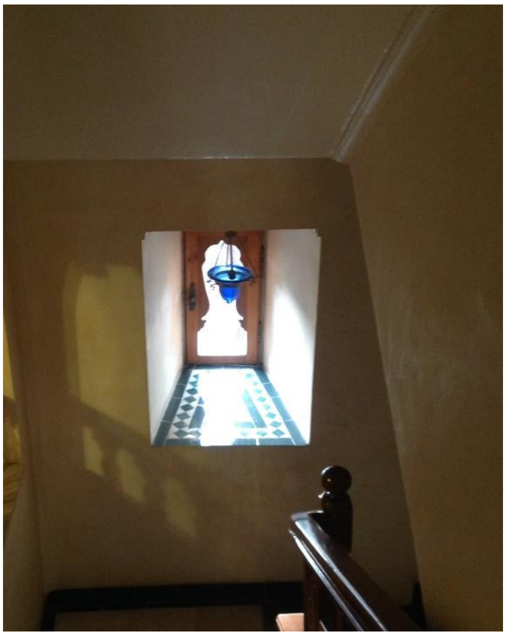


Figure 60 opening on the main elevation wall to show the wall thickness (Author, 2017)

In the contemporary houses, the roof could be an alternative for the courtyard that provides an outdoor private area for the house residents. There are a number of solutions in the Al-Makkiyah house that were applied to ventilate the roof. Figure 61 shows that the designer used bricks (this type of brick locally called Alajure) in some of the roof walls but in a way that allows the airflow to move through it. In addition, it allows the house residents to see the street through it while they are sitting on the roof. Moreover, Figure 62 shows another material used in the walls, which is wood. The wooden strips were fitted with the intention of protecting the house resident’s privacy and to allow the house residents to view the outdoors. Besides that, it provides the resident with airflow. Interestingly, although the different wall types and materials are used in the roof, they act as passive ventilation elements that provide the roof residents with airflow through them and a private sociable area to interact in.

Figure 61 using the bricks in some of the roof walls (Author, 2017)

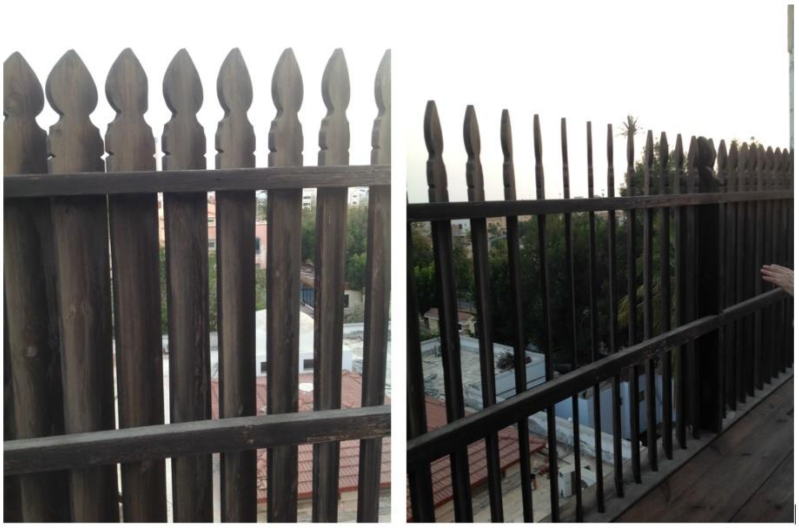


Figure 62 wooden walls in the roof (Author, 2017)

Entertainingly, although the roof provides the house residents with eye contact with the outdoors, Figure 63 shows that there is also an eye contact between the roof user and the courtyard user through a dome located in the side of the courtyard and a number of windows.

Figure 63 having eye contact between the roof (outdoor) and the courtyard (indoor) (Author, 2017) and (Usher, 2019)

Figure 64 and Figure 65 shows how the air conditioning is combined with the passive ventilation system. In addition, the ceiling height in the North side of the house is higher than the other sides of the house. This is to provide a bigger passive area behind the openings and in addition, to provide indoor eye connection.

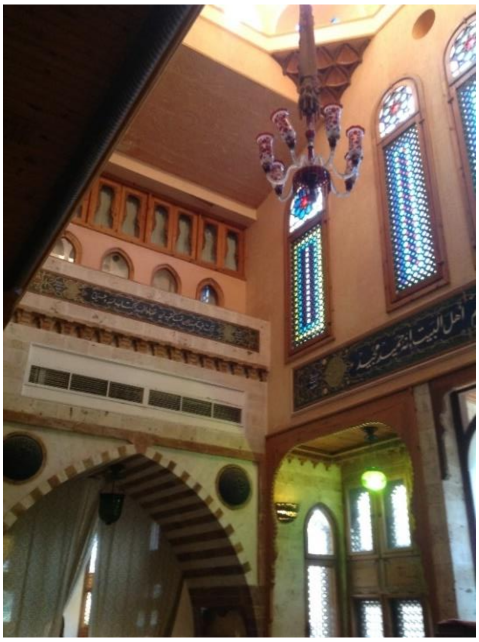


Figure 64 ceiling height in the dining room (Author, 2017)

Figure 65 ceiling height in the living room (Autor, 2017)

Courtyard

The courtyard is located in the centre of the Al-Makkiyah house and the different rooms in the different levels have a direct or indirect view to it. Furthermore, Figure 66 shows that the courtyard has a large swimming pool. Interestingly, locating the swimming pool in the courtyard in the centre of the house has an environmental function which is to provide humidity to the house especially that the courtyard opening is located on the top of the swimming pool. Besides that, the social function of the swimming pool is to have a focal point for the family members to interact beside and in it. Moreover, having a swimming pool in the courtyard which is a semi-public area could be a way to reflect the house resident's social status.

Figure 66 Al-Makkiyah courtyard (Susie, 2013)

Unlike the traditional courtyard, the ceiling of the courtyard in the Al-Makkiyah house is covered (see Figure 67). The main reason for covering the courtyard is to reduce the incoming solar heat and to control the heat exchange between the indoor and the outdoor temperature.

Additionally, other reasons to cover the courtyard are to control the incoming airflow and to resist the climate changes for example, if the weather was dusty or rainy the house resident can close the ceiling to protect themself and house from the weather changes. Therefore, the ceiling has two types of windows, the first is fixed windows to provide the indoor area with lighting. The second type of window can be closed or opened remotely. Besides that, the openings are protected with mosquito nets to be sure that the insects and animals cannot enter the house through them.

Figure 67 the ceiling of the courtyard in Al-Makkiyah house (www.google.com, 2019)

Having the courtyard in the centre of the Al-Makkiyah house affected the spatial organization i.e. although most of the rooms might have a street view, the majority of the rooms have a direct or indirect view to the courtyard (see Figure 66). Figure 68 shows a semi-public room (the dining room) that has a direct view of the courtyard. However, if there are visitors using this room, the windows and curtains on the windows could be closed and the house residents can still have their privacy. Alternatively, the Mashrabiyyah facing the street or the setback could be used to intake the outdoor airflow.

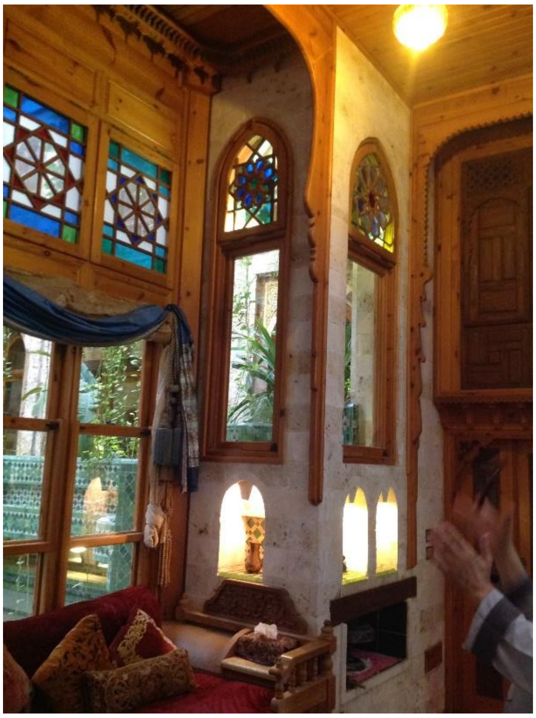


Figure 68 direct view to the courtyard (Author, 2017)

Figure 69 shows an example of the room that has an indirect view of the courtyard. The indirect view was created because of having a corridor between the bedroom (left side of Figure 69) and the courtyard (right side of Figure 69). However, there is a high number of openings on the bedroom wall to intake the airflow coming from the courtyard, to allow light in and to also have eye contact with other house residents. Furthermore, the corridor can be an area for the house residents to enjoy staying in and interact with the residents on the other side of the house and in the courtyard. In other words, having the corridor between the private rooms and the semi-public area (in this case it is the courtyard which is a passive ventilation element) generates a social area for the house residents.

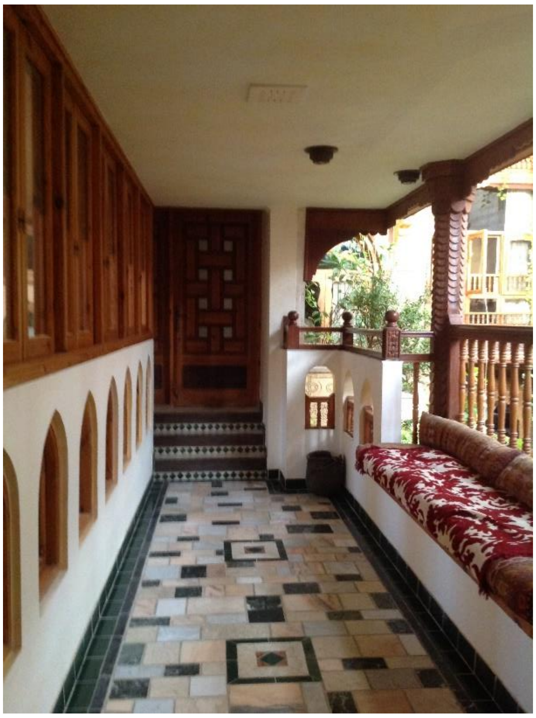


Figure 69 indirect view to the courtyard (Author, 2017)

5.4 Discussion

The previous section described a traditional residential building case study, a contemporary residential building and a contemporary residential building with a traditional design in Jeddah city. The dissertation focussed on building design, the spatial organization and the social life and on the environmental technology and system used in the house and how it affects the spatial organization. This section will compare the changes in the environmental technology and systems in Jeddah houses. Then it will explore how the changes in the environmental technology and systems affected the spatial organization and the family social interaction.

5.4.1 The building design

The building design was mainly affected by the lot and building area. i.e. The traditional houses' built area were nearly 900m^2 and the contemporary houses' built area are between 140m^2 to 300m^2. Consequently, the spatial organization of the residential building is affected and there is a need to use air conditioning because there is not enough area to have most of the passive ventilation elements.

The urban design of Jeddah city determines the house orientation, main elevation and entrances. As a result, it is hardly possible for the architect to orient the house toward the North or West side. In addition, the building regulation from Jeddah municipality limits the total residential villa building built area to 60% of the lot area and the total height to 10m and the floor height to 3m. As a result, the passive area behind the windows is negatively affected. Because the passive area behind the windows is double the ceiling height (Ratti et al., 2005) Therefore, the traditional houses have a larger passive area and stronger indoor airflow than the contemporary houses.

5.4.2 The spatial organization

It is clear from the previous section that the different residential buildings in Jeddah have three main privacy zones. However, the location of the private areas and their size has changed. Figure 70 shows that the majority of the ground floor in the traditional house is for the public area. It also shows that the semi-public area is the corridor and staircase. On the other hand, in the contemporary house, the majority of the public area is the outdoor setback and, indoors, is the male visitor's room. It is clear from Figure 70 that the semi-public area in the contemporary house contains a number of rooms such as the dining room, the female visitors room and the kitchen. The change in the location and size of the different private zones could be a result of the change in the residents lifestyle.

Figure 70 ground floor private area, traditional house (left side) and contemporary house (right side), similar scale (Author, 2018)

The first floor in the traditional house is mainly used for family interaction. Therefore, the biggest mass of the first floor is for the semi-public area (see Figure 71). The private area in the traditional houses are mainly located in the back side of the house and used as bedrooms. Although the number of residents in the traditional house is higher than the number of residents in the contemporary house, the bedrooms are for the married members of the family or are for females only. On the other hand, Figure 71 shows that the semi-public area in the contemporary house is smaller and it has moved to the centre of the house. In addition, the number of bedrooms is higher. This might be because each member of the family prefers to have their own private room.

Figure 71 first floor private area, traditional house (left side) and contemporary house (right side), similar scale (Author, 2018)

Figure 72 shows that the roof floor in the traditional house is mainly an indoor semi-public area. Unlike the contemporary house that has the semi-public area in its outdoor area. In addition, it contains a private area for the housemate and laundry room.

Figure 72 reef floor private area, traditional house (left side) and contemporary house (right side), similar scale (Author, 2018)

5.4.3 The passive ventilation system and air conditioning used in the houses

There is a major change in the environmental technology and systems used between Jeddah's traditional houses and Jeddah's contemporary houses. The passive ventilation system in the traditional houses mainly depends on a number of elements such as the windows, Manwaar, Mashrabiyyah and others. Using these elements affect the spatial organization of the house. On the other hand, the new air conditioning technology depends on different air conditioner devices that are flexible to be adopted with any design and does not require any specific spatial organization (Al-Azzawi, 1996). he most popular devices used in Jeddah city are the window type, split unit, concealed unit and the central unit (Akbar, 2020). Moreover, Akbar (2020), Mashat and Makkey (2005) highlight that there are other air conditioner types that are popularly used in Saudi Arabia such as the desert cooling air conditioner unit, but this unit type is inappropriate for Jeddah city because of its high humidity.

Figure 73 shows the different passive ventilation systems and air conditioning used in the traditional houses and in contemporary houses. In addition, Figure 64 shows how the passive ventilation system and air conditioning could be combined. It might be clear that there are some elements in the contemporary house that have been discarded such as the Mashrabiyyah. Furthermore, there are some elements that have been changed such as the Manwaar, the windows and the walls. Also, that some elements have been replaced such as replacing the courtyard with the setback. Finally, there are new solutions that arose such as the setback and the air conditioner. In other words, changing from using the passive ventilation system and its set of elements to using the air conditioning affected the residential building spatial organization. Likewise, importing designs from other countries that do not use the passive ventilation solutions as well as the improvement in building materials, technology and changing in the resident lifestyle are other reasons that led to changing the spatial organization.

Figure 73 environmental elements, traditional house (left side) and contemporary house (right side), similar scale (Author, 2018)

5.4.3.1 The Manwaar

In the Nassif house, the Manwaar is combined with the staircase. On the other hand, although the Manwaar is also at the back side of the house in the Al-Makkiyah house, it stands alone. The airflow generated from the Manwaar is directed to the multi-function room, the bedroom and the service rooms through big openings (see Figure 73). Although these rooms do not have a view to the Manwaar, they surround it and have big openings to allow the airflow.

On the other hand, the Manwaar in the Alfaredah house is located in different sides of the house and its size is much smaller than the traditional Manwaar. Also, its size differs throughout the different levels. This is because most of the house residents, to a high extent, are not aware of how to benefit from it to provide them with the airflow. In addition, the built area is much smaller compared with the traditional house. Therefore, the majority of the house residents prefer to use the area traditionally intended for the Manwaar to create larger rooms, but they construct it because it is required by the municipality. Thus, in the contemporary houses, the service rooms have their opening toward it. Also, the opening size is much smaller than the opening in the traditional house. Interestingly, in the Nassif house the Manwaar has openings toward the street, on the top of it and toward the rooms to enhance the airflow unlike the Alfaredah house that only has an opening on the top of the Manwaar and toward the service rooms.

The function of the Manwaar in the contemporary house has been changed from intaking the outdoor airflow to exhausting the indoor airflow out. This could be due to not using any of the passive ventilation elements in the contemporary house, but depending on the air conditioning to provide thermal comfort (see Figure 73). However, although the Manwaar is provided in the contemporary houses, it might not function as required because the other passive ventilation elements are not used properly or not available in the house.

Therefore, not having the Manwaar in a good location with the proper size and opening affects its ventilation effect and the spatial organization of Jeddah residential buildings. For example, Figure 73 shows that the rooms that surround the Manwaar are the service rooms. Also, it affects the level of privacy that the Manwaar could provide for the house residents when gathering.

5.4.3.2 Walls

In the traditional buildings, the only available construction method was the load bearing walls. Consequently, the wall thickness was up to 90 cm as shown in Figure 74. The main building material in Jeddah city was the Mankaby stone. Besides the construction function of the thick walls, it had another major function, which was providing indoor thermal comfort because of its thermal performance. More specifically, in the daytime the walls stored the outdoor heat and then radiated it indoors at night, On the other hand, at night it stored the outdoor coolness and radiated it indoors during the daytime (Abdulkareem, 2016). However, the building technology and materials improved in the contemporary houses and used different forms of construction systems that mainly depended on concrete. Unfortunately, concrete does not have a high thermal performance. Therefore, different insulation fabrics are used with it. On the other hand, using concrete led to changing the wall thickness from nearly 90cm to nearly 30cm (see Figure 74). Moreover, the Al-Makkiyah design combined the different building materials by adding the stone over the concrete. As a result, this solution helped to benefit from the new construction system and use the local materials Figure 60. Although the combined solution helps to increase the thermal performance of the wall and to reflect the local building materials, the wall thickness is nearly 45cm and this could negatively affect the spatial organization because the building lots are small.

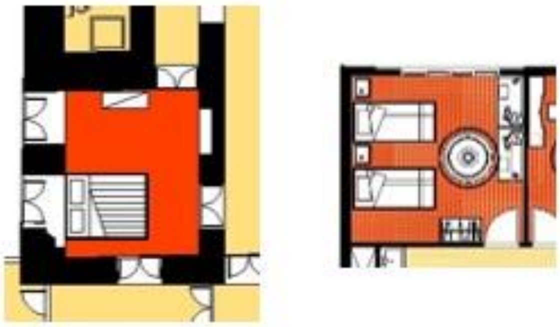


Figure 74 similar scale bedroom, traditional house (left side) and contemporary house (right side) (Author, 2018)

The change in the wall thickness could have two effects on the spatial organization. The first effect is having more indoor space in the different rooms, for example, adding nearly 60cm in each side of the room. The increase in the room size could be an advantage for the contemporary house especially that the building area is small. The second effect from having straighter and thinner walls is having more flexibility in changing the room function. More specifically, Figure 74 shows that the traditional houses' rooms had cavities in the walls and a high number of indoor and outdoor openings. The different cavities and openings could help to identify the room function. On the other hand, the contemporary house rooms have straight walls with mainly outdoor openings. This could give more flexibility for the house resident to change the room function, disregarding its location. Moreover, identifying the room function could be done through its furniture and view. For example, in Figure 74 one of the rear bedrooms could be changed to an office or playroom.

Generally, although the wall thickness is not one of the passive ventilation elements, it had an important effect on thermal exchange between the outdoor and indoor and the spatial organization. Many reasons led to a shift toward using thinner walls such as the improvement in the construction solutions and building materials and the use of air conditioning.

5.4.3.3 Windows

El-Shorbagy (2010a) described that the passive ventilation airflow intake in Jeddah traditional houses was through the big openings in the North or the West sides. Then, the airflow is distributed to the different rooms through the different indoor openings and then exhausted through the South side that had the smaller openings. Usually, the rooms that have the biggest openings are the family living rooms and the rooms that have the smaller openings are the service rooms. In other words, the size, distribution and number of openings could reflect the room function and the number of residents using it.

Figure 75 shows an elevation for both the traditional residential building and a contemporary one. It is clear that the number and size of windows in the contemporary residential building is fewer and much smaller than the traditional residential building. To a high extent, the reason for this change could be that the contemporary houses depend on the air conditioning to have indoor thermal comfort. Another reason could be that the windows in the contemporary houses observe more solar heat because they are not shaded with the Mashrabiyyah. On the other hand, having smaller windows could help to have more privacy for the house resident. The different size of the windows could help to indicate what room is behind this opening. For example, in the traditional houses, the big opening indicated that the family room was behind it. On the other hand, because of the similar opening size in the contemporary house, it is hard to identify what rooms are behind the opening.

Figure 75 elevation, traditional house (left side) and contemporary house (right side) (Author, 2018)

Besides the environmental function of the elevation windows, it also has a social function for the house residents, such as providing privacy for them and encouraging the family to interact and enjoy the outdoor view. Also, to have a stronger communication with the outdoor society. Unfortunately, the majority of Jeddah house residents agreed that the living room window is always closed because its view looks out onto the neighbour and it does not provide them with any airflow if they open it (see section 7.2 Interview findings for more details).

Abdulkareem (2016) highlighted two factors that affect the airflow generated from the windows, which are the window size and its distribution in the space. Furthermore, Ratti et al. (2005) point out another reason that could affect the incoming airflow which is the ceiling height. In more detail, the passive area behind the window is usually double the height of the ceiling. Thus, the passive area behind the opening in Nassif house and Al-Makkiyah house are much bigger because of the higher ceiling height. On the other hand, in AlFaridah, the passive area behind the opening is smaller because of the low ceiling height. Unfortunately, the ceiling height is restricted by Jeddah municipality to 3m for the villa residential building and 10m as a total height for the villa residential building (Jeddah Municipality, 2018).

The Nassif house in Figure 76 shows that although each room is surrounded by four walls, the windows distributed on all the four walls are different sizes. Moreover, Kamal (2014) added that the window size and distribution would not only provide the spaces with optimal airflow but will provide them with natural lighting. This might be another advantage from having big windows; it could certainly help to reduce the energy consumption in the house. On the other hand, Figure 76 shows that having small windows distributed in one side of the room affects the incoming airflow. Likewise, not having openings between the different rooms negatively affects the indoor airflow. A possible explanation for not having openings between the different spaces could be that using the air conditioning requires all the windows and doors to be closed in order to cool the room faster (Alomari, 1993, Huang et al., 2013). Moreover, the different sizes of windows in the contemporary houses are not related to its passive ventilation function, but the different sizes could be more about having an aesthetic effect on the different elevations.

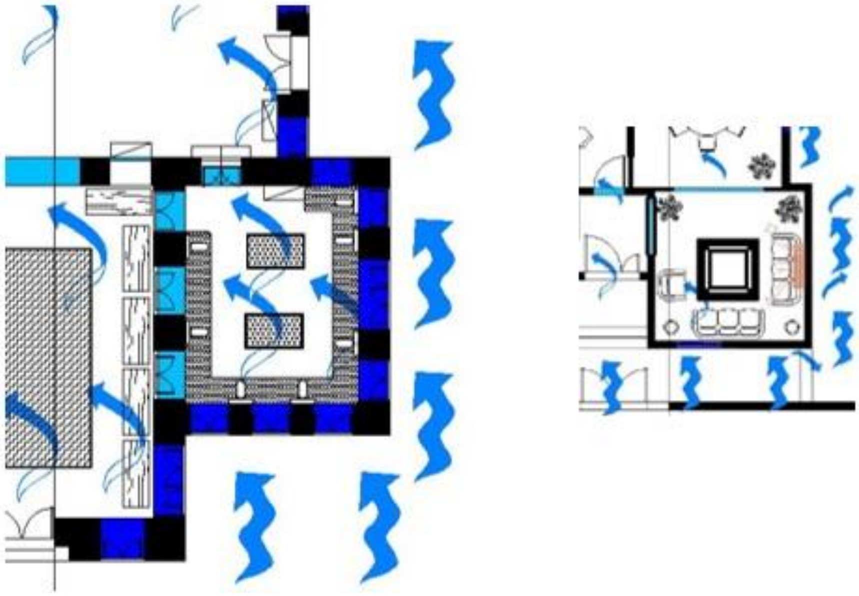


Figure 76 airflow in the visitor's room, traditional house (left side) and contemporary house (right side) (Author, 2018)

Generally, to have an indoor airflow and circulation from the window, two factors must be applied which are, distributing the windows in different walls and having a proper window size. Moreover, the window could affect the social activities in the different rooms. For example, if the privacy level is negatively affected because of having big windows, the residents will not prefer to interact in this room. Finally, although air conditioning is the main environmental technology used in houses nowadays, the windows could be a useful passive ventilation alternative at different times of the year.

5.4.5 The effect of the air conditioner on the spatial organization and the family social interaction

After analysing the different environmental technology and systems used in Jeddah houses, this section will explore how environmental technology and systems could affect the spatial organization and the family social interaction.

The traditional and contemporary residential buildings share a similar concept in having three different levels of privacy areas which are the public zone, the semi-public zone and the private zone. In the traditional house, one of the main factors in organizing and linking the three private zones is to benefit from the outdoor weather and the passive ventilation system.

Figure 70 shows a ground floor plan in a traditional house, the main entrance and the visitor’s room are located towards the main street in the North side of the house. From a social point of view, this could provide an interaction between the indoor resident and the street. Also, the rooms in the North side are the biggest rooms to occupy the house residents and their visitors. In addition, these rooms have the biggest openings to intake the airflow. On the other hand, the South side of the ground floor has the semi-public rooms. The area of these rooms is smaller than the rooms in the North side of the house. This might be because the rooms are occupied by fewer residents. However, the Manwaar is combined with the stairs and located in the centre of the South side of the house or the back side. This is to provide the rooms in the South side or the back with proper airflow by sucking it from top to bottom. In comparison, the contemporary house ground floor plan in Figure 70 shows that the public area is also located in the front side of the house. Furthermore, it has a separate entrance from the setback and a separate bathroom. Interestingly, the visitor’s room located in the back side of the house is considered to be within the semi-public zone. The reason could be that it is used for the family social interaction because it has a higher privacy level than the family living room on the first floor, it also has a better view. However, the windows in the contemporary houses are smaller because of the use of air conditioning.

The different passive ventilation elements organized specific room functions around it such as the bedroom or the living room. In other words, it has control over the spatial organization. On the other hand, not having these elements changed the spatial organization, for example, the bathroom location was shifted from the back side of the house to the front side of the house. Likely this could be because the air conditioning provides it with the airflow, and it is exhausted by the Manwaar. Another example is moving the location of the main kitchen from a higher floor to the back side of the ground floor. The cooking smell might not be a concern for the house residents because they are using a different ventilation system to exhaust the cooking smell. The change of the kitchen location has a social effect which allows the kitchen user to have eye contact and to spend more time with the family while cooking.

Figure 71 shows the first floor plan in a traditional house (in the traditional house the first, second and third floor are similar). It might be clear that the first floor does not have a public area, but it has the semi-public and private areas. This could be because these areas have higher privacy and non-family members are not allowed to enter them. On this floor, nearly all of the family members interact in the semi-public area that contains the multi-function room, which is used for the family living rooms, dining, prayer room, children's play area and could also be used as a sleeping room for males. Therefore, they are the biggest rooms on the floor. The family living room is usually located in the front side of the house facing the street to allow the house residents to interact with the outdoors and to face the incoming airflow. Nearly all the rooms have one entrance and four walls. In addition, there are a lot of openings between the different rooms to allow the transmission of the airflow.

Similar to the traditional house, the first-floor plan of the contemporary house also contains the semi-public and private zones. On the other hand, Figure 71 shows that the private zone is massively bigger than the semi-public zone. Although the contemporary house is occupied by one family, the family needs have changed, and each resident requires their own private room.

The family living room shifted from facing the street to facing the setback. Thus, the shifting of the living room led to reducing the social connection between the indoor and outdoor environment. Also, it required more privacy solutions because the neighbours could easily see each other. As a result, the windows are covered and closed most of the time. Furthermore, although the windows are closed for most of the time, the indoor airflow is not affected by using the air conditioning. Moreover, the family living room size is smaller compared with the family living room in the traditional building. Fascinatingly, the living room size is similar to the bedroom size. A possible reason could be that the contemporary house is occupied by one family only. Another reason could be that, in the contemporary house, the functions of the family room is split to other rooms such as the dining room Figure 77 shows that the family living room is more open than the other spaces because it is combined with the stairs. Also, nearly all the different rooms on the floor have their access toward it. In other words, the living room is no longer a closed room but could be considered a corridor. Also, the privacy level in the living room is negatively affected. This explains why although the traditional residential building spaces are subdivided, they were more sociable than the contemporary residential buildings. As a result, the value of the family living room is weakened, and the family members might not prefer to interact in it for long periods of time.

Figure 77 living room, traditional house (left side) and contemporary house (right side) (Author, 2018)

Finally, Figure 50 shows that the bedrooms in the contemporary house have different locations. Ironically, the bedroom is one of the rooms that requires a high level of privacy, yet it has a direct view to the street or neighbours. Also, it shows that the bedroom changed from a private room that is mainly used for sleeping to a multi-function private room. For example, it is possible to find in the bedroom a study area, a storage room, mini-living area or a private bathroom.

5.5 Conclusion

The urban design of the city and the building regulations could be the main outdoor factors that had a massive impact on Jeddah building typology besides the environmental technology and systems used. Having straight streets and the setback negatively affected the air pressure created between the buildings and its flow through and into the buildings. Moreover, it changed the house design from indoor-oriented to outdoor oriented.

In Jeddah residential buildings, the environmental technology or systems, the spatial organizational and the family social interaction are strongly linked together. Thus, changing one of them will affect the other two, for example changing the passive ventilation system to using air conditioning led to affecting the spatial organization and the family social interaction. The passive ventilation system required a set of elements that work homogeneously. For example, the traditional house has two different airflow feeders. The first feeder is the Mashrabiyyah that feeds the front and central area of the house, and the second feeder is the Manwaar and the courtyard that feeds the back and central area of the house. The airflow between the different spaces is controlled through the indoor openings.

On the other hand, although in the contemporary house there is a Manwaar and windows, their size, location and function have changed. As a result, they are not working homogeneously. The main factor that affects the environmental function is being dependent on air conditioning. Furthermore, not functioning from the passive ventilation elements led to changes in the spatial organization. For example, in the traditional houses the multi-function room, bedroom and kitchen were located next to the Manwaar. On the other hand, in the contemporary house the kitchen and the bathroom are usually located next to the Manwaar with a smaller window size.

Although the different passive ventilation system ventilates the house, it provides the house residents with private focal points to interact in or to view from the different rooms. Unfortunately, because of using air conditioning the focal points were dispensed with. As a result, the family social interaction, and the spatial organization was changed. Not having an indoor focal point could be another reason, besides the urban design of Jeddah and the building regulations, that led to having outdoor oriented houses. Moreover, having an outdoor view of the different rooms affected resident privacy. As a result, the location, and the room function in the different private zones of the house was changed. One of the changes in the private zones and the spatial organization that affected the social interaction was modifying the single use private room such as the bedroom into a multi-function private room.

This chapter highlighted different variables that could provide a baseline guidance and highlight some items in the questionnaire that need a deeper understanding from a large sample such as what new room function was added in the contemporary houses, what room functions can be dispensed with, what changes the residents made to their houses if they need to make changes, the change in the number of house residents, and the responses to what they believe has changed the residents' social interaction in the houses.

In general, the main factor that could improve the spatial organization, the family social interaction, and the environmental technology or systems used in Jeddah houses is designing the house with consideration to benefiting from the different passive ventilation systems, providing focal private points for the family social interaction and in addition, having a view from the different rooms of the private focal point. Although using the passive ventilation systems inspire from Jeddah traditional houses could improve the spatial organization and the family social interaction, one of its limitation that it helps to provide thermal comfort for the house residents for part of the year (see section 2.3.2 for more details).

Chapter 6

Phase two: Jeddah house resident's questionnaire

6.1 Introduction

This chapter will focus on describing the outcome from the questionnaire that was distributed to Jeddah house residents. It is important to understand what Jeddah house residents view about whether their social interaction is affected by the environmental technology and systems and the spatial organization in the house and how. Questionnaires are a helpful and well-organized data gathering method (Friedmann et al., 1978). They permit us to study public opinion and attitudes; they can also be used to find information and trends. The aim of this chapter is to examine the relation between the different research areas by analysing the statistical data using the SPSS program.

This chapter will be divided into three sections. The first section will be the descriptive statistic of the questionnaire and will report the outcomes of the questionnaire questions item by item. In addition, it will report the relation between the different variables through appropriate statistical tests using SPSS. The second section will be the results and discussion. In this section, the researcher will discuss the relation between the different variables in order to clarify if there is a link between the three research areas. The final section is the conclusion.

6.2 Questionnaire descriptive statistic

The questionnaire included 33 preliminary questions. The range and variety of questions produced much useful information about the link between the three research areas. This section will describe the questionnaire outcomes that cover four different subsections:

- General background of the participants. A Chi-square test for goodness of fit was applied to find out if the collected sample represented Jeddah house residents' answers
- The architectural section. This section shows the different relation between the variables that help to answer the research question such as if there, for example, is a relation between making changes in the residential building and the building age and others
- The house resident's social interaction. this subsection will examine if there is a relation between the common meeting room and the building age.
- The technology section. this subsection will examine the relation between the different technology and the building age, the dependency on the technology used and the house residents age and others.

Finally, the questions will not be discussed in order as they appear on the actual questionnaire, but the questions will be addressed based on their relation to the different subsections i.e. the questions that are related to the spatial organization area will be discussed in the spatial organization subsection.

6.2.1 General background of the questionnaire and the participants

The questionnaires were distributed using social media such as WhatsApp and Twitter to collect the data. The questionnaires collected 594 responses between the 4th and the 4th of May 2017. Unfortunately, 12% of the questionnaires were excluded because they were not fully completed. Moreover, 36.9% were also excluded because they were not living in Jeddah city because the social media used to collect the data is a tool that can spread widely. Consequently, the total number of house resident responses that have been analysed in depth and discussed were 302 responses where, to a high extent, each response reflected one dwelling.

Question

How old are you? (Q1)

Outcome

Table 4 shows that there were four age groups of Jeddah house residents. The majority of the resident's (39.4%) were within the 31-40 years. On the other hand, the minority (15.9%) of the participants were older than 51 years. Furthermore, the remaining age groups have nearly similar numbers of participants.

How old are you			
		Frequency	Percent
Valid	20-30	79	26.2
	31-40	119	39.4
	41-50	53	17.5
	51+	48	15.9
	Total	299	99.0
Missing	System	3	1.0
Total		302	100.0

Table 4 Jeddah house residents age

To ensure that the proportion of the different age groups who responded to the questionnaire represents Jeddah citizens' age group proportions, A null and alternative hypotheses were assumed based on General Authority for Statistics (2019). The null hypothesis assumed a significant difference between the two proportions. while the alternative hypothesis is that there is no significant difference between the two proportions and thus the sample proportions represent the age groups proportions of Jeddah citizens. Table 5 shows that the P-value is 0.07. In more details, the P-value is the amount of mistakes in the test and statically if the P-value is more than 0.05, it is not acceptable because it means that there are more than 5% of mistake in the null hypothesis (Field, 2018). Accordingly, statistically, there is no evidence to suggest that the sample proportions of the age groups are different from the real proportions in Jeddah city and the alternative hypothesis is accepted.

Chi-Square Tests	
	Aged grouped
Chi-Square	7.005a
df	3
Asymp. Sig.	.072
) cells (0.0%) have expected frequencies ess than 5. The minimum expected cell frequency is 48.6.	

Table 5 P-value that shows the significance of the age groups

Question

What is your gender? (Q2)

Outcome

Table 6 shows the number of male and female participants in the questionnaire. It is important to show that the proportion of the male and female participants in the sample size represents the real proportion of Jeddah city. According to the General Authority for Statistics (2019) the male represents 63% and the female represents 37% of the Saudi population living in Jeddah. A null hypothesis assumed there is a significant difference between the two proportions. while the alternative hypothesis assumed that there is no significant difference between the two proportions and thus the sample proportions represent the true proportions of Jeddah citizens. Table 7 shows that the P-value is 0.06. As a result, statistically, there is no evidence to suggest that the sample proportions of the resident's gender are different from the real proportions in Jeddah city.

What is your gender			
		Frequency	Percent
Valid	Male	230	76.2
	Female	71	23.5
	Total	301	99.7
Missing	System	1	.3
Total		302	100.0

Table 6 Jeddah house residents' gender

Chi-Square Tests	
	Gender
Chi-Square	3.367a
df	1
Asymp. Sig.	.067
a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 111.4.	

Table 7 P-value that shows the significance of the resident's gender

Question

What is your education? (Q3)

Outcome

Figure 78 illustrates that 57% of Jeddah residents that responded to the questionnaire hold a bachelor's degree. On the other hand, the minority of the participants (5%) have either a diploma degree or do not hold a degree.

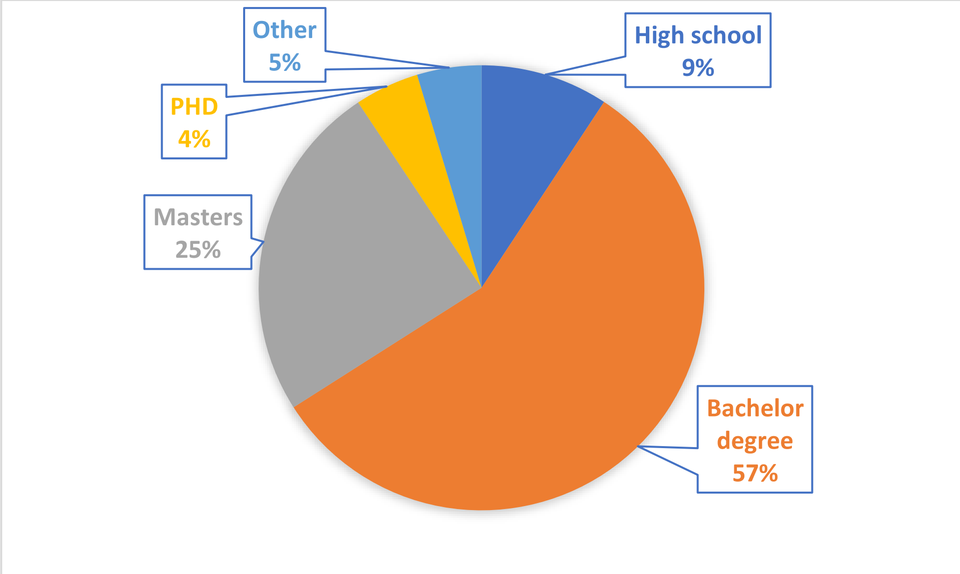


Figure 78 Jeddah house residents' education

To test if the proportion of the sample collected reflects the true proportion of Jeddah residents, a null hypothesis assumed there is a significant difference between the two proportions. while the alternative hypothesis assumed that there is no significant difference between the two proportions and thus the sample proportions represent the through proportions of Jeddah citizens. Table 8 shows that the P-value is 0.00 which means that there is a significant difference between the proportions of the sample collected and the real proportion of Jeddah residents. As a result, the variable of Jeddah house residents' education won't accurately reflect the Jeddah residents.

	Chi-Square Tests Education level
Chi-Square	3915.312a
df	4
Asymp. Sig.	.000
a. 2 cells (40.0%) have expected frequencies less than 5. The minimum expected cell frequency is .1.	

Table 8 P-value for Jeddah house resident's education

Question

What type of residential unit do you currently live in? (Q5)

Outcome

Figure 79 shows that the majority of Jeddah residents live in apartments. Additionally, it shows three types of villas that other Jeddah residents live in which are roof villas (28%), duplex villa (10%) and standalone villa (7%). However, to test if the collected sample proportions reflect the real proportions of the building type in Jeddah city, the roof villa, duplex villa and standalone villa were combined as one category to match with the status report of Jeddah city.

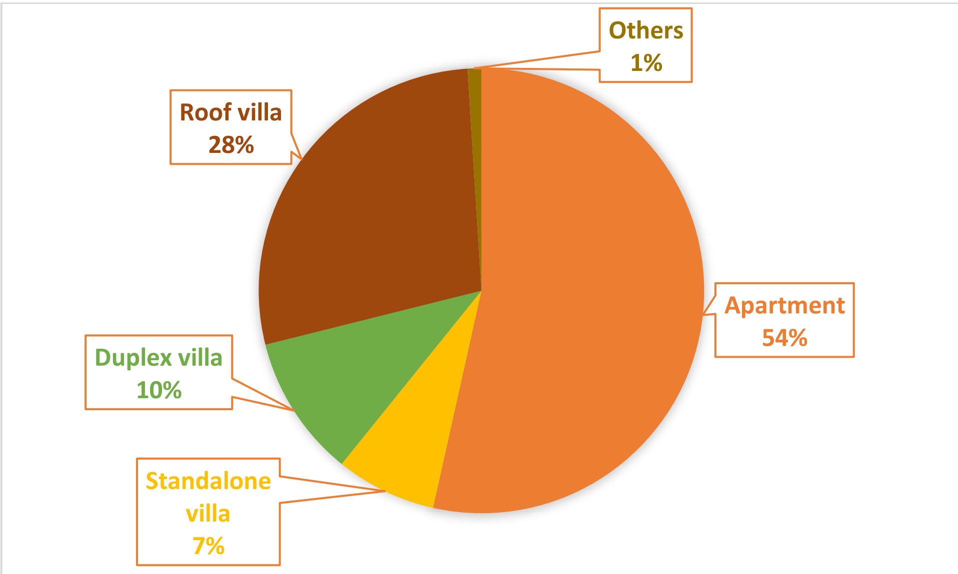


Figure 79 Building type

A null hypothesis that there is a significant difference between sample proportions and the real proportions of Jeddah city. Table 9 shows that the P-value is 0.00 which means that the hypnotises is correct and there is a significant difference between the proportions of the sample collected and the real proportion of Jeddah residents. As a result, the variable of

Jeddah buildings type will not represent the building types of Jeddah city.

	Chi-Square Tests Building type
Chi-Square	70.701a
df	2
Asymp. Sig.	.000
a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 51.0.	

Table 9 P-value for Jeddah building type

Question

Approximately how old is the building you live in? (Q6)

Outcome

Figure 80 illustrates that the majority of the participants (44.7%) live in residential buildings that were built 16 to 20 years ago. In addition, the participants that live in residential buildings that were built less than 10 years or 11 to 15 years are, to a high extent, equal. Finally, only 7% of the participants live in houses that were built more than 21 years ago.

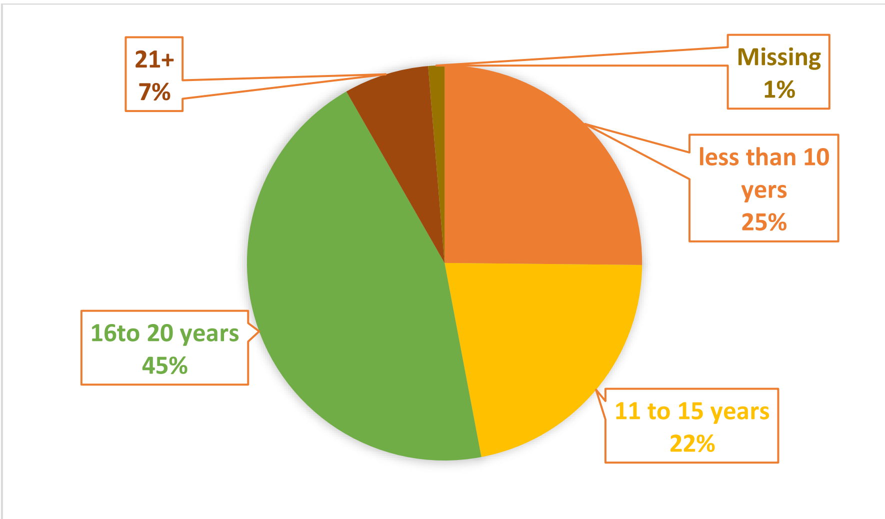


Figure 80 building age

Before testing if the sample proportion of the building age represents the real proportion of the building age in Jeddah city, it is important to re-code the category of the sample to be similar to the category of the building age group in the General Authority for Statistics (2019) reports. Therefore, in the sample, the building age 11 to 15 and 16 to 20 are combined in one group which is 11 to 20.

A null and alternative hypothesis was assumed. The null hypothesis assumed that there is a significant difference between the sample proportion and the real one. Table 10 shows that the P-value is 0.07. As a result, statistically, there is no evidence to suggest that the sample proportions of the age groups are different from the real proportions in Jeddah city.

Chi-Square Tests	
	Building old
Chi-Square	5.198a
df	2
Asymp. Sig.	.074

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 32.8.

Table 10 P-value that shows the significance of the building age

Question

If you had the opportunity to redesign your house, what would you do differently? (Q 33)

Outcome

The final question in the questionnaire was an open-ended question asking the Jeddah residents what they might do differently if they have the chance to redesign their houses. Unfortunately, this question did not provide enough and useful information because most of the answers were too general and unclear such as, "redesigning the house" or "having bigger rooms" and other general answers.

Generally, statistical tests were applied to the different general variables to test if these variables reflect the current proportions of Jeddah city. The collected data that is related to Jeddah residents' education and building type did not reflect the proportions of Jeddah city when the Chi-square for goodness of fit test was applied. Thus, they were not considered in the analysis and discussion. In contrast, the variables of house residents' age, house residents' gender and the building age do reflect the real proportions of Jeddah city.

6.2.2 The spatial organization of Jeddah residential buildings

Question

Which rooms are most commonly used at home? (Q7)

Outcome

Table 11 illustrates that the most commonly used rooms are the living room (28.4%), the bedroom (21.6%), the kitchen (15.6%) and the bathroom (13.7). These rooms are the basic daily used rooms that must be available in every residential building to meet the house resident's basic needs. Moreover, the less commonly used rooms are the female visitor's room (1.6%), the courtyard (1.8%) and the setback (2.7%).

		Responses	
		Number	Percent
Room use	Male visitor’s room	34	3.5%
	Female visitor’s room	16	1.6%
	Living room	280	28.4%
	Dining room	71	7.2%
	Bedroom	213	21.6%
	Setback	27	2.7%
	Courtyard	18	1.8%
	Kitchen	154	15.6%
	Bathroom	135	13.7%
	Storage	37	3.8%
Total		985	100.0%

Table 11 commonly used room

To explore if there is a relation between the building age and the most common room that Jeddah residents selected, a statistical test (Chi-square) was applied with the null hypothesis that there is a relation between the two variables. The test outcome shows that there is no relation between residents’ selection of the most commonly used room and the building age except for where the courtyard is selected. The test shows that the only relation between the two variables appears in the courtyard. Furthermore, it was tested if there is a relation between the most commonly used room and the resident’s gender. The Chi-square test shows no relation between the resident’s selection of what room they usually meet in and the resident’s gender.

Question

What are the rooms that can be dispensed with? (Q8)

Outcome

Table 12 shows that the majority of the participants agreed that the most popular three rooms that they could dispense with are the setback (23.9%), the female visitor’s room (20.8%) and the male visitor's room (16.9%). On the other hand, the rooms that the participants would be least likely to dispense with are the kitchen (0.2%), the living room (0.6%), the bedroom (0.6%) and the bathroom (1.0%). Interestingly, this outcome supports the outcome of Table 11.

		Responses	
		Number	Percent
Room use	Male visitor's room	105	16.9%
	Female visitor's room	129	20.8%
	Living room	4	0.6%
	Dining room	86	13.9%
	Bedroom	4	0.6%
	Setback	148	23.9%
	Courtyard	90	14.5%
	Kitchen	1	0.2%
	Bathroom	6	1.0%
	storage	47	7.6%
Total		620	100.0%

Table 12 rooms that can be dispensed with

The buildings of different ages have different spatial organization and building size. Therefore, it is important to explore if there is a relation between the rooms that could be dispensed with and the building age. The Chi-square tests show that there is a relation between the building age and the need to dispense with the visitor's room (P-value 0.04), the dining room (P-value 0.01) and storage (P-value 0.05). On the other hand, there is no relation between the building age and the need to dispense with the living room, bedroom, setback, courtyard, kitchen and bathroom.

Question

In your opinion, what is the most important reason for changing the spatial organization in the house? (Q9)

Outcome

Table 13 demonstrates that 39.4% of the responses agreed that modernising the house design is the biggest reason why the spatial organisation of Jeddah houses is affected. Surprisingly, Table 13 shows that Jeddah residents' second highest reason is related to the family social life in the house which is related to the increase of family members. Also, the participants agreed that the reason that affects the spatial organization the least is the decrease of the family members. Moreover, the two lowest rating reasons why spatial organisation is affected could be linked to the environmental technology and systems used in the house. The first reason is the change in the technology used in the house (8.9%) followed by climate changes (4.6%). To some extent, this finding might be acceptable because, currently, the contemporary residential buildings are designed to depend on using air conditioning. As a result, the resident's thermal comfort is not affected by Jeddah's microclimate. Finally, the participants who selected "others" mainly pointed out that economic change is the reason that affects the spatial organization.

		Frequency	Percent
Valid	Climate changes	14	4.6
	Air conditioning changes	27	8.9
	Modern design houses	119	39.4
	Increase family members	106	35.1
	Decrease family members	14	4.6
	Other (mainly economical)	21	7.0
	Total	301	99.7
Missing	System	1	.3
Total		302	100.0

Table 13 reasons that changed the spatial organization

Table 14 shows that most of the residents who selected the modernising of the house design is the reason that changed the spatial organization are living in houses aged between 11 to 20 years. However, the result of the Chi-square test shows that there is no relation between the resident's selection and the building age (see Table 15). As a result, the outcome of the link between the two variables must be interpreted with caution.

		Less than 10	11 to 20	21+	Total
Q9	Climate changes	6	7	1	14
	Air conditioning changes	8	16	3	27
	Modernising the house designs	33	80	6	119
	Increase family members	17	79	8	104
	Decrease family members	7	6	0	13
	Other (mainly economical)	5	13	3	21
Total		76	201	21	298

Table 14 the breakdown of the reasons for changing the spatial organization and the building age

Chi-square tests			
		Value	Approximate Significance
Nominal by Nominal	Phi	.235	.088
	Cramer's V	.166	.088
N of Valid Cases		298	

Table 15 the Cramer's V that shows the relation between the changing the spatial organization and the building age

Question

Do you need to add new rooms to the house? (Q10)

Outcome

Jeddah house residents' responses show that 45% added new rooms to their houses and 53.3% are intending to add new rooms to their houses. However, within the 53.3% that did not add new rooms to their houses, 66.4% intend to add new rooms to their houses.

Question

If yes, what rooms have you added to the house? (Q11)

Outcome

More than one-third of the residents agreed that they needed to add extra bathrooms. The second most popular room that the house residents felt they need to add to their house is storage space (25%). Interestingly, Figure 81 shows that around 20% of the participants selected the answer "others" in the questionnaire. After analysing the suggested rooms in the option "others", the data revealed that most of the participants added an entertainment or playroom (9%) and an office room (6.3%).

The remaining participants who did not add or are not intending to add new rooms to their houses mainly gave two reasons. The first reason was because of the building regulations, the buildings are small, and it might not be possible to build new external rooms. The second reason is the high cost of making changes. These reasons will be explored in more depth in the interview and will be discussed in following chapters.

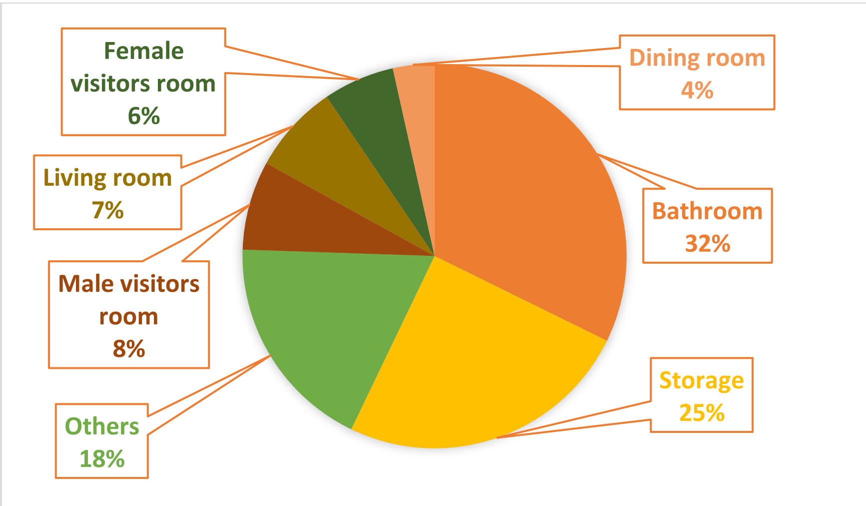


Figure 81 rooms that need to be added to the house

Question

Did you make any changes to the house? (Q12)

Outcome

Jeddah house residents' responses show that 44% made changes to their houses. On the other hand, 52.3% of the residents did not make any changes to their houses (see Table 16). Indeed, the different aged buildings have different spatial organization and building size (see Chapter 5 for more details). Therefore, it is important to clarify if there is a relation between applying changes to the residential building and the building age. The Chi-square test results show that there is a relation between making changes in the residential building and the building age (see Table 17).

Q12 Did you make any changes in the house?			
		Frequency	Percent
Valid	Yes	133	44.0
	No	158	52.3
	Total	291	96.4
Missing	System	11	3.6
Total		302	100.0

Table 16 responses for Q12

Chi-Square Tests Symmetric Measures			
		Value	Approximate Significance
Nominal by Nominal	Phi	.209	.001
	Cramer's V	.209	.001
N of Valid Cases		298	

Table 17 the Cramer's V results show that there is a relation between the two variables

Figure 82 shows the frequencies of the responses that made or did not make changes in the different aged buildings they live in.

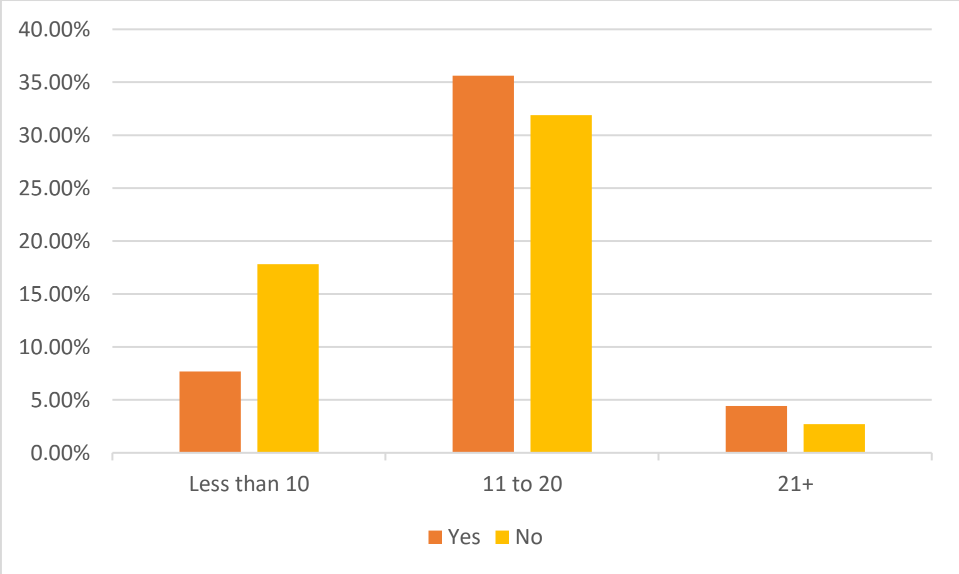


Figure 82 frequency of the responses that applied changed to their houses in the different building age

Question

What are the changes you made? (Q13)

Outcome

Figure 83 shows that 42% of the residents changed the technology used in the house such as changing from using the window air conditioner to the split unit. In addition, Figure 84 shows the change in technology in different age buildings. Following that, Figure 83 shows that 36% of the residents changed the room function. For example: changing the dining room to a living room. Finally, 22% of the residents changed the room size. The main reason for changing the room size is to combine rooms or add new functionality to the room. This change could be by expanding the living room to have a bigger living room for the family social interaction. On the other hand, making some rooms smaller to add a new room. Indeed, these changes are within the footprint of the house. In addition, this type of change could be limited to the building size, building construction, cost and others. These reasons will be explored in more depth in the interview and will be discussed in following chapters.

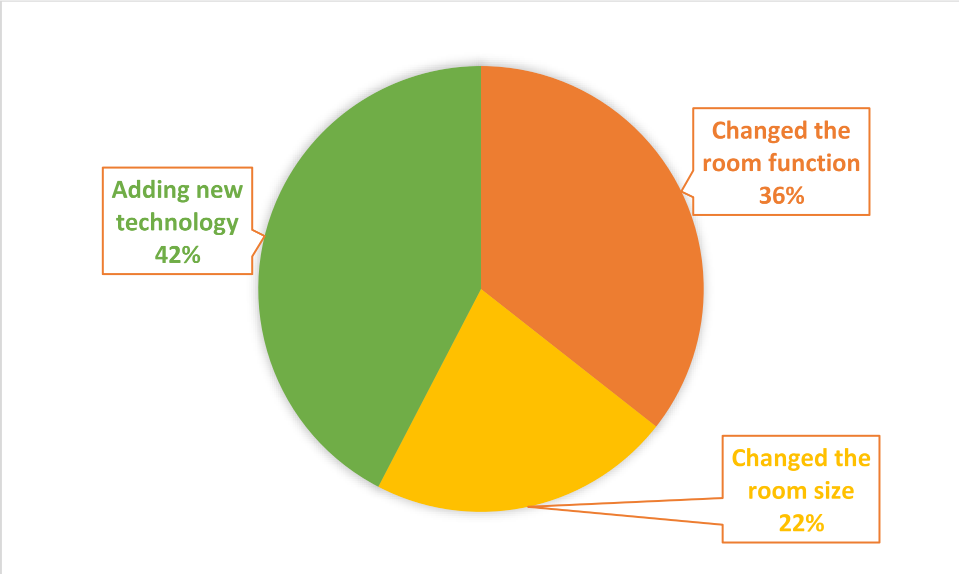


Figure 83 type of changing Jeddah residents applies to their houses

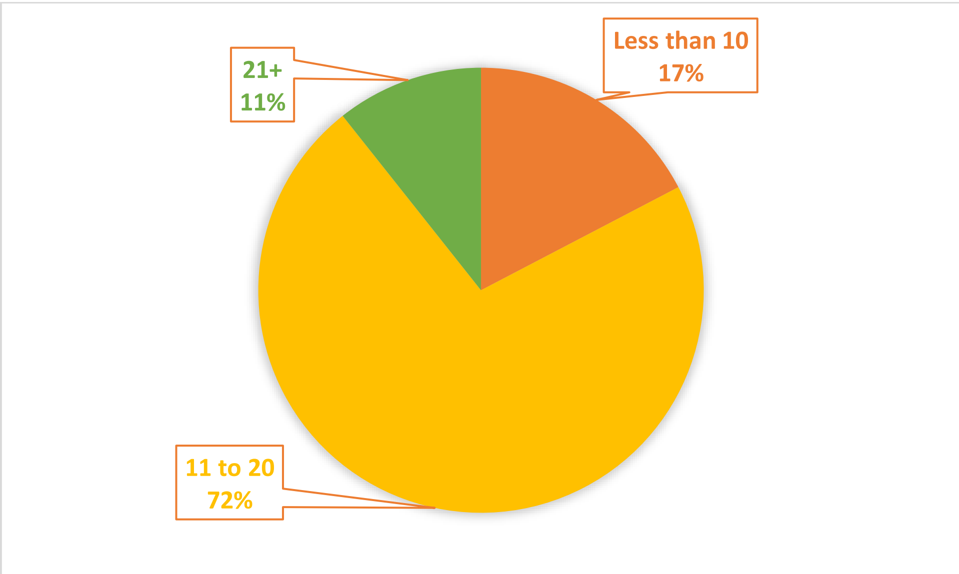


Figure 84 changing the technology in the different building age

Question

What are the rooms you made changes to? (Q14)

What are the rooms you are intending to apply changes to?

(Q16)

Outcome

This question included five different rooms for the participants to select from and the selection of "others" if they made changes to rooms that are not mentioned in the questionnaire. Figure 85 shows that the living room is the most common room that the participants agreed that they made changes to or intend to make changes to. Moreover, the second most common room the house residents made changes to is the visitor's room. Interestingly, in this question, the participants that selected the answer "Others'' wanted to say that they made changes in both the living room and the visitor's room. This could be by combining the living room with the visitor's room. The third highest rating room that the house residents made changes to is the dining room which is a semi-public room. Moreover, Figure 85 shows there is a high similarity between the participants' selection of the rooms that they made changes to or intend to make changes to.

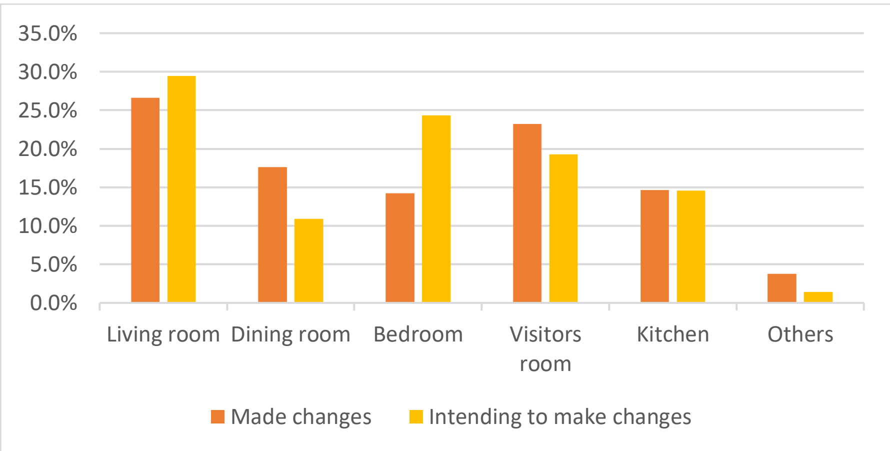


Figure 85 rooms that the participants made or are intending to make changes to

Question

What are the changes you are intending to make? (Q15)

Outcome

Figure 86 shows that nearly half of the sample of Jeddah residents intend to improve the technology they are using in their houses. While 26% of Jeddah residents intend to change the room functions and the remaining 25% intend to change the room size. Furthermore, a Chi-square test was applied to clarify if there is a link between Jeddah residents' intention to make different changes and the building age. Table 18 shows that there is a link between the resident's intention to make changes in their houses and the age of the building they live in. Unfortunately, although the statistical test shows that there is a relation between the two different variables, it did not show the correlation between the two variables. On the other hand, there is no relation between the building age and the resident's intention to change the room function or size, as the P values are higher than 0.05.

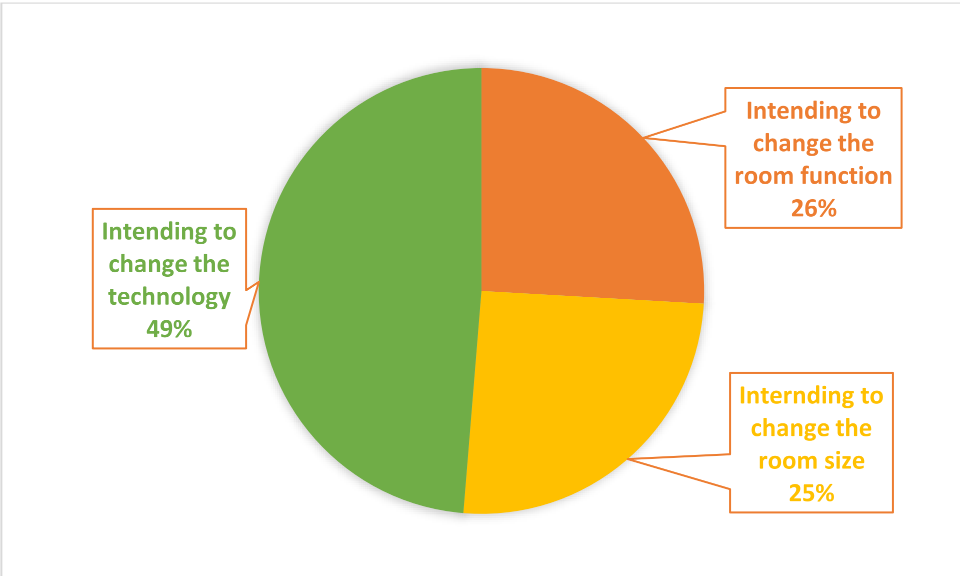


Figure 86 type of changing Jeddah residents intending to apply to their houses

Chi-Square Tests

		Value	Approximate Significance
Nominal by Nominal	Phi	.187	.006
	Cramer's V	.187	.006
N of Valid Cases		297	

Table 18 Cramer's V that shows there is a relation between the building age and the intention to change the technology

6.2.3 The social interaction of Jeddah house residents

This subsection will describe the outcomes that are related to the family social interaction section.

Question

How many people live in the house? (Q17)

Outcome

Nearly half of the participants (48.3%) are living with 5 to 10 members in their houses. Following that 36.1% of the participants live alone or with a maximum of 4 residents in the house. Finally, only three participants (1%) point out that they live with more than 11 residents in the same house. Unfortunately, 14.6% of the participant's did not answer this question and are reported as missing data.

Question

What activities do you do jointly in your home? (Q18)

Outcome

One of the activities was watching the TV. This activity usually includes other sub-activities such as chatting, playing, drinking and others. The second selection was meeting with visitors i.e.

meeting with non-family members. This activity is usually held in the visitor's room or in a public zone such as the setback. The final selection was playing computer games. This activity is selected because, nowadays, most of the contemporary houses in Jeddah have a separate playroom for this type of activity. Table 19 shows that the most popular Jeddah family activity (48.1%) in the house is watching TV. The second highest scoring family activity (27.7%) is meeting visitors who are usually non-family members. Finally, nearly a quarter of the participants point out that playing computer games is their most popular activity.

		Responses	
		N	Percent
Frequent activities	Watching TV	248	48.1%
	Meeting visitors	143	27.7%
	Play computer games	125	24.2%
Total		516	100.0%

Table 19 frequent family activities

Question

In which room/s does the family usually meet? (Q19)

Outcome

Table 20 shows that 50.4% of the participants selected the living room and 14.2% selected the dining room as the usual meeting rooms. This indicates that the family generally interacts in the semi-public zone. Surprisingly, the bedroom was the third-highest selected room in which the Jeddah residents' responses agreed they usually interacted with each other the most (9.9%). A possible explanation for that could be that the bedroom in the contemporary houses has more than one function. In addition, the size of the bedroom is as big as the living room. The selection of "others" (1%) highlighted mainly two rooms that the participants usually meet in, which are the office and the playroom.

		Responses	
		N	Percent
Semi-public zone	Living room	259	50.4%
	Dining room	73	14.2%
	Kitchen	37	7.2%
	The roof	24	4.7%
Public zone	Visitors room	27	5.3%
	Setback	38	7.4%
Private zone	Bedroom	51	9.9%
	Others	5	1.0%
Total		514	100%

Table 20 usual meeting room

Question

In which room/s do you prefer to have family activities? (Q20)

Outcome

Although, there was a high similarity in the answers to this question with the answers for question 19 (see Table 20), the major difference between the most common room that the participants are meeting in and where they prefer to meet is in the setback. While 7.4% of the participants point out that they meet in the setback, 17.7% pointed out that they prefer to meet in the setback. To a high extent, if different solutions were added to the setback area to provide the house residents with privacy while they are using it, it is expected to see more social interaction in the setback. Moreover, although Jeddah residents' responses show that they prefer to meet in the setback, Figure 87 shows a high similarity between the different gender's preferred meeting room except for the roof. The females prefers to meet in the roof more than the males.

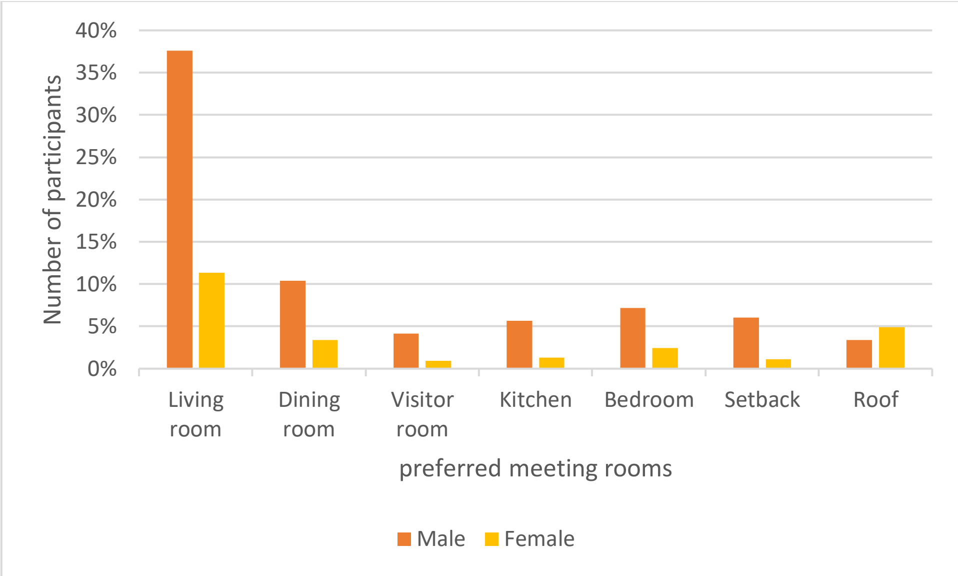


Figure 87 preferred meeting rooms from the different gender point of view

Question

In your opinion, what is the most important reason for changing social activities in the house? (Q21)

Outcome

Unfortunately, this question has 35 missing answers. In addition, 2.6% agreed that economic changes are reasons that affect family interaction in the house. However, the outcome of this question could be divided into three main outcomes. The first outcome is that technology innovation is the highest factor that affects family interaction (45.4%) (see Table 21).

The modern design houses (17.9%) and the increase in family members (16.2%) are the second highest factors that affect the family interaction in Jeddah houses. Finally, Table 21 shows that the lesser chosen two reasons that could affect the family interaction in the house are the decrease in family members (3%) and climate changes (3.3%).

		Frequency	Percent
Valid	Climate changes	10	3.3
	Technology changes	137	45.4
	Modern design houses	54	17.9
	Increase family members	49	16.2
	Decrease family members	9	3.0
	Others (mainly economic)	8	2.6
	Total	267	88.4
Missing	System	35	11.6
Total		302	100.0

Table 21 reasons that affect the family interaction in the house

A Chi-square test was applied to explore if there is a relation between the building age and the resident's selection of the reasons they think it affects the social interaction in Jeddah residential building. Table 22 shows that the P-value is 0.14 which is more than 0.05. Consequently, there is no relation between the two variables. As a result, the link between the two variables should be discussed with caution.

Chi-square tests			
		Value	Approximate Significance
Nominal by Nominal	Phi	.237	.140
	Cramer's V	.167	.140
N of Valid Cases		264	

Table 22 Cramer's V that shows the relation between the building age and the reasons that affect the resident's social interaction

Question

Is there a room with a specific function that the family has different social activities in, for example, chatting in the kitchen or studying in the dining room? (Q22)

Outcome

39.7% of Jeddah residents replied yes, there are rooms with multi-functions. In contrast, 47.4% replied no, there are no rooms with a multi-function. Finally, 12.9% of the responses are missing because the residents did not answer this question.

Question

What are these room/s? (Q23)

Outcome

The living room is the highest selected room that has more than one function (see Figure 88). Interestingly, the bedroom was not expected to score second highest as a room with multi-functions. Moreover, Jeddah residents agreed that the visitor room (14.8%), the kitchen (14.4%) and the dining room (13.6%) could have more than one use. On the other hand, the setback (3.8%) and the roof (3.4%) are generally considered to have a single-use. This might be because they are an outdoor space. Finally, Jeddah residents who selected "others" wanted to highlight that there is a new room with more than one use that the researcher did not mention in the questionnaire which is the office and the playroom.

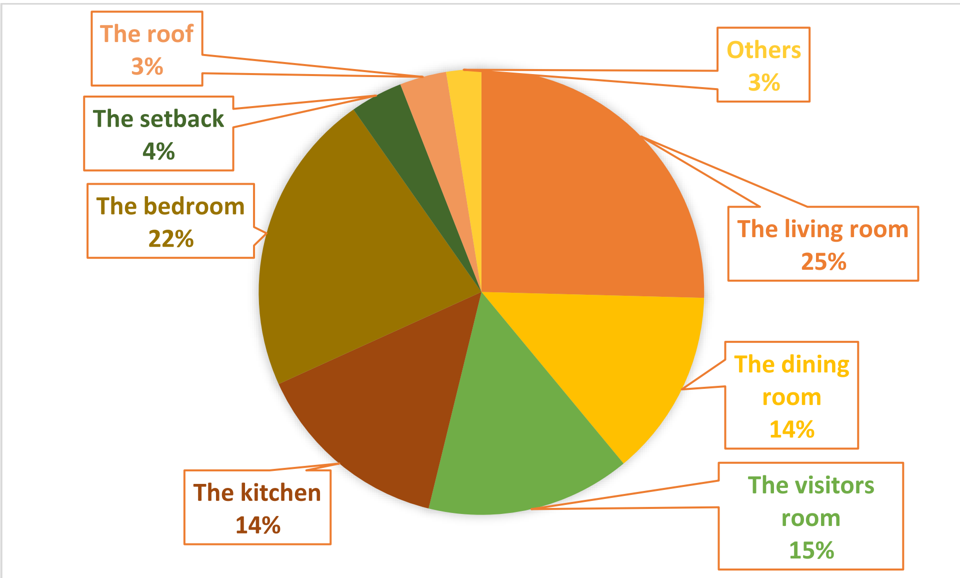


Figure 88 rooms that have more than a function

6.2.4 The technology used in Jeddah houses

As mentioned in the previous chapters, the technology is a new layer that was added to Jeddah houses. Also, it was mentioned that the different technologies could affect the spatial organisation of the residential building and the social interaction of the house residents. Therefore, this subsection will explore if there is a relation between the technology used in the residential building and the building or residents' age.

Question

What is the most important technology that must be used in the house? (Q25)

Outcome

Table 23 shows that 16.6% of the answers are either missing or the participants selected others. However, most of the participants who did not select any of the options or selected 'others' commented that they wanted to select all three technologies. Unfortunately, selecting all of the technologies would not help the research highlight the most important technology that affects the spatial organization and the house resident's social interaction.

Table 23illustrates that more than half of the participants (54.3%) agreed that the most important technology that must be available in the residential building in Jeddah city is the air conditioning. Furthermore, Table 23 shows that 17.2% of the participants nominated media technology as the second most important technology in the house and the appliances technology is the least important technology (11.9%) that must be provided in the house.

		Frequency	Percent
Valid	Air conditioning	164	54.3
	Media Technology such as the TV	52	17.2
	Appliances technology	36	11.9
	Total	252	83.4
Missing	System or others	50	16.6
Total		302	100.0

Table 23 most important technology in the house

A Chi-square test was applied to explore the relation between the building age and the need for the different types of technologies in the building. Unfortunately, the result revealed that there is no relation between the two variables. However, there is a high number of missing data (67). Therefore, discussing the link between the two variables must be treated with caution. Figure 89 shows the residents' need for the different technologies in the different aged buildings.

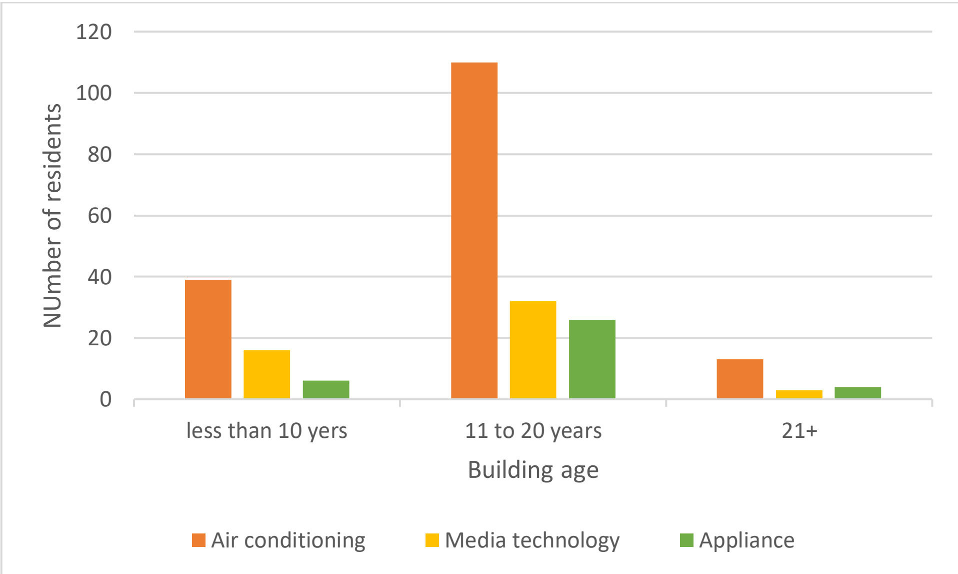


Figure 89 used technology and the building age

Question

To what extent do you depend on technology in the house? (Q26)

Outcome

Figure 90 illustrates that the majority of the participants' dependency on technology is neutral (48%). In addition, nearly one-third of the participants (33%) depend on technology. On the other hand, the minority of the participants (2.3%) do not depend on technology. Unfortunately, 17% of the data is missing. This might be because the participants do not know to what extent they rely on different technology.

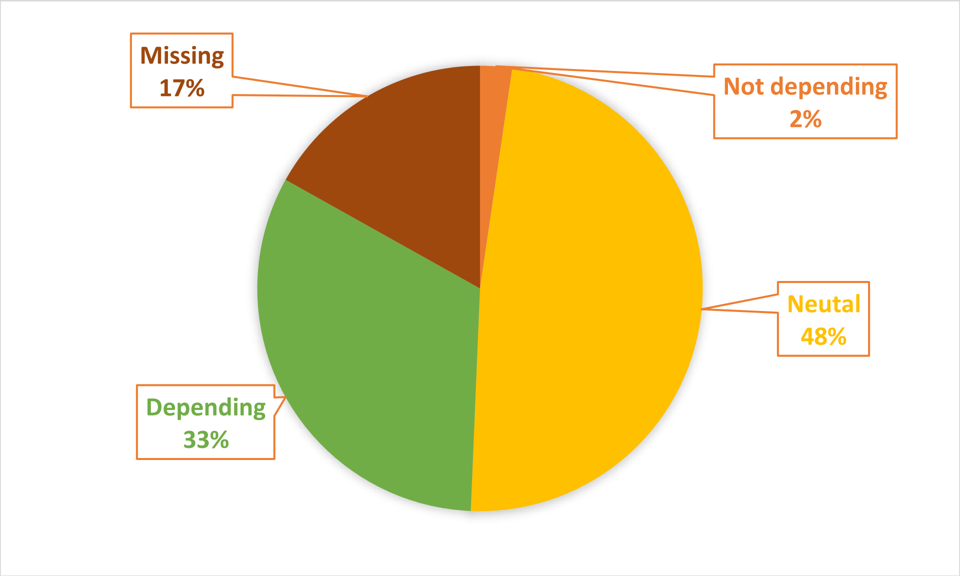


Figure 90 the participant's dependency on technology

Selwyn (2003), mentioned that there is a strong link between resident dependency on technology and the resident age. Thus, to have a deeper understanding if there is a link between the resident dependency on technology and the resident age, the results of the Chi-square test show that P-value is 0.03 which is acceptable because it is less than 0.05 (see Table 24). Consequently, there is a relation between the two variables. On the other hand, another Chi-square shows that there is no relation between the building age and the dependency on technology.

Chi-square tests			
		Value	Approximate Significance
Nominal by Nominal	Phi	.214	.034
	Cramer's V	.152	.034
N of Valid Cases		296	

Table 24 Cramer’s V that shows the relation between the resident's age and the dependency on technology

Question

What are the technologies that must be available in the following rooms? (Q27)

Outcome

The outcome of this question will be described based on the different privacy zones. Figure 91 shows that the air conditioning is more important than the other technology in the visitor’s room which is in the public zone.

However, the semi-public zone is divided into two categories. The first category is the indoor rooms, such as the living room. Figure 91 shows that in the living room there are high similarities between the need for air conditioning and media technology. On the other hand, some of the residents (16 residents) point out that they do not need any technology in this room. The second category is the outdoor spaces such as the setback and the roof. Figure 91 illustrations that most of the residents do not require any air conditioning in these spaces. This might be because these spaces benefit from the natural airflow.

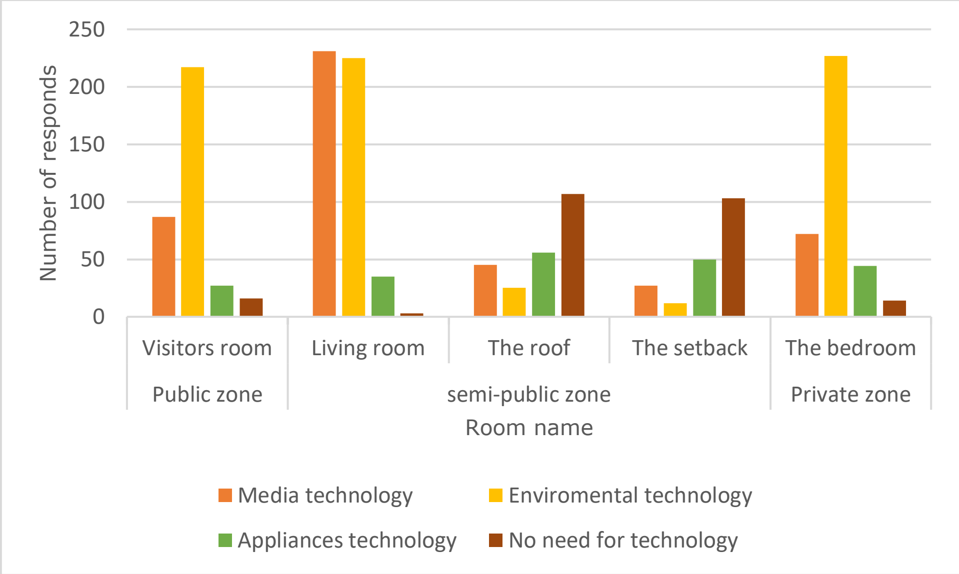


Figure 91 the availability of the technology in the different rooms

Question

Which of the following gadgets you can dispense with in the house? (Q 28)

Outcome

To support the findings from question 25 and to ensure that the participants understood the question, the participants were asked what technology they could dispense with. It was surprising that 33% of the participants would dispense with the appliance's technology. On the other hand, only 2% of the participants could dispense with the air conditioning (see Figure 92).

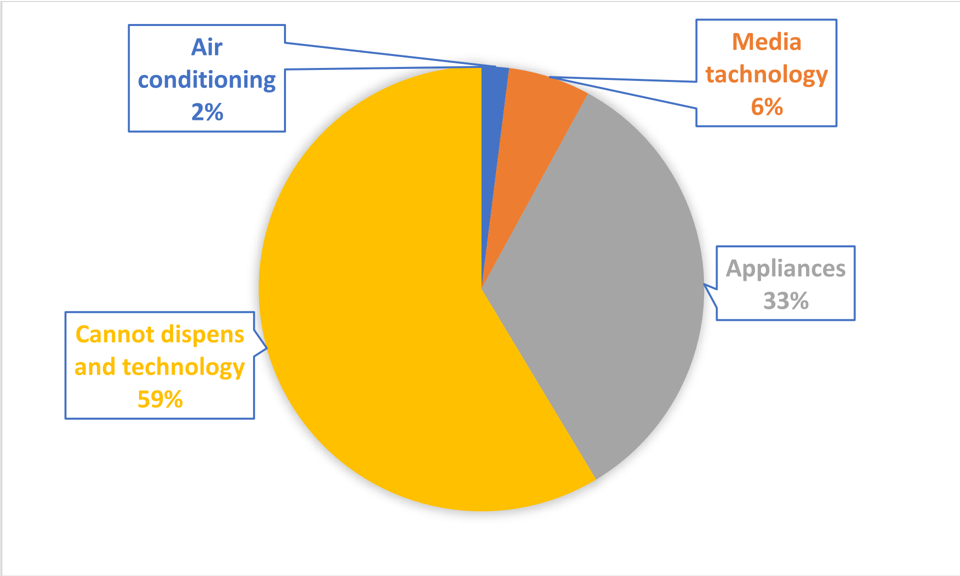


Figure 92 what technology you can dispense with?

Question

In acceptable outdoor weather such as in winter or spring, could you depend on any alternative to air conditioning such as opening the windows to have fresh air? (Q29)

Outcome

Although the majority of the resident's responses in Q27 showed that the air conditioning is one of the most important technologies that must be available in nearly all the different rooms in the house, surprisingly, approximately two-thirds of the participants (66.9%) accepted the use of other passive systems such as opening the windows (see Table 25). Although the majority of the resident's responses in Q27 showed that the air conditioning is one of the most important technologies that must be available in nearly all the different rooms in the house, surprisingly, approximately two-thirds of the participants (66.9%) accepted the use of other passive systems such as opening the windows.

		Frequency	Percent
Valid	Yes	202	66.9
	No	46	15.2
	Total	248	82.1
Missing	System	54	17.9
Total		302	100.0

Table 25 can you use other ventilation solutions than environmental technology

It was necessary to explore if there is a relation between accepting using other passive systems when the outdoor weather is cold than totally depending on the air conditioning and the building age that the residents are living in. Table 26 shows the results of a Chi-square test that show a relation between the two variables (P-value 0.34)

Chi-square tests			
		Value	Approximate Significance
Nominal by Nominal	Phi	.166	.034
	Cramer's V	.166	.034
N of Valid Cases		245	

Table 26Cramers V that shows that there is a relation between the building age and the acceptance of using a passive system

Table 27 shows the Jeddah house resident sample that responds that they could accept using passive alternatives than the air conditioning and the building age.

Crosstab						
			Less than 10	11 to 20	21+	Total
Q29 In acceptable outdoor weather such as in winter or spring, could you totally depend on any alternative than the air conditioning devices such as opening the window to have fresh air?	Yes	Count	56	126	20	202
		% Count	27.7%	62.3%	9.9%	100.0%
		% of Total	18.5%	41.7%	6.6%	66.9%
	No	Count	5	38	3	46
		% Count	10.9%	82.6%	6.5%	100.0%
		% of Total	2.0%	15.5%	1.2%	15.2%
Total		Count	61	164	23	248
		% Count	24.9%	66.9%	8.2%	100.0%
		% of Total	24.9%	66.9%	8.2%	100.0%

Table 27 the frequency of the responses on accepting using passive alternatives linked with the building age

6.3 Discussion

The previous section generally reported the questionnaire outcomes, this section will discuss how air conditioning affects the spatial organization and the house residents' social interaction in the house. In addition, how the three research areas are linked.

6.3.1 The technology used in Jeddah houses

Although different aged buildings have different needs, the different technology is required in all the buildings of different ages. Table 23 shows that the most important technology that must be provided in Jeddah residential buildings is air conditioning. The air conditioning is important for many reasons such as the unstable weather in Jeddah. Besides that, because the contemporary residential buildings in Jeddah have smaller building areas than the traditional ones (Al wafi, 2006), the courtyard and the other passive ventilation elements were discarded (see Chapter 5). Thus, the spatial organization was affected and changed.

Figure 89 shows the relation between the different technology required in the Jeddah residential buildings and the building's age. It was predictable that the 21+ year old buildings are the buildings that depend on the air conditioning the least. This might be because these buildings have bigger building areas that allowed the designer to use passive elements such as the courtyard and other elements. In addition, the distribution of the windows allows an indoor airflow in the building (El-Shorbagy, 2010b). In other words, these buildings were designed to benefit from the outdoor environmental conditions. Surprisingly, the findings show the building that was built from 11 to 20 years ago was the residential buildings that depend on air conditioning the most. A possible explanation could be that, in that period of time, most of the designs were imported from different cultures and these designs were not compatible with the weather in Jeddah. For example, some of the designs had a balcony that was infrequently used in Jeddah residential buildings because of the weather and the need for resident privacy. As a result, the balcony was changed to a room (see Figure 93).

Figure 93 changing the balcony to a room (Author, 2018)

The participants were asked if they completely depend on air conditioning to provide them with thermal comfort if the outdoor weather is cold such as in winter or spring. Table 27 shows that 62.3% of the residents who replied yes, they can use the air conditioning less live in houses that were built 11 to 20 years ago. This could be because these houses could have alternative solutions such as the courtyard or other elements to control the thermal mass of the building and to provide indoor thermal comfort. Unlike the residents who live in houses that were built less than 10 years ago. This could be because the newly built houses have air conditioning and much better isolation techniques. Generally, there is a high acceptance to use other passive ventilation systems than air conditioning.

Table 25 shows a high acceptance from the responses of Jeddah house residents to the use of alternative passive ventilation systems. On the other hand, Figure 88 shows that although they are willing to use the alternative passive ventilation system, they are not willing to dispense with any of the air conditioning used in the house. This could be for many reasons. Selwyn (2003) points out one of the reasons, which is that the house residents are getting a better experience out of using the air conditioning because they provide fast thermal comfort for the residents and are mostly available in different forms. Another reason is that the weather in Jeddah is not stable i.e. it is changeable and not acceptable for most of the time (Almazroui et al., 2012, Salagoor, 1990). In addition, outdoor environmental pollution, such as having bad smells and street noise are other reasons for not using the alternative passive ventilation system (Anqawi, 2017). Finally, the contemporary residential building is not designed to have much indoor air circulation. In other words, although the windows are one of the passive ventilation elements, the window distribution in the rooms and the window size are not designed to have much natural air ventilation as illustrated in Figure 76.

6.3.2 The spatial organization of Jeddah residential buildings

The room function and the technology used in it could be one of the main reasons that affect the spatial organization. Figure 91 shows the availability of different types of technology in different rooms. However, the criteria for the availability of different technology is the room function. For example, the kitchen does not have a computer and the computer gaming device (PlayStation and other) because the space is used for cooking. Therefore, it might be acceptable to have a TV in the kitchen for the user to watch while preparing food. Nevertheless, although, nearly all types of technology are available in some of the spaces, the air conditioning is available in most of the spaces of the house. In other words, air conditioning is mostly available in all of the different spaces, but the function of the space might be one of the factors that control the need for the other different technology.

Moreover, using different technology in a room that does not match its function could lead to negatively affecting the room geometrics and the family social interaction in the house regardless of the room function. For example, the main function of a bedroom, which is a private room, is for sleeping. Therefore, traditionally, the bedroom has a small area and the main technology used in the bedroom is the passive ventilation system. On the other hand, nowadays, the bedroom has a bigger area because, besides its main use, it contains an area for watching TV (media technology). In addition, it could contain some gadgets such as minor kitchen gadgets. As a result, the bedroom in the contemporary residential building requires a bigger space (see Figure 94).

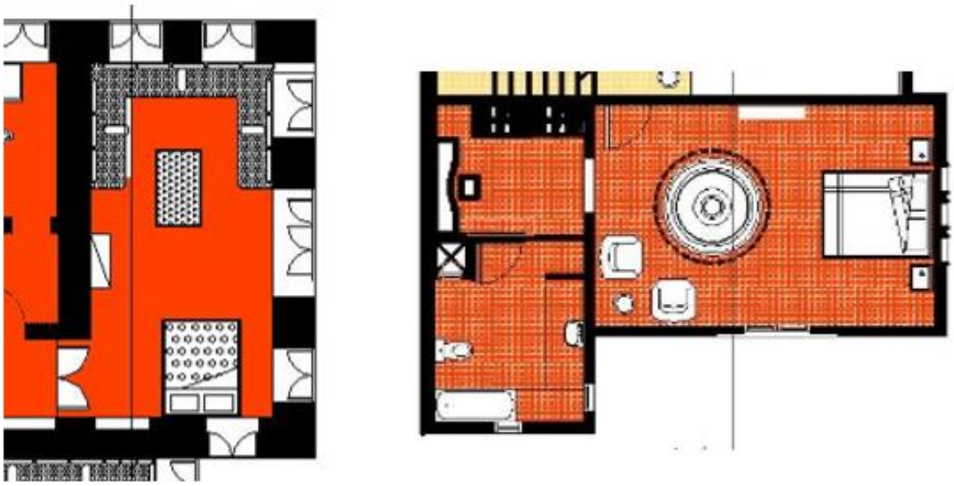


Figure 94 the bedroom in the traditional building (left) and contemporary building (right)

Table 12 shows that the visitor's room, the setback and the dining room are the most frequently selected rooms from the Jeddah resident sample that could be dispensed with. However, it might be important to link the room that can be dispensed with to the building age. A reason for linking the rooms that can be dispensed with to the building age is that the lifestyle of the house resident and the family social interaction is changing through time. Consequently, these changes could affect the spatial organization of the residential building. The statistical test shows that there is a relation between the building age and the acceptance of dispensing with the visitor's room, the dining room and the storage room. Contrarily, there is no relation between dispensing the other rooms and the building age. This might be because the rooms that the residents nominate that they cannot dispense with are the basic rooms in the residential building and changing the resident's lifestyle won't affect the need for these rooms.

Figure 82 shows that the houses that were built 11 to 20 years ago are the houses that had more different spaces that the residents wanted to make changes to. Moreover, the houses that were built 21+ years ago had a reduced amount of changes. This could highlight that the houses that were built from 11 to 20 years ago were the houses that experienced the most changes to their spatial organization.

Table 12 illustrates that the visitor room (male or female) is the room that the highest number of participants expressed they could dispense with in the Jeddah contemporary residential building. Besides how small the building is and the need to have a bigger living room, to a high extent, the change in the family social interaction is the main reason that led to marginalizing the visitor room. For example, nowadays, the house residents prefer to meet the family members or the visitors in a coffee shop or a restaurant rather than meeting them in the house (will be discussed in the following chapters). As a result, the visitor's room is predominantly unused for most of the time and could be considered as a waste area in the house. In addition, the lifestyle of the house residents is changing. For example, it is acceptable nowadays to have an office room in the house to work from (Mandilaras et al., 2013). Moreover, the second most popular space that the house residents want to dispense with is the setback space. Although the setback space could be an alternative for the courtyard, the need to have a bigger building area led to the need to either cancel, change the setback to a car parking area or massively reduce the setback area and combine the setback area with the house's built area.

Unpredictably, the dining room is one of the top three spaces that could be dispensed with. Even though the dining room is a multiple-use space, has multiple technologies and a social space that the family is interacting in regularly as the questionnaire responses point out. Notably, traditionally the family members were dining in the living room and they were dining in the visitor's room with non-family members (AboZade, 2012). In other words, there was not a special room for dining. Nowadays, the dining room is a special space and it is combined either with the living room or the visitor room (see Figure 95 and Figure 96). Another reason for dispensing with the dining room is that its activities are limited and could be done easily in any other space. However, it might not be acceptable to totally dispense with the dining room, but it could be more reasonable to locate the dining room between the family area and the visitor's area to fully benefit from it.

Figure 95 combining the dining room with the visitor room Masat Alkhaldiyah (Author, 2017)

Figure 96 combining the dining room with the living room Diyar AlManar building (Author, 2017)

To use the changes in the house as a major way of reflecting the social life in the house, it is important to define the changes (Morris and Winter, 1975). The questionnaire highlighted three different types of changes. The first type of change is changing the room function such as changing the storage room to a playroom or adding more than one function to a room such as having a dining area and reading area in the living room. Another type of change could be by discarding one of the room functions such as not having a visitor room in the house. However, according to Heidegger (1971), house residents could apply some changes to engage with space. To a high extent, changing the room function could be a reflection of engaging with the different spaces especially with the exotic factors such as the change in the building area, lifestyle and the use of the new technology. However, according to Krier (2015) applying the changes in the residential building does not mean reflecting the traditional way of engaging with space, but means that the residents are reflecting their own way of engaging with space. The other type of change being made is the room's geometry i.e. changing the room size. For example, combining the visitor's room with the living room. These two types of changes are strongly expected to affect the spatial organization of Jeddah residential buildings. Furthermore, the final type of change that the questionnaire highlighted is changing the technology in the house i.e. using new types of technology. Unfortunately, when the questionnaire was distributed it focussed on three types of technology which was air conditioning, media technology and the different gadgets. However, the main type of technology that Jeddah residents responded they depend on is air conditioning. Nevertheless, Alexander et al. (1977) emphasize that the different technology is adding new layers to the building which affects it..

Figure 97 shows that the most common type of change in the different aged residential buildings is the technology used in the house. This could be because the different types of technology are rapidly improving and the users prefer to use the most modern technology available (Selwyn, 2003). However, to some extent, using the new technology does not affect the room size. For example, although the kitchen could be the space that has the highest turnover in terms of changing technology, to some extent the size of the kitchen was not affected and changed.

Furthermore, one-third of the participants point out that the living room and the bedroom are the rooms that most often have new technology added to them. Adding the different types of technology in the semi-public space such as the living room could help the house residents to interact more in the space. On the other hand, adding the different types of technology in private rooms such as the bedroom might lead to weakening the family interaction in the semi-public space (Hirsch and Silverstone, 2003). Furthermore, adding different types of technology in one space might lead to affecting the space function and the family interaction in the space. As a result, the size of the space will be affected to match the new uses of the space (for example see Figure 94).

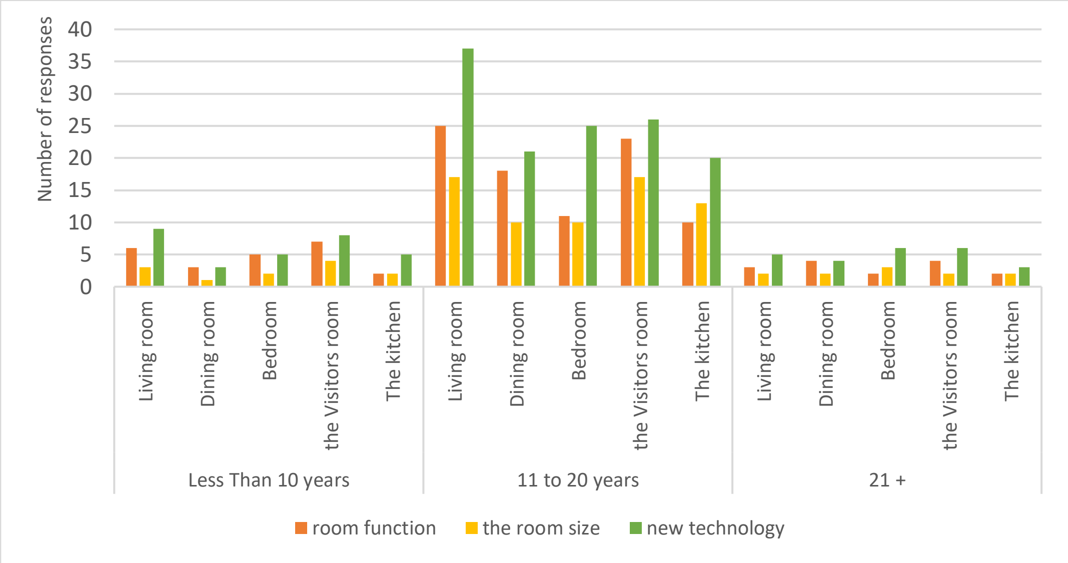


Figure 97 the different types of changes in the different aged buildings

Figure 97 illustrates the different changes in the residential buildings that were built 10 years ago or less. It is clear that generally, the main changes in the different rooms is improving the technology used in the house. Although the buildings are newly built, the reason for changing the technology could be that the residents are trying to keep up to date with the latest technology. The room the residents most commonly change the technology in is the living room and the visitor's room. It is clear also that the visitor's room is the most prevalent room that the residents change the function and area of. These changes could occur by decreasing its space because, to a high extent, this room is often used.

The rooms in the building aged 11 to 20 years old have different results relating to which spaces are changed. Figure 97 shows that mainly all the different changes in these buildings are to the living room. This might be because the living room is the most common room for the family interaction in the house. Interestingly, the dining room is the second highest chosen room that has changes made in its function and technology.

This might be because the dining room could be combined with the living room or the visitor's room. Furthermore, the bedroom in the building aged 20 years old and less did not experience many changes in its size, function and technology. This could be because it is a private space. In addition, there might not be much flexibility in the residential building to be able to apply changes in the bedroom because of the building area or the privacy setup.

Interestingly. Figure 97 shows that buildings aged 11 to 20 years old are the buildings that had nearly all types of changes in all the spaces, especially in the living room. The less recurring type of change in this building group is changing the room size. On the other hand, the most frequent type of change was changing the technology used in the building. As mentioned previously, adding the new technology could lead to having more than one function in the space. This might explain the relation between changing the technology in the building aged 11 to 20 years old and the changes in the room function. Interestingly, it might be clear that technology started to strongly affect the room function and the spatial organization in Jeddah residential buildings 20 years ago.

The participants point out that the modernization of the house design followed by the increase in family members are the main reasons that led to changing the spatial organisation of Jeddah residential buildings. On the other hand, the two least common reasons that led to changes in the spatial organization are changes in technology and climate change. In addition, the economic fluctuations is a reason that some of the participants point out that could affect the spatial organization (see Table 13). Table 14 shows the responses breakdown between the different ages of residential buildings in Jeddah and the reasons changes are made to their spatial organization. It might be clear that the reasons that affected the spatial organization in the different aged buildings are, to a high extent, in the same order.

Nowadays, most of the house residents are trying to copy western designs without questioning if these designs are the correct dwelling that reflects their way of thinking and engaging with the different spaces. Therefore, copying western designs is the biggest reason that affects the spatial organization in the different aged Jeddah houses. Table 14 shows that although the house residents are brainwashed with wanting the western designs, the modernising of the design is a continuing process in the different ages of the buildings. A possible explanation might be that the house residents could not adapt to living in the western design and are trying to find a proper design that reflects their way of engaging with the house (Mallett, 2004). Unfortunately, this might be a reason that most of Jeddah's house residents apply changes in the different spaces after they live in their houses. Another explanation could be that the house residents are not accepting living in traditional designs and are trying to replace it with a contemporary design. In other words, "the house is not an architectural design of the past but of who we are" (Krier, 2008).

The second most common reason that affected the spatial organization is the increase in the number of house residents. However, this outcome might not be acceptable because previously there were approximately 19 members living in one house (Akbar, 1998, Salagoor, 1990). Having a high number of residents might be because there was more than one family living in the same house (Salagoor, 1990). On the other hand, nowadays there is usually one family living in one house and the average number of family members that live in the house is five (General Authority for Statistics, 2019). Yet, the reason for changing the spatial organization could be because of the different requirements from the house residents (will be discussed in the next chapter), the expansion of the city, the building regulations toward the building area, building height and the economic fluctuations (Daghistani, 1993).

Unanticipated, Table 13 shows that the changes to the technology used in the house (8.9%) followed by climate changes (4.6%) are not essential reasons that affected the spatial organization. To a high extent, these two reasons could be strongly linked together because the climate changes affect the building mass and the indoor thermal comfort, consequently, the residents will try to find solutions to provide them with thermal comfort to be able to live in the house. A possible explanation that the participants point out why the air conditioning and the climate changes are the reasons that affect the spatial organization the least is that the air conditioning is considered while designing the house and combined with the construction work or the internal design of the house. Therefore, thermal comfort is not a concern for the house residents. On the other hand, it might not be acceptable that the air conditioning and the climate changes are the lesser factors that affect the spatial organization because the air conditioning replaced some of the traditional passive ventilation elements such as the Manwaar. Regrettably, not having the passive ventilation elements inspired by Jeddah traditional houses led to changing the building design and the social activities in the house.

6.3.3 The family social interaction in the house

Previously it was mentioned that the most commonly used room in the house for family social interaction is the living room. A possible explanation is that the house residents are reflecting their way of engaging with the living room and its function (Suvanajata, 2001). Previously it was mentioned that the most commonly used room in the house for family social interaction is the living room. A possible explanation is that the house residents are reflecting their way of engaging with the living room and its function (Müller and Reichmann, 2015). For example, previously, the living room had a bigger space and windows. In addition, it could have a view of the courtyard or the Manwaar. The different elements such as the bigger space, windows and view enhanced the family's interaction in the living room because they were providing indoor airflow and privacy for the residents. Currently, the living room has moved from the front side of the house to the middle of the house. (see section 5.4.1 The building design for more details). Consequently, the view changed from viewing the street to viewing the setback and neighbours. In addition, the living room size has changed and become either similar to the bedroom size or smaller and the window size has become smaller. As a result, the house resident's interaction changed from mostly meeting in the living room to meeting in the living room and the bedroom (Table 20).

According to Heidegger (1971), Suvanajata (2001), the house residents are trying to reflect their way of living and engaging with the different rooms in order to dwell in their house, but if they do not reach the level of dwelling with the different spaces, to a high extent, they will apply changes in the spaces. Although the air conditioning and systems could affect the spatial organization, it could also help to reorganize the different spaces. Figure 93 shows an example of the house residents trying to reflect their way of engaging with the different spaces by applying changes to it. The house in Figure 93 was built more than 40 years ago and it had a balcony. The house residents modified the balcony by closing it and adding it to the living room. However, although the balcony was added to the living room, it was used as a dining room.

Some of the spaces such as the courtyard were discarded because of the use of air conditioning. Nowadays, most of the contemporary residential buildings in Jeddah do not have a courtyard. As a result, they cannot benefit from its social uses. Moreover, although the setback area could be an alternative outdoor area for the house s to interact in, it does not provide the residents with a similar privacy level as the courtyard (Alharbi, 1989). Moreover, even though the residents mentioned that the setback is one of the spaces that they prefer to meet in, Figure 98 and Figure 99 shows that the setback area does not provide any privacy to its residents, it is small and the layout is affected by the air conditioner compressors.

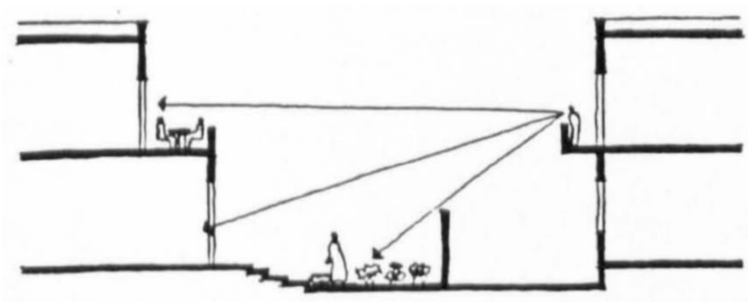


Figure 98 lack of privacy (Alharbi, 1989)

Figure 99 the setback in Masat AlKaldiyah villa (Author, 2017)

Figure 87 shows that the female participants, to a high extent, agreed with the male participants that the living room and the dining room are the rooms that the family regularly meets in. On the other hand, the third space that the female participants mentioned that the family regularly interacts in is the roof. However, both the setback and the roof are outdoor spaces that could be alternatives for the courtyard because they provide, to some extent, similar functions (Suvanajata, 2001, Sidawi, 2008). However, the females might prefer to meet on the roof rather than the setback because it is more private than the setback (Al-Kodmany, 1999, Mubarak, 1999). In other words, the setback area could be easily seen by the other neighbours, unlike the roof.

Table 21 shows that the use of the technology in the house is the main factor that affects the family interaction in the house. Technology is used to provide the house residents with their needs (Gordon and Killick, 1993, Basalla, 1988). Also, Lawson (2001) highlighted that the technology could change the social life of its users especially if they accept it completely. Figure 90 shows that house residents totally depend on technology. On the other hand, Basalla (1988) argued that the resident's social life could be a barrier to using the technology and different societies will only use the technology they need in order for their social life to not be affected. But, if the spatial organization was affected by the air conditioning, to a high extent, the family social interaction will be affected. However, the questionnaire results agree with (Lawson, 2001) and rate the air conditioning as the main reason for changes to the social activities in Jeddah residential buildings (Table 21). However, Table 21 shows that there are minor differences between this and the second reason that the family social interaction in the house is affected which are the modernization of the house designs and the change in the family numbers. However, although the modernized designs could provide the residents with a different experience of using the spaces, the modernized house design is affecting the spatial organization and the family social interaction.

The use of air conditioning led to replacing or removing some of the traditional passive ventilation elements. Figure 100 shows the elevation of a contemporary residential building in Jeddah, the elevation does not show any of the traditional architectural elements such as the Mashrabiyyah, local building materials or the Manwaar. Moreover, it shows that the window sizes are smaller than the traditional residential building. Although having small windows helps to reduce the incoming solar heat, it leads to weakening the social connection between the indoor and outdoor users. However, the passive ventilation elements on Jeddah traditional residential buildings were not only functioning to provide the indoor residents with thermal comfort, but it also had social functions (Al wafi, 2006, El-Shorbagy, 2010b). For example, the courtyard had the function of providing an open space in the house to allow heat exchange ventilation to all of the rooms (Abdulkareem, 2016). In addition, the courtyard’s other function is to provide the family with a private space to interact in on a daily basis (El-Shorbagy, 2010b, Zein Alabidin, 2010). Therefore, the air conditioning might be the main factor that affects the architectural design of the residential building unlike what is shown in Table 13. Table 13 shows that the air conditioning changes is one of the lesser reasons that affect the spatial organization in Jeddah residential buildings, this might be because the use of the air conditioning is included in the house design and the resident might not realise its existence. In addition, the air conditioning is used daily by the participants and they might not be aware of its effect on the spatial organization.

Figure 100 Massat Al Kahldiyah (Author, 2017)

The second reason for changes to the family social interaction in Jeddah houses is the change in the number of family members in one house. According to Salagoor (1990), Jeddah residential buildings accommodated extended families, unlike the contemporary houses that are designed to accommodate one family only. The resident’s participant's comment that the reason for this change is the economic fluctuations. Besides that, Al wafi (2006) mentioned that the expansion of the city, the building regulations and using different techniques such as cars are the reasons that led to building smaller houses that occupy less number of residents.

6.4 Conclusion

A Chi-square test for goodness of fit was applied to the collected responses to test if they represent Jeddah house residents. The test finding shows that the house residents' age, house residents' gender and the building age reflects the real proportions of Jeddah city. Moreover, a Chi-square test for independence was applied to test if there is a relation between the different variables of the questionnaire. Most of the test result shows that there is a link between the different variables. For example, there is a link between the architectural design, house residents' social interaction and the environmental technology and systems used in the house.

The questionnaire results in a number of findings that confirm the link between the three research areas and how changing one of them could affect the other two areas. The first finding is that although there are different types of technologies that are used in Jeddah residential buildings, air conditioning is the main technology that must be available all of the time and in nearly all the different spaces. Yet, changing from the traditional passive ventilation system to air conditioning affected the spatial organization of Jeddah residential buildings because it led to discarding some of the spaces. In addition, it led to having fewer functional elements such as the windows. In addition, air conditioning and the passive ventilation system are inflexible to being moved between the different spaces. This is because the houses were designed to operate the different air conditioning and passive systems and could not be moved from one room to another because it would affect the spatial organization and the electricity distribution in the different rooms. Consequently, the different spaces must be designed and organized to function from the air conditioning and/or the passive system.

Another finding is that Jeddah house residents depend on different types of technology, but air conditioning is the main one. A possible explanation for that is to resist the harsh climate of Jeddah. On the other hand, although the residents show that they cannot dispense with the air conditioning, they accepted using alternative passive ventilation systems.

The third finding is that the different technologies are available in nearly all spaces in the house. Interestingly, the room function, the privacy zone and the spatial organization could be the main restriction to what technology should be available in the different spaces. As a result, new spaces and new uses in the houses appear such as the playroom, the office, the mini-kitchen, car parking and others. Also, some of the spaces have more than one function. Thus, the family social interaction could be affected because of having more than one function in the space that could change the spatial organization, the elements used in the space and the experience of using the space.

The questionnaire results highlight that there are two factors that led to changing the spatial organization of Jeddah houses beside the air conditioning. The first factor is the change in the number of family members in the house. The second factor is the import of other cultures' house designs. This might be because most of the architects at that time were non-Saudis. It might also be because the citizens were trying to copy other cultures' houses and way of living without questioning if such designs matched with their way of engaging with space. Also, it could be a way of resisting the traditional design by living in a contemporary design. Moreover, the residents might prefer to have more flexibility in the designs to apply changes in order to adapt their way of living.

The questionnaire results underline that there are two main reasons that led to changing the family social interaction in Jeddah houses. The first reason is depending on and using air conditioning. The second reason is the change in the number of house residents in one house.

Because the aim of the research is to explore the link between the three areas, it will explore how using the passive ventilation system as an alternative for air conditioning could affect the spatial organization and the house resident's social interaction. The following method will be interviewing some of Jeddah's house residents. One of the interview's aims was to ask them in-depth if they accept using passive ventilation systems. In addition, if they accept it, how it will affect their social interaction, the spatial organization of the house and if they will apply it (see chapter 7 and 8). On the other hand, if they did not accept using a passive ventilation system, what might the reasons.

Chapter 7

Phase three: interview findings

7.1 Introduction

The aim of the interviews was to ascertain how reusing passive ventilation solutions inspired from Jeddah traditional residential buildings could affect the spatial organization and the family social interaction in Jeddah houses. Also, if the house residents accept the use of passive ventilation solutions. In addition, the interviews help to provide in-depth understanding and answer in more detail the unanswered questions from the questionnaire.

The interviews from both stages focussed mainly on Jeddah house residents (Appendix 5 provides details regarding the interview's stages and participants). The interviews were conducted in two stages. Underpinned by grounded theory, the second interview was subjected to many modifications after the analysis of the first stage, as discussed in chapter 4. Importantly, in order to make the questions clearer for the general interviewees, figures for different passive ventilation solutions and elements were provided to the interviewee in the second stage (see Appendix 2 for the interview questions). Moreover, the sample of the interview of the first stage included only the house resident and architects, as mentioned in section 4.6.3. Other actors who participated in this interview stage such as building contractors, academics, investors, and real-estate agencies were included as house resident actors. This was because, as the following data will reveal, these actors responded to the interview questions as a house resident, though the research strived to discuss their perception from their profession point of view. Thus, these actors were combined with the house residents which resulted in two main actors on the first interview stage, the house resident and architect, and only the house resident in the second interview stage.

The interview from both stages, 23 interviews, were transcribed and translated from Arabic to English. Then, from the transcript, the different statements/phrases were segmented and categorised into initial code. Following that, the codes were rearranged into different themes (architectural, social. Others and environmental technology and systems), as discussed in section 4.6.5. Finally, the different themes were analysed and discussed. This chapter will present the findings of the interviews.

7.2 Interview findings

This section presents the interview findings that resulted from analysing the interviews and combining the different themes. This section will be divided into four subsections. The first subsection will discuss some of the general factors that could affect the three research areas such as reflecting the house resident's social status through their houses and the house resident's awareness. The second subsection will discuss how changing the air conditioning to using passive ventilation systems could affect the spatial organization and family social interaction. The third subsection will discuss how the spatial organization is affected and how it affects the other two areas. The final subsection will discuss how the family's social interaction is affected and how it affects the other two areas. Appendix 6 is an example of one of the interviewee transcripts.

7.2.1 General factors

After analysing the interviews, two general factors were identified that could help to strongly link the three research areas (spatial organization, family social interaction and environmental technology and systems). The first factor is how the social status of the house residents is reflected in the residential building in Jeddah. The second factor is the lack of house resident's awareness and understanding of how to dwell in the house effectively.

One of the most important factors that reflects the personal status for Jeddah house residents is the house they live in (Alomari, 1993). Jeddah residential buildings could reflect the social status of their residents in many ways as the interviewees mentioned. For example,

The building elevation: two of the interviewees agreed that, "the elevation of the house gives you an impression about the house residents". To a high extent, this could be right because of the size of the elevation, its design and the building materials used are features that distinguish the different houses. In addition, Salagoor (1990) agreed with the interviewees and mentioned, the Mashrabiyyah is an element where the design and material show the wealth of the house owner.

The room function and size: the majority of the interviewees agreed that the visitor's room is the scale that shows the status of the house residents. Interviewee SAS believes that the visitor's room is not functional and it is a waste of area in the house because, as he stated, "in my house, half of the ground floor is a visitor room, dining room and toilets. The visitors might visit me 2 to 4 times a year. This is a problem". Interviewee YQR added, "when we design our houses, we cared more about visitors than we cared about our daily use rooms". Unfortunately, from a cultural point of view, it is important to have a room that functions to some extent as a visitor's room even if it is not fully used. Interviewee SAS stressed that, "in my community, the most important things are having a visitor room and a dining room".

Number of rooms: one of the interviewees points out that the number of rooms, specifically the bedrooms, could be another factor that reflects the house resident's status. According to interviewee TSQ, "If the family man was wealthy, he would provide for each of his sons/daughters a room and if not, he will provide a room for the boys and a room for the girls".

Using the air conditioning: the interviewees mention indoor factors that reflect the social status of the house residents such as using the newest air conditioning units and supporting technology to provide the residents with thermal comfort.

The second factor is the lack of house residents' awareness of how they could dwell more effectively in their houses. In this context, based on the interviews findings, the lack of awareness could be spotted in many areas such as:

Having often used rooms: one interviewee stated that, "We must correct the wrong understanding. Why in every house there is a Salon room (visitor's room) and a dining room". The interviewee also commented that having these rooms might be very obvious because the house residents care more about the visitor's room, which is not used daily, than they care about the common rooms that they do use daily. Unfortunately, caring about the visitor's room could be a method of reflecting the social status of the house residents and displaying their wealth.

Unexpectedly, a minority of the interviewees agreed that it is important to increase the resident's knowledge on how to benefit from the waste rooms and the daily used rooms. This agreement is important, especially nowadays, because the building costs and the utility bills have massively increased. Likewise, the house building area has decreased i.e. there is no more generosity in the building area. Interestingly, interviewee SAS questioned, "Why do we live in a 500m^2 house while a 100m^2 house is enough". In other words, the interviewee meant that it is possible to live in smaller houses, but it is important to identify what spaces are needed in the house.

Having an extended family: another example of the house resident's lack of awareness is that the residents are trying to maintain the extended family concept in the contemporary house. Many of the interviewees mention that they prefer to have houses with separate entrances. They also added that the reason for having different entrances is to separate the house to two or more units with separate entrances for each extended family group. Moreover, interviewee AQD mentioned that most of the house residents have considered this concept while designing the house, but unfortunately, they are more concerned about the number of rooms, especially bedrooms, to occupy the family members in each unit than the room size i.e. the residents are searching for quantity rather than quality.

In conclusion, reflecting the house residents' social status on the residential building and the lack of understanding of how to dwell in the house effectively are the two general factors that could affect the spatial organization of Jeddah residential buildings, the family social interaction in the house and the environmental technology and systems used in the Jeddah residential buildings.

7.2.2 The environmental technology and systems and its effect on the other two areas

This section will discuss, based on the interviews' outcomes, how the different air conditioning and passive ventilation systems could affect the spatial organization of Jeddah residential buildings and the family social interaction. Also, it will discuss the different factors that affect the airflow in Jeddah residential buildings and how the passive ventilation alternatives could help in reducing power consumption. In addition, what are the air conditioning alternatives that the interviewees suggested if the air conditioning is not working? Finally, to what extent the house residents accept the use of passive ventilation systems.

At the beginning, the majority of the interviewees in both interview stages agreed that the air conditioning must be available in their houses. However, having the air conditioning or the passive ventilation system has different effects on the spatial organization. One of the interview findings shows that using the air conditioner helps, in general, with better utilisation of the different spaces within the building boundaries. For example, interviewee AAM mentioned that having an air conditioner in the corridor facing the living room changed the corridor use from a corridor to a small playroom. Moreover, interviewee ISK, mentioned that because of using the air conditioning, the kitchen in his house is located on the ground floor with two open walls and his wife has eye contact with the different residents and rooms.

Another finding from the interviewees' point of view is that using passive ventilation systems in the contemporary houses could convince the house residents to change some of the room locations and view. For example, changing the bedroom location from viewing the street to viewing the Manwaar or courtyard. Unfortunately, one of the participants claimed that the passive ventilation systems could not change the spatial organization because, nowadays, the building area is smaller than before and it is not possible to use the different passive ventilation elements such as the courtyard or having a bigger Manwaar. In other words, because of the smaller building size the courtyard is not required by the house residents and the Manwaar is smaller. Consequently, it is not expected to have a courtyard or Manwaar that could affect the spatial organization and room view. On the other hand, other interviewees accepted to use other passive ventilation solutions such as the double facade wall which is a modified version of the Mashrabiyyah.

Recently, interviewee ALA, ASK, TSQ and others agreed that it is the architect's responsibility to select either using the air conditioning or passive ventilation systems in the contemporary residential building. Furthermore, the interviewees also agreed that the house residents are not sharing the technical decisions with the architects but are sharing decisions relating mainly to the room design such as the different room locations, size and the number of rooms. As a result, most of the architects prefer to use air conditioning. A possible explanation could be the limited building area that led to dispensing with some of the passive ventilation elements and using other alternatives that do not require a large building area.

One of the participants claimed that using air conditioning could not affect the family social interaction because it provides similar thermal conditions in all the rooms of the house. In addition, it could not affect the family lifestyle. In other words, the house residents no longer need to move between the different rooms in the house to avoid the heat because the air conditioning provides all the different rooms in the house with a similar indoor temperature. Nonetheless, the house residents move between the different spaces because of their functions. As a result, the house residents might prefer to be isolated in their room for longer lengths of time. On the other hand, nearly one-quarter of the participants agreed that using the passive ventilation system could improve the family social interaction because it provides a focal area to gather in with a proper airflow in the gathering areas. interviewee AML stressed that this could be achieved if the passive ventilation elements are "integrated with daily use areas". Consequently, it is highly expected that it would change the spatial organization and change the different room's view from having an outdoor view to an indoor view. Moreover, having the focal meeting area indoors and changing the room's view will result in having more private areas in the house.

Interestingly, many of the interviewees point out that not having proper indoor airflow is one of the factors that affects their social interaction in Jeddah contemporary houses. Accordingly, it might be important to highlight what affects the airflow in Jeddah contemporary houses. The traditional houses were dependant on having proper cold airflow in order to ventilate the different spaces in the house by using different passive ventilation elements such as the windows, the different indoor openings, the Manwaar and others (see section 5.3.1.3 for more details).

Thus, because of the dependency on air conditioning, the cross ventilation in Jeddah contemporary houses was negatively affected. Also, the contemporary houses in Jeddah do not effectively use the different passive ventilation elements such as the windows that could help to generate the indoor cross ventilation. A possible explanation could be that there might be a lack of the house residents' awareness of how to create a proper indoor airflow through using the different passive ventilation elements. For example, interviewee MBB points out that his house had a nice and good airflow while he was building it, but after installing the windows the nice airflow stopped. i.e. the type of windows used blocked the airflow. Besides that, there are other outdoor reasons that could affect the airflow such as the urban design of Jeddah city. For example, the average distance between the buildings is 4M and this distance is not sufficient to generate an airflow between the buildings.

Figure 101 illustrates the interviewee's different reasons for what they think affects the airflow in Jeddah contemporary houses. One-third of the interviewees agreed that the Jeddah contemporary house design, "was not built based on the environmental conditions" (interviewee TAN). In more detail, the building design, orientation and windows are not benefiting from the outdoor microclimate. In addition, most of the interviewees mentioned that they prefer to live in modern house designs rather than a traditional house design. Moreover, one of the interviewees mentioned that the houses are not designed to exhaust the cooking and toilet odours out. In other words, the architects who designed the houses did not care about the indoor air circulation and how it could be exhausted.

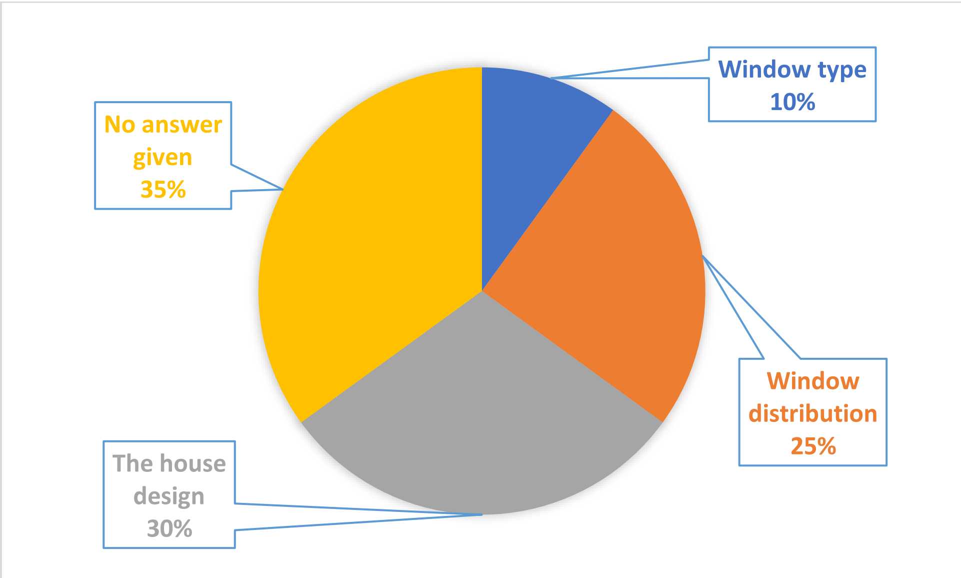


Figure 101 what affects the airflow in Jeddah contemporary houses

Figure 101 shows that 25% of the interviewees agreed that another factor that affects the airflow in Jeddah residential buildings is the window distribution, which is a passive ventilation element that negatively affects generating cross ventilation in the house. In more detail, the windows in the different rooms of the house are not distributed to allow the airflow in from one side of the house and to exhaust it from another side. In other words, the air circulation is neglected. Besides the window distribution, having small windows that are mainly closed most of the time to maintain the residents' privacy, are other reasons that affect the airflow in the residential building (see Figure 75). Moreover, the minority of the interviewee's (10%) point out that the window types such as the glass type or the material of the window are factors that lead to negatively affecting the indoor airflow because it might not be flexible in opening and closing. However, Tzempelikos et al. (2010) point out that the window material could massively reduce the incoming solar heat and provide the residents with thermal comfort, but they did not mention if the windows and their materials could affect the indoor airflow.

Interestingly, Figure 101 shows that 35% of the interviewees did not give a response for what they think could affect the airflow in Jeddah contemporary houses. A possible explanation is the absence of knowledge of how the cross ventilation is generated and how it could improve the quality of the indoor airflow and how it could also improve power consumption. A number of the interviewees agreed that one of the reasons for the absence of knowledge could be that the architect did not consider explaining the use of passive ventilation systems to the house residents. In addition, interviewee ABQ stated that there is a lack of examples of different residential buildings that benefit from passive ventilation systems.

Reducing power consumption and using other sources of power are two of the Saudi Vision 2030 objectives. Nearly 60% of the interviewees believed that using passive ventilation could reduce power consumption. On the other hand, the many of interviewees point out that, "unfortunately, 70% to 80% of young people must use air conditioning even if you provide them with the natural ventilation solutions" (interviewee SAS). In other words, the preference of the residents could be one of the main reasons that lead to increasing power consumption in the house. Furthermore, other reasons the interviewees mentioned that could increase power consumption in Jeddah residential buildings are the poor design of the houses and not benefiting from the windows or the Manwaar i.e. not using the available passive ventilation elements in a proper way.

Figure 102 demonstrates the different ways that the interviewees believe that using passive ventilation could help to reduce power consumption. The two main ways that could help the house residents reduce their power consumption are by raising resident's awareness of how to benefit from the passive ventilation system (30%) and using the passive ventilation elements which could be a source of light alongside providing cold air (30%). Moreover, 20% of the interview participants mentioned that having passive ventilation elements in the house could help to reduce the power consumption because it provides well ventilated areas. Finally, the data revealed that changing the spatial organization and benefiting from the window to create air circulation are considered the least effective two ways that could lead to decreasing power consumption in Jeddah residential buildings.

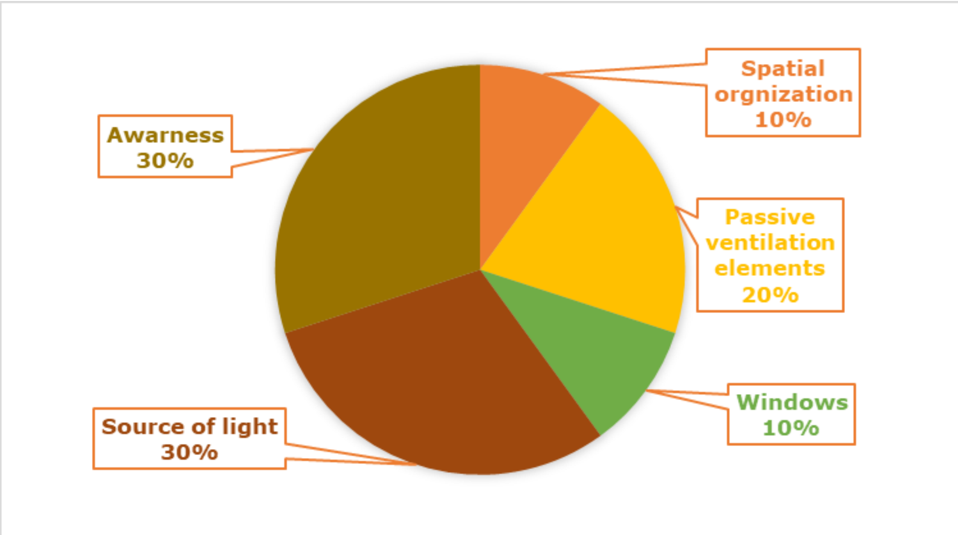


Figure 102 how could the passive ventilation help in saving the power

The interviewees were asked what alternatives they might use if the air conditioning was not working. Figure 103shows that there are four different alternatives which are moving between the different spaces in the house (8%), opening the windows (17%), using a manual fan (25%) and using supporting elements to allow the airflow such as louvers and shutters (50%). In other words, the majority of the interviewees preferred to open the windows (opening windows 17% and using the louvers or shutters on the windows 50%). Although it was mentioned earlier that the window size and distribution could be a limitation to having proper indoor airflow, the house residents nominated opening the windows to have indoor airflow as one of the best alternatives to air conditioning. On the other hand, only one of the interviewees mentioned that he "can stay at the setback or the roof for some time" until the electricity is back, and the air conditioning could work. Interestingly, these alternatives are temporary because as interviewee TAN and other interviewees mentioned that if it would take a long time for the air conditioner to start functioning again, they might leave the house and go to a hotel or a relative. Foruzanmehr and Nicol (2008) agreed with the interviewees and highlighted that because contemporary Jeddah houses were not designed to adapt with the outdoor microclimate, the houses are highly expected to be vacated quickly if the air conditioning was not available for an extended period.

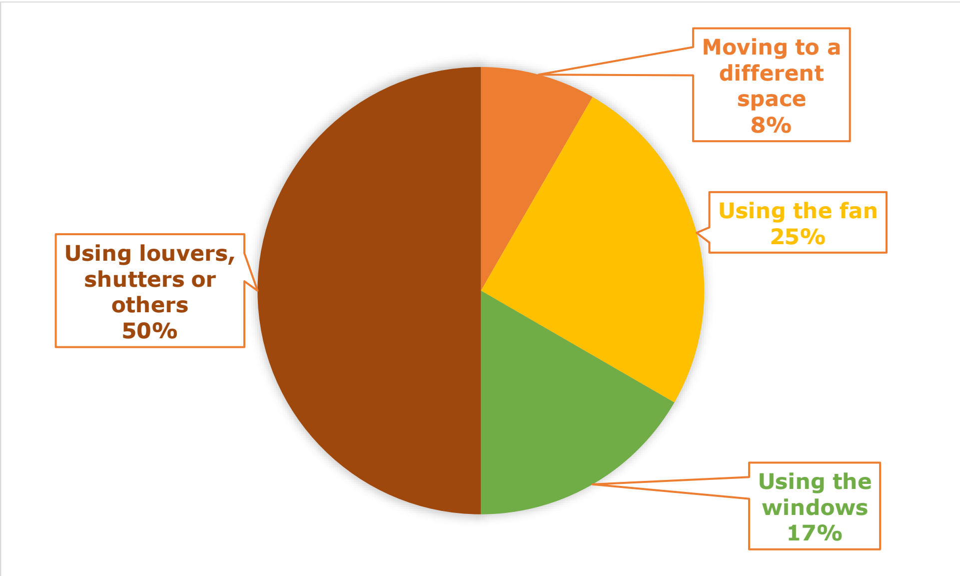


Figure 103 air conditioner alternative

In the questionnaire, the house residents were asked close-ended questions about if they will accept using a passive ventilation system. Consequently, to have an in-depth answer, the interviewees were asked if they would be willing to accept using the passive ventilation system in their houses. The answers vary between total acceptance of using the passive ventilation system (with or without some conditions), not willing to accept it or combining the air conditioning with the passive ventilation system, see Figure 104. Besides the passive ventilation solutions' main function, which is to ventilate the house, few participants would totally accept using the passive ventilation for two reasons. The first is that it provides a good view from the different rooms and the second reason is that it provides an "enjoyable" space in the house for the house residents. The majority of the participants that would accept using the passive ventilation system had different conditions in accepting it such as; the passive ventilation elements would need to provide the required level of privacy for the house residents, the traditional elements would need to be modified to be in line with the contemporary style, would need to provide good airflow in the building and finally would need to be secure from "the animals such as cats or rats so that they could not come in to the house through them".

On the other hand, one of the interviewees did not accept using the passive ventilation and mentioned that, "if you went back in time and gave the house residents the air conditioner, they would close the Manwaar and all the other solutions". This interviewee was supporting the idea that there is no need to use any of the passive ventilation systems because using air conditioning provides faster thermal comfort solutions despite any social or architectural effects. However, the minority that did not accept using the passive ventilation options gave mainly two reasons. The first reason was that the contemporary houses “were not built based on the environmental conditions”. In other words, the contemporary houses are designed to use and depend on the air conditioning but are not designed to function with the passive system. To some extent, if the houses were designed to rely on the passive ventilation system, the house residents might accept using them more readily. It might be important to mention that designing a house that benefits from the environmental conditions or the microclimate of Jeddah could be by orienting the house toward the North, Northwest or West side (Goetzler et al., 2014), using different shading device (Kamal, 2012), benefiting from the building thermal mass and heat exchange (Abdulkareem, 2016, Sharif et al., 2010) (see 3.3 Passive building design more details). The second reason is that the thermal performance of the new building materials is not as effective as the thermal performance of old building materials. Consequently, the new building materials do not function in the same concept as the old building materials but there are heat insulations that do not allow the heat to filtrate to the indoor atmosphere and do not allow the indoor cool temperatures to filtrate outdoors.

Moreover, half of the participants concede that, currently, the Manwaar is not a fully functional element because they use it for piping or storage. On the other hand, the Manwaar could be functional and used if it could be modified. In particular, the Manwaar is not used as a passive ventilation element because of the piping on it and its location. Contrarily, if the Manwaar is modified in a contemporary way and “If we can change its place and integrate it with daily use areas”, it could function better and be used as an environmental and social element. Unfortunately, nowadays, because of the small building size, the Manwaar is smaller in size. Furthermore, the courtyard is not generally available in most of the contemporary residential buildings in Jeddah and it has been, to a high extent, replaced with the setback or the roof.

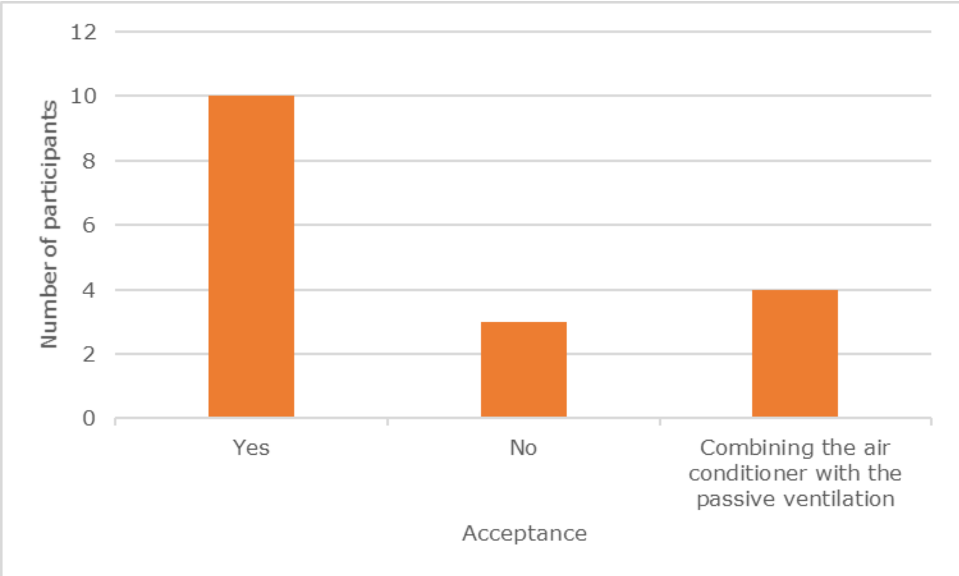


Figure 104 accepting using the passive ventilation in Jeddah houses

Figure 105 shows the different limitations that the interviewees point out which might prevent them from accepting the use of the passive ventilation system. The lesser chosen reasons are the design style of the house, the building area and the cost of adding and using the passive ventilation system. Obviously, adding the passive ventilation elements to an existing building is costly and might not be effective because, as mentioned previously, the building was not designed to adopt the passive ventilation system and to benefit from the outdoor microclimate. However, although these reasons could be important, most of the interviewees agreed that the outdoor weather and their preference to totally depend on using the air conditioning are the main limitations of using the passive ventilation system. Moreover, it is interesting that the lack of awareness is one of the moderate reasons that limit the house residents from using the passive ventilation system. This lack of awareness is because there is a lack of "proof that the passive ventilation could provide indoor thermal comfort and reduce the utility bills" (interviewee ABQ), or that the house residents "do not know how to benefit from it" (interviewee SAS).

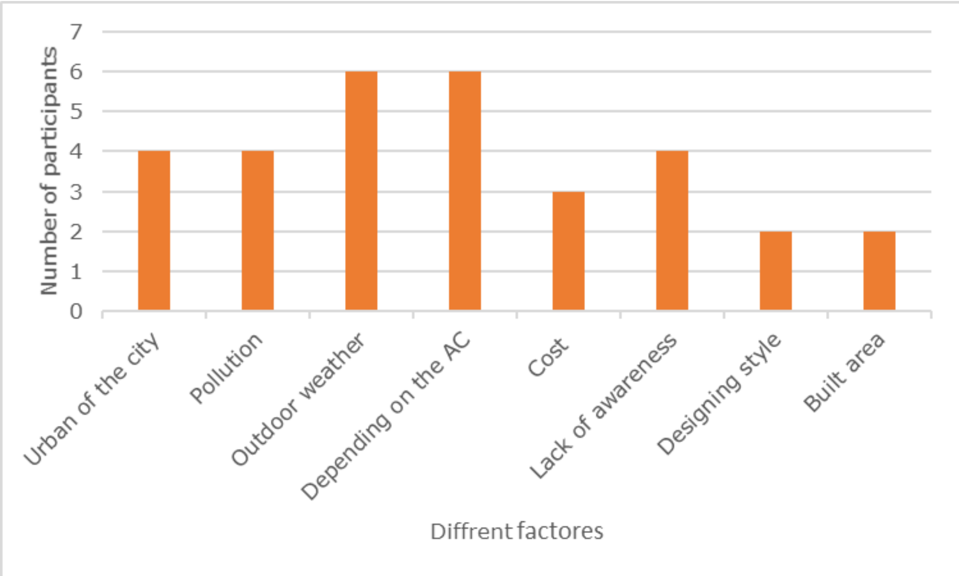


Figure 105 limitation of using the passive ventilation

7.2.3 The spatial organization and its effect on the other two areas

This section will discuss, based on the outcomes of the interviews, what factors could affect the special organization of Jeddah residential buildings and how these factors could affect the family social interaction and the environmental technology and systems used in Jeddah houses. The interviews result in highlighting different factors such as the number of rooms, the room functions, the room size, the waste areas in the house and the architectural elements.

The different spatial organization has different effects on the house residents’ selection of which room they prefer to interact in. Although it might be obvious that the living room is the preferred meeting room, Figure 106 confirm that and illustrates that nearly one-third of the house residents prefer to gather in the living room. On the other hand, nearly one third of the house residents prefer to interact in other rooms such as the roof (10%), the setback (10%), the corridor (5%) and the courtyard (5%). According to interviewee YQR, one reason that weakens the family interaction in the living room is its location. In more detail, nowadays, the living room in the contemporary residential buildings is commonly in the middle of the house and, to a high extent, is used as a corridor between the different rooms. A possible explanation could be that nearly all the different rooms have their door opening into it (see Figure 5). Therefore, the level of privacy in the living room is negatively affected and the house residents prefer to stay in their rooms, especially when there are visitors using the living room. On the other hand, interviewee ISK claims that, “it is important to have a common area in the middle that all of the rooms can access such as a courtyard, a room, anything in the middle”. Although this claim could be right, it will not really be an effective solution because if the location of the common room is in the centre between the different rooms, it could be used as a corridor. Therefore, in order for the common room to be much more beneficial, it is important to have it as a buffer between the public and private rooms of the house (see Figure 6).

Unexpectedly, two of the interviewees mentioned that the room size does not affect the selection of where the family gathers, but what is really affected is how you can attract the family members to interact in the living room. Interviewee SAS mentioned that, providing the different entertainment elements in the living room was not really enough to encourage the family members to interact in the living room and there is a need to find other ways to encourage the family members to interact in a common area such as having a good view or acceptable room size. Moreover, the data reveals that although one-third of the participants mentioned that they prefer to gather in the roof, the setback, the corridor and courtyard, they strongly agreed that the reasons for selecting these spaces are because there is a good airflow and view.

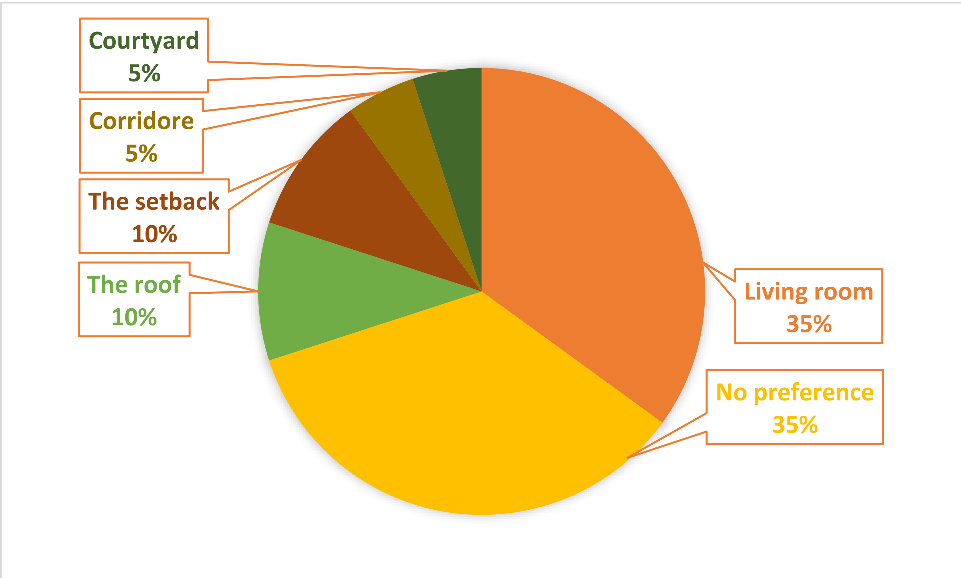


Figure 106 preferred meeting room (based on the interviews)

Reorganizing the different room locations could have an effect on the number of rooms in Jeddah contemporary houses, specifically the number of bedrooms. Also, it could affect the view from the rooms. Therefore, interviewee GDT claimed that some Jeddah house residents are building half of their site as a house to live in and the other half of the site as a special building for the family's social interaction. The data shows that Although a minority of the interviewees (5%) agreed with this concept, to a high extent, this solution could not be verified because of the lack of building sites and the high cost of building, maintenance and bills.

As mentioned, the family members might require a specific number of rooms and room functions for their residents, but the data indicates two limitations might lead to not providing the family with their requirements, which are the building costs and the building area. The interviewee agreed that the building area is the main factor that controls the spatial organization. Thus, it significantly influences the family gathering. Generally, 25% of the interviewees agreed that Jeddah contemporary houses' building area is much smaller than before, and this might limit them from having frequent family social interaction in the house because there might not be enough space for them to meet in. Nowadays, some of the interviewees agreed that the ground floor area has been reduced from nearly 450M2 to nearly 250M2. Consequently, as interviewee ASR reported, "there won't be that generosity in the building area", i.e. the number of rooms and their size will be reduced. Thus, some room functions might be combined, some room functions vanished, and new functions have appeared. The questionnaire findings agreed with this and added that the house residents are making changes and combining rooms to reflect their needs in the house.

The data reveals that having different room functions could also affect the family's social interaction in the house because they need to move between the rooms based on the room function. For example, having a dining room to eat, a playroom to play, a reading room to read and others. To a high extent, not all the residents will have the same interest at the same time. As a result, the different room functions could affect family interaction. Interviewee GDT suggested combining some of the functions in one room. This means having a multi-function room. This solution was functional in the traditional houses and could be much more functional nowadays if the room has a good location in the house, a good view, good airflow and an acceptable room size.

However, although combining the room functions in one room could help to reduce the number of rooms in the house, there was not an agreement between the interviewees that this solution could help to improve the family's interaction. Interviewee AML claimed that, "the bed suite has nearly all the needs, so why do I need to meet with the others or to leave my room". On the other hand, interviewee TSQ stated that, "there is a salon and a dining room and a living room, before there was only a multipurpose room". The reason for this misunderstanding, which is combining different functions in one room or having separate rooms for different functions, could obviously be because of the lack of awareness from the residents of how to reflect their needs and way of engaging in their houses. Combining the function in the private areas, such as the bedroom, could lead to isolating the residents in their room and reduce the time that they might spend in the living room as interviewee AML mentioned. On the other hand, combining the functions in the semi-public or public area could lead to improving the family social interaction habits in the house and to reduce the number of rooms which could positively affect the size of the other rooms.

The room size could be affected because of the requirement of having a high number of rooms and room functions in the residential building which has a limited building size. Most of the participants agreed that the visitor’s room and its services is given the largest area in the house, especially on the ground floor. Unfortunately, although this room and area are required by the house residents, it is not used for most of the year and it could be considered as a wasted area in the house. As a result, the wasted area negatively affects the other room areas because all of these rooms are in one residential building with a limited building area. Besides that, the average dimensions of the living room are 4M X 6M and the bedroom’s average dimensions are 4M X 6M (see Chapter 5). The similarity in the room size clearly shows that the bedroom is as important as the living room. Accordingly, in order to have a spatial organization that provides a dwelling and reflects the house resident’s needs, the residents need to be more aware and to change their thoughts and standards about the room size.

The waste area could be defined as rooms that the house residents are not fully benefiting from or not often using. This might be because of the functions of these rooms, their location, their size or change in lifestyle. Based on this definition, interviewee SAS, TSQ and other interviewees agreed that the visitor’s room and the dining room are waste areas in Jeddah contemporary houses. One participant commented, “in my house, half of the ground floor is a visitor room, dining room and toilets. The visitors might visit me 2 to 4 times a year”. Although the visitors and the dining room are the biggest areas and having them increases the building and operation cost, they are not often used. One reason could be that these rooms are, from a social point of view, what shows the house residents status. As a result, these rooms must have a bigger area in the house and a prime location. However, not considering how to maintain the residents’ thermal comfort in the different rooms and its different size could be because of the dependency on the air conditioning. Hence, Interviewee AAT points out the power consumption will be high to cool the different rooms. On the other hand, a small number of interviewees suggested that the visitor’s room is not as important as it was, and they have changed its use. This might explain why the residents apply changes and what type of changes are applied in the contemporary residential building. For example, one participant changed the use of the visitor’s room to a photo studio that reflects his profession. Other residents changed the visitor’s room into a robot workshop that helps him and his family to interact there for a longer time. This can indicate that there is a change in Jeddah house resident’s ways of dwelling and reflects their needs in their houses. In other words, the change in the house resident’s lifestyle and preference has led to changing the expectations of the different room functions and size.

Finally, the interviews outcomes show that the architectural elements are another factor that affects the spatial organisation and the family social life. For example, some of the families are maintaining the extended family concept in the house, but they only designed the house to accommodate two or three families. In order to design the house to accommodate the different families, they located the staircase on the side of the house next to the family entrance (the side entrance) so they can have access to the upper floor without meeting their extended family on the ground floor. This might be a primitive solution, but it provides the family with its need to have more than a family in one house. On the other hand, this solution mainly prevents the family from meeting frequently, because instead of just isolating the family members in their rooms, it also isolates them on different floors. Another architectural element is the Manwaar, its use was to provide the different indoor spaces with natural airflow and the residents with privacy. However, nowadays, the Manwaar is used to provide lighting to the different rooms, a space to locate the piping and to exhaust the bad smells and the hot air resulting from the air conditioner compressors. As a result, the new use of the Manwaar has led to reorganizing the different rooms facing it and as a result of that, nowadays, the service room faces the Manwaar instead of the private rooms.

7.2.4 The family social interaction and its effect on the other two areas

This section will mainly discuss the different factors that led to limiting Jeddah house residents from having frequent family social interaction.

Figure 107 provides the different reasons the interviewees pointed out that affect the family social interaction in the house. The data shows that a minority of interviewees (5%) indicated that one of the factors could be that the meeting area, such as the living room, does not provide enough privacy for its users. This might be because of the location or the view from the room. Especially that in the contemporary houses, the living room is located in the middle of the house with a side view to the neighbours. In addition, having the living room in the middle of the house, between the public and private areas, led to use it as a corridor (see section 2.2 The link between architectural design and social life). Besides that, the data illustrates that having the living room view to the setback, viewing the neighbours negatively affected the privacy of the house residents and the neighbours. Finally, most of the interviewees agreed that having a smaller building area led to having smaller and fewer rooms which is another factor that affected having frequent family interaction.

Moreover, another minority of the participants (5%) points out that the changes in the family size is also another reason that limits the family social interaction in the house (see Figure 107). Unfortunately, the contemporary houses are designed to contain one family and not an extended family (Salagoor, 1990, General Authority for Statistics, 2019). As well, the interviewees agreed that having a smaller building area for the house led to smaller room sizes and a smaller number of rooms. Therefore, interviewees HDT, TSQ and others agreed that the house residents are experiencing fewer meetings in the house and prefer to meet in an event hall or a restaurant outside the house. Nevertheless, Figure 107 illustrates the other three main causes that affect the family social interaction in the house which are: the spatial organization, the number of rooms and having multi-function activity in one room.

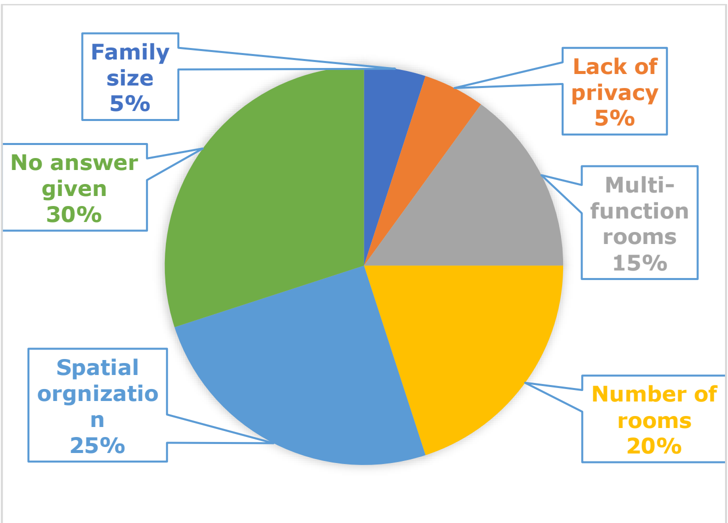


Figure 107 limitations of having a frequent family social interaction

A quarter of the interviewees (25%) agreed that the spatial organization could be the main factor that affects the family social interaction in the house. Moreover, the spatial organization could reflect how the different privacy zones are distributed in the house. In other words, changing the location of any of the rooms could affect the private zone distribution, the house design and affect the chances of the family interacting. Additionally, besides the distribution of the different spaces, two of the interviewees agreed that the spaces for the family to interact in the contemporary house, are the smallest room areas compared with the other rooms in the house (see section 5.3.3 Contemporary case study for more details). Interviewee YQR stated that, "most of the building area is used for the bedroom instead of using it to have meeting areas", and interviewee AMS added that, "we are concerned about the visitors and give them a bigger space in the house", this concern reduces and negatively affects the area and number of the daily used family entertainment spaces. Interviewees YQR and AMS agreed that, while designing a house the house residents are focused on giving the public and the private zone bigger spaces than the semi-public zone, such as the living room that could be used daily by all of the family members. Interestingly, none of the interviewees mentioned any effect from using the air conditioning on the spatial organization or the family social interaction. As mentioned previously, this might be because the house residents are more concerned with how the design of the house reflects their social status, rather than how the design could impact on their social interaction. In addition, the air conditioning is flexible and could be adapted and changed.

The second highest ranking factor that affects the family gathering is having a high number of rooms (20%). Interviewee

GDT agreed with the others and stated that, "the more you provide rooms, the more the residents will be isolated.'' Having a lot of rooms could be an advantage in giving each resident a private area. On the other hand, it has led to having higher privacy levels between the family members and isolating each member in their private zone as interviewee AJD mentioned. Also, it leads to creating more private zones in the house than the semi-public and public zones(see section 5.4.2 The spatial organization for more details).

Moreover, isolating each room with walls and not having any eye contact between the different rooms in the semi-public zone could be another reason for the weakening of the family interaction because the meeting area (living room) is surrounded by four solid walls like the other spaces as interviewee MBB indicated. Consequently, there might not be a big difference between the living room and the bedroom. Finally, it is interesting that the interview and questionnaire findings show that the Jeddah house residents are concerned about the number of rooms more than the size of the room.

The final reason that could limit the family from frequent social interaction is having multi-function spots in one room. Although the multi-function room was an advantage in the old houses because it was in the semi-public rooms, now it is a disadvantage because it applies in the private rooms. For example, interviewees ASR and OQB highlighted that previously, the living room was for the family gathering and having different activities such as watching TV, eating, drinking tea, playing and other activities. Nowadays, the living room might have the same functions but, each bedroom, or bed suite, has similar functions as the living room such as a mini-kitchen, toilet and different devices. As a result, there might not be a strong reason for leaving the bedroom or bed suite to sit in the living room. Predominantly, the idea of having a multi-function bedroom or suite is new to Jeddah house residents and this idea could have been imported from western designs. Thus, importing the western designs could have some advantages, but if they do not reflect the Jeddah resident's way of dwelling, they could lead to having negative effects.

In general, clearly, it seems that the family size, lack of privacy, number of rooms, multi-functional rooms and the spatial organization are the reasons that have led to affecting how frequently or infrequently the family interacts in the house. But, as discussed previously, there are other hidden reasons, such as the lack of the house residents' awareness, and importing foreign designs that might not meet the Jeddah house residents' way of living.

7.3 Conclusion

It might be clear that if any factor affected any of the research areas such as air conditioning, it would affect the other research areas, the spatial organization and the family social interaction. In other words, the three-research areas are linked together to adopt any causes for change when providing the house residents with a dwelling. The aim of the interview was to understand how reusing the passive ventilation system could affect the spatial organization and the family social interaction in Jeddah houses. Also, to know to what extent the house residents could accept using passive ventilation in their houses.

Figure 108 concludes the interviews findings of how each of the research areas could adopt the changes, fully or partly, in using the passive ventilation system in Jeddah residential buildings. Using air conditioning results in designing houses that depend on the air conditioner and could not function and benefit from the outdoor microclimate. Furthermore, the power consumption of the air conditioning in the contemporary house is more than 70% of the total power used by the house resident because of the dependency on it (Taleb and Sharples, 2011, Vision2030.gov.sa, 2016). Moreover, although the air conditioning provided extra area for the house residents, it led to dispensing with some of the passive ventilation elements such as the courtyard and it led to other passive ventilation elements, such as the windows and the Manwaar, no longer functioning. In addition, it led to not having eye contact between the different house residents in the different spaces. On the other hand, although the building area is limited and the passive ventilation elements require extra space, they provide the house residents with enjoyable interaction areas alongside its function as a ventilation element.

Based on the finding of this phase, Figure 108 illustrate the conclusion of how environmental technology and systems and the family social interaction adopt each other's needs. Using air conditioning provides the different rooms with similar indoor thermal conditions. In addition, it led to multi-function uses in one room. The multi-function rooms could be an advantage if applied to the semi-public rooms but if the multi-function room is any of the private rooms it would be a disadvantage. On the other hand, it led to affecting the indoor and outdoor privacy of the house residents. Finally, it is important that the house residents are aware of how to benefit from the different air conditioning and not to overuse them especially to reduce power consumption.

Finally, the house residents usually require to live in modern designed houses disregarding if these designs reflect their way of engaging with the house. This could be a way of resisting living in a traditionally designed house. Unfortunately, although Jeddah residents require the modern designs, they also require a high number of rooms with different functions. Unfortunately, the contemporary houses have limited building space because of the building regulations and the high cost of building. As a result, the residents might require a high number of rooms but in smaller sizes. Therefore, although having the passive ventilation elements could reorganize the different house spaces and, to a high extent, Jeddah house residents accept using the passive ventilation system, providing the passive ventilation elements in Jeddah contemporary houses could be a challenge. This is because of many reasons such as the lack of proof in how using the passive ventilation system could help to improve power consumption, the limited building area, and the high cost of building.

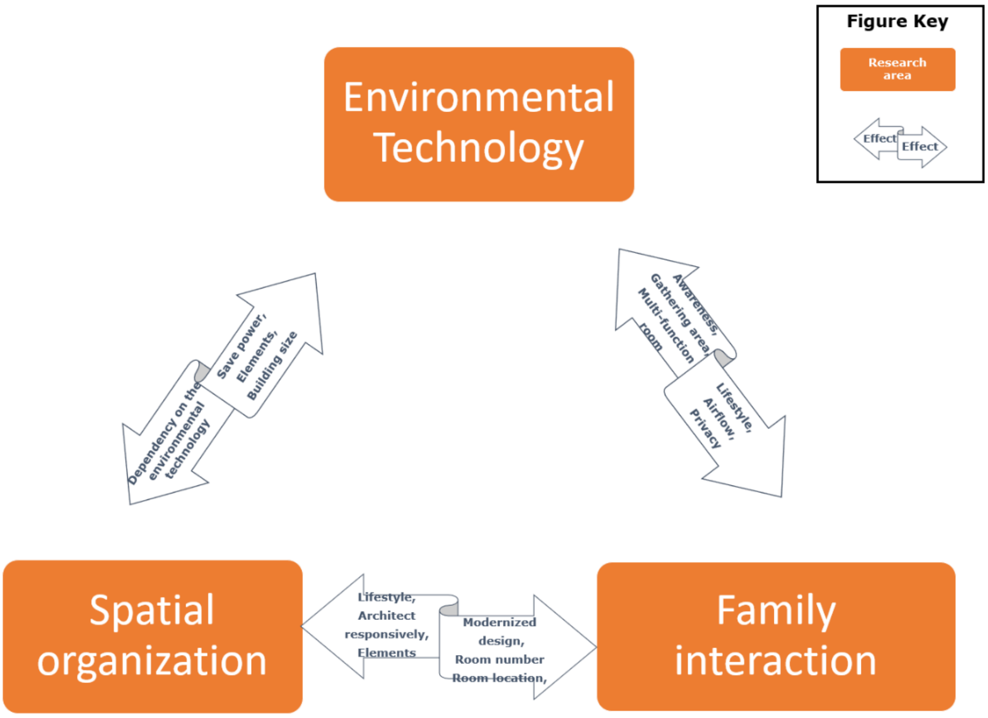


Figure 108 the effect of changing the environmental technology on the research areas

Chapter 8

Discussion and recommendations

8.1 Introduction

Previous chapters discussed the link between the spatial organization, house residents' social interaction and air conditioning or passive ventilation systems used in the residential building. Moreover, the questionnaire and interview findings revealed considerably many acceptances from Jeddah house residents to use the passive ventilation systems with different conditions. However, the questionnaire did not reveal the extent of the expected real use of the passive ventilation. Moreover, although the researcher observed the interviewees and their houses while conducting the interviews, the participants might pretend differently while conducting the interview. Yin (2017) points out that this is one of the observation limitations. Unfortunately, it seems that although the different methods found an acceptance of using the passive ventilation systems, it is not clear if the participants will really use them as they stated. Therefore, the theory of planned behaviour will be used to explore the research participants' intention to use the passive ventilation system in light of the resulting data from all research phases.

This chapter will be divided into four sections. The first section defines the framework of the theory of planned behaviour. The second section applies the theory to the findings. The third section outlines the recommendations. The final section is the conclusion.

8.2 The Theory of Planned Behaviour

The theory of planned behaviour was founded by Icek Ajzen in 1985 and has played an important role in predicting and explaining human behaviour in different areas. Figure 109 shows the framework of the theory of planned behaviour that contains three predictors to help to predict and shape the individual intention and behaviour. The first predictor is the attitude toward behaviour that refers to the person's personal thoughts such as if the behaviour is favourable or unfavourable. The second predictor is the subjective norm that refers to the social pressure to perform or not to perform the behaviour. The third predictor is the perceived behavioural control that refers to what extent the person is ready to act out the behaviour, i.e. is it easy or not? what obstacles might I have and others? Yet, generally the more likely the three predictors are, the greater the person's intention to perform the behaviour under consideration. On the other hand, Armitage and Conner (2001) point out that in the prediction of social behaviours, there are no absolutes.

The theory of planned behaviour was used based on a quantitative data method in a wide range of fields such as business environments (Greaves et al., 2013), health (Conner & Sparks, 1996), the use of public transport (Bamberg & Schmidt, 2003; Heath & Gifford, 2002) and others. In addition, it was used in a qualitative data method in a wide range of fields such as teaching and learning (Renzi and Klobas, 2008), business such as understanding beverage consumption behaviours (Zoellner et al., 2012) and others. In this research, the application of the planned behaviour theory will be based on the findings from both quantitative (which shows the significant relation between the different variables and the qualitative method) and the qualitative data (which explores the users perception more in-depth).

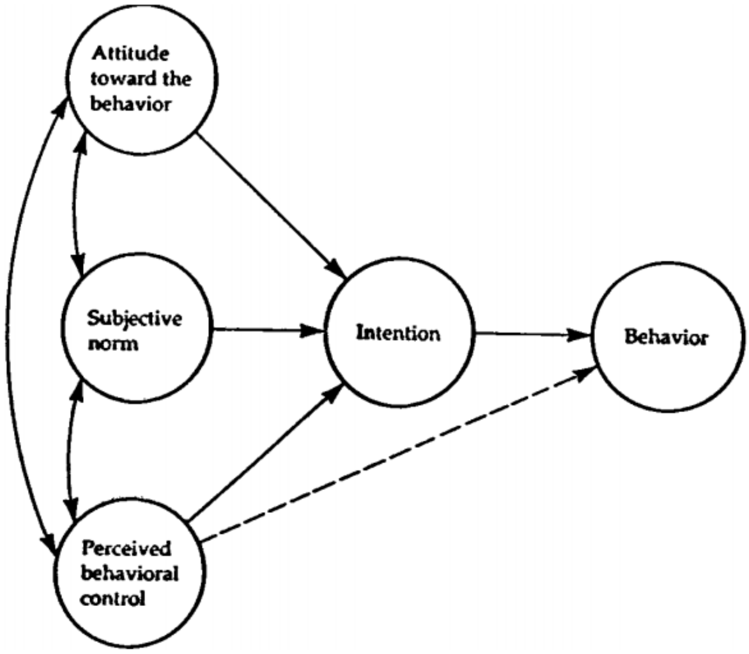


Figure 109 planned behaviour (Ajzen, 1991)

8.2.1 Attitude toward the behaviour

The attitude toward the behaviour is an indication to show how the individual is motivated, ready and willing to accept trying a behaviour (Ajzen and Driver, 1992). Armitage and Conner (2001) point out that the more the attitudes toward a behaviour is, the more likely the individual will perform the behaviour.

Smith (2013) divided the attitude into an affective attitude and instrumental attitude. The affective attitude is the individual's belief if the attitude is enjoyable or not. Furthermore, the instrumental attitude could be defined as if the behaviour is beneficial or harmful.

8.2.2 Subjective norms

The subjective norms indicate the social pressure to perform or not to perform a behaviour (Ajzen and Driver, 1992). Deriling (2015) added that the subjective norms could be non-human factors that surround the individual such as the cost, regulation and others that could influence the decision. Moreover, nowadays, the people’s opinion is mostly provided with every product, for example, the product review section.

Smith (2013) divided the subjective norms into injunctive and descriptive norms. The injunctive norms refer to if others are motivating the individual to do the behaviour or not. While descriptive norms refer to if the others are doing the same behaviour or not.

8.2.3 Perceived behaviour control

Perceived behavioural control refers to people's awareness of the ease or difficulty of performing the behaviour and if there is any past experience that could influence doing the behaviour (Ajzen, 1991, Ajzen and Driver, 1992). In addition, perceived behaviour can vary across situations and actions. Moreover, different investigations agreed that people’s behaviour is strongly influenced by their confidence to perform. Furthermore, Armitage and Conner (2001) added that, if the individuals believe that they could achieve a behaviour, they are more likely to intend the behaviour.

According to the theory of planned behaviour two factors affect the people’s behaviour achievement. The first factor is the confidence to act the behaviour that has a strong effect on behaviour achievement. In other words, if two persons are acting the same behaviour, the one that is more self-confident will have better results than the other. The second factor is the people’s knowledge about the behaviour i.e. what do they know about the behaviour?

According to Ajzen (1991), the intention and perceived behaviour are joint functions that help to predict behaviour. Furthermore, according to the theory of planned behaviour, two factors must be considered to have an accurate behaviour prediction. Firstly, the behaviour needs to be specified and clear. For example, the behaviour needs to be that Jeddah house residents will use the Manwaar as a passive ventilation element. It is clear that the passive ventilation element that the participant wants to use is the Manwaar and not another element. Secondly, to have more accurate predictions, it is important while predicting behaviour that the surrounding context and the people's conditions do not massively change. However, it is important to mention that the past behaviour or experience could have an impact of predicting the new behaviour but it does not mean that it will have similar outcomes because the surrounding conditions may change. Consequently, the behaviour is expected to change (Ajzen, 1991).

8.2.4 Intention

The intentions could be defined as the motivation factors that impact a person's behaviour. The intention shows to what extent people are willing to try in order to perform a behaviour. in other words, "the stronger the intention to engage in a behaviour, the more likely should be its performance" (Ajzen, 1991). Figure 109 shows that the attitude, subjective norms and perceived behaviour are the three factors that could help to shape and predict people's intentions.

8.3 Application of the theory of planned behaviour

This section will be the application of the theory of planned behaviour on the research finding. The section will be divided into the participants of Jeddah house resident attitude, Residents subjective norms, the residents perceived behavioural control and intention.

8.3.1 Attitudes

Jeddah house residents that were participants in the questionnaire and interview agreed that recently, the majority of Jeddah contemporary houses have been built to entirely depend on using different air conditioning solutions because it is the fastest solution to provide indoor thermal comfort in all the different spaces. The findings reveal that using the passive ventilation systems (alone or combining them with air conditioning) have different effects toward having better spatial organization, better social interaction and saving power.

The questionnaire findings show a significant relation between the house residents depending on air conditioning and the building age. In more detail, 5% of the residential buildings that were built 20+ years ago depend on air conditioning. On the other hand, 41% of the contemporary buildings depend on air conditioning as shown in Figure 89. This might be because the old buildings have different spatial organization and depend less on air conditioning than the contemporary ones (see chapter 5 for more details). Interviewee MBB stated, "if you went back in time and gave the traditional house residents air conditioning, they will close the Manwaar and all the other elements". As a result, using air conditioning has affected the spatial organization through massively reducing the need and use of most of the passive ventilation elements. On the other hand, other participants such as interviewees AMB, HOT and others agreed that, "using the passive ventilation system and elements will help to better utilise the spatial organization" and "better eye contact between the house residents".

Nearly 80% of the interviewees agreed that after using the air conditioner, the location of the different rooms was not a concern for them. Interviewee ISK stated, “The house I took, the kitchen is in the centre of the house, and it is open from two sides”. On the other hand, after conducting the second stage of interviewees and showing the interviewees the effect of the different passive ventilation elements on the space, most of the interviewees were concerned about the location of the different rooms and believed that the use of passive ventilation could help to better utilize the space and reduce the waste area in the house. Interviewee AMB mentioned that “changing the Manwaar location and combining it with the daily common room would help to have eye contact, better airflow and give the residents more intention to interact in the daily common room or the Manwaar”. In addition, interviewee YQR mentioned that using the passive ventilation elements, specifically the double façade wall, will be useful for him to change the location and view of the different rooms.

Importantly, one third of the participants in both stages of interviews pointed out that the living or common room should have good airflow. In other words, in the gathering rooms, the participants prefer natural ventilation instead of using air conditioning. Interviewee AAM stressed that “the house residents prefer to meet in spaces that have good airflow”, such as the courtyard. This reason affirms that, although there is a dependency on using air conditioning, the residents require natural ventilation in the common room. Thus, it is important to apply changes to the spatial organization when using passive ventilation elements to enhance the family social interaction.

The quantitative data reveals that 62.3% of the participants are willing to benefit from the outdoor weather at different times of the year. Moreover, Jeddah house resident's interviewees believe that it is better to combine air conditioning with the passive ventilation systems to use at different times of the year. As a result, this will help to reduce power consumption and lighting. However, the participants agreed that to reduce power consumption, it is important to benefit from the outdoor microclimate. For example, architect TSQ highlighted, "it is important to provide the indoor with fresh air". The fresh air and the indoor air circulation could be provided if the passive ventilation elements were effectively used. Consequently, it is important to design a house that benefits from the outdoor microclimate (Feist et al., 2005, Morrissey et al., 2011). In addition, increasing the residents' awareness of how to benefit from passive ventilation solutions at different times of the year as interviewee ABG, mentioned, "using the passive ventilation element helps to save money at different times of the year".

8.3.2 Subjective norms

This subsection will discuss the human and non-human subjective norms that create social pressure on the individual that could affect the individual intention to use the passive ventilation systems.

8.3.2.1 The municipality requirements (non-human)

Most of the architects and one-third of the general interview's participants in both stages agreed that the main factor that creates pressure and affects their designing decisions is the different municipality building regulations. For example, the architects agreed that not building more than 60% of the lot could negatively affect the building design and size especially in the smaller lots. In addition, the interview data revealed that the general Jeddah house residents care more about having a high number of private rooms and a big area for the public and private rooms. As a result, it might be not possible to use some of the passive ventilation elements because they might occupy more of the building area.

Another municipality requirement is to have a Manwaar in most of the residential buildings in Jeddah city. The Jeddah municipality required the Manwaar to ventilate and provide lighting in different spots of the house (Jeddah Municipality, 2018). Inappropriately, the municipality also required that the minimum size of the Manwaar is 1.5M by 1M. Interestingly, the majority of the participants (architects and house residents) agreed that they incorporate this Manwaar just because it is a requirement from the municipality but without any function. Moreover, Jeddah house residents consider it as a waste area. Thus, architect AQD and others mentioned they use it for piping, exhausting the bad smells and storing the air conditioner compressors to exhaust the hot air. As a result, they are locating the service room's window toward it. In addition, architect TSQ mentioned, "Frankly speaking, we are using the Manwaar because it is a requirement from the Municipality, but we are not thinking how to benefit from it". This might show a lack of awareness from the house designer and residents because they are not fully benefiting from it.

Another requirement from the municipality that affects the contemporary house orientation is having a setback from all the sides of the house. As a result, nowadays, most of the contemporary houses are outdoor oriented mainly because of having the setback surrounding the house (Alharbi, 1989, Al-Kodmany, 1999). Although having an outdoor oriented house could meet the resident's requirement of living in a modern house, having the setback surrounding the house affects the need and use of the passive ventilation elements. Furthermore, this regulation led to consuming more power in cooling the house because it led to having more elevations observing the solar heat.

Nowadays, although Jeddah municipality requires reflecting the traditional theme in Jeddah contemporary buildings (Jeddah Municipality, 2018), unfortunately, most of the reflection of the traditional theme is aesthetic without any function. According to interviewee AAM, "I can use the Mashrabiyyah if the municipality requires", but, as interviewee AAM added, most of the architects are reflecting the traditional theme aesthetically without any function. In other words, the reflection of the local theme on the residential buildings is aesthetical without any function or effect on the spatial organization i.e. adding an aesthetic layer to the current contemporary residential buildings. As a result, the traditional passive ventilation elements are not functioning in the contemporary residential building and are replaced with air conditioning.

8.3.2.2 social status (human)

One of the most important factors that affects the individual subjective norm is reflecting the social status. Moreover, reflecting the social status could also affect the individual understanding and way of how to dwell in their houses.

According to interviewee AAS, "The most important thing is that the rooms are big". Also, Interviewee HOT mentioned that, "one of the most important things in the house is to have a big welcoming entrance". Finally, interviewee SAS points out that, "In my house, half of the ground floor is a visitor room, dining room and toilets" these interviewees were mainly focusing on reflecting their social status by having often used areas in their house. For example, although interviewee SAS has half of the ground floor for visitors', he stressed that "The visitors might visit me 2 to 4 times a year" and he was wondering "why we live in a 500m2 house while a 100m2 house is enough". The quantitative data reveals that 44% of the responses of Jeddah house residents made changes to their houses after they had lived in it and 25% are intending to make changes in the spatial organization and room size in the future. On the other hand, other interviewees are more aware, especially after they lived in their houses, and started to correct their misunderstandings. For example, interviewee AMB stated that, "we are concerned about the visitors and give them a big space in the house and from the family entertainment that we might use daily", and interviewee YQR stated that, "most of the built area is used in the bedroom instead of using it to have gathering areas". To confirm this the questionnaire outcomes reveal a significant relation between the building age and the need to make changes in the building in general and the need to make more practical changes to the visitor's room, dining room and storage room.

8.3.2.3 the architects (human)

The space in a building is designed by an architect and accepted and used by its residents (Singh et al., 2009). Thus, the architect designs the spaces based on their experience, the municipality requirements, how the residents might use it, how they might move in the space and what elements they expect to find there (Serageldin, 1979). Moreover, some architects might restrict the residents to use the space in a certain way and furnish it with special furniture (Bloomer and Moore, 1979). Therefore, the architect could affect the individual subjective norms by their design of the house and their advice of what indoor thermal comfort solution the house residents must use in the house.

The questionnaire findings highlighted that many of the participants are not dwelling in their houses and are making changes in their houses to have better dwelling for example, 22% have changed the room size , 36% have changed the room functions and 42% added new technology. The findings show that the architect can help to provide a better residential building that benefits from the Jeddah microclimate and provide the residents with their needs. For example, interviewee AAS emphasised and mentioned that he believes that he has a better house because his architect advised him to reduce the room numbers required in order to have bigger rooms, especially in the family room. In addition, his architect also advised him to apply some solutions in the setback that helped him to benefit from the setback and outdoor weather. Therefore, it is important for the residents not to create pressure and to explain their need to the architect and to be flexible in their requirements in order to have a better house design. Furthermore, clarifying the resident’s needs are highly expected to reduce the building cost and to provide a dwelling for the house residents that reflects their needs. On the other hand, the architects must advise and motivate the residents and increase their awareness of how to dwell in their houses and how to use the passive ventilation systems.

The questionnaire and both interview stages findings agreed that the architects are not really designing Jeddah residential buildings to benefit from the Jeddah microclimate. In more detail, the orientation of the house, the distribution of the windows, the size of the windows, using passive ventilation elements and others are not well considered while designing the house. Architect AQD gave a number of reasons for not designing a house that benefits from the Jeddah microclimate which are the municipality building regulations and the requirements of the high number of rooms with big areas in a limited building area. Therefore, architect AQD mentioned that it is easier to use air conditioning than the passive ventilation elements in the small building area to meet the client's requirements. In other words, the architect might be aware of how to provide an acceptable residential building, but the house residents might have requirements that limit the architect from being creative.

In Jeddah city, the architects who design the residential buildings are designing them either for investment companies, a high number of houses with a similar design, or for individuals. Interviewee, AAS and others point out that, "The people are now buying ready-built houses, they are searching for the best thing that fits them, but the others who are designing their house have a better chance to design a house that reflects their needs and lifestyle." In other words, most of the residential buildings on the Jeddah market do not fit the resident's requirements, but the architects and the investors are designing them based on their understanding of what the residents might need and, obviously, what makes them more profit. Interviewee GDG stressed, "The investors are copying each other's projects as long as they are selling the houses without asking if this is what the residents want." As a result, the questionnaire shows that the majority of the house residents apply changes in their houses to adapt their way of dwelling after they have lived in it. Therefore, the house residents who design their houses have a better chance of having a dwelling to live in.

8.3.3 Perceived behavioural control

8.3.3.1 past experience by others

The passive ventilation system was used in Jeddah traditional houses and in some of Jeddah's contemporary houses (see Chapter 5 for more details). According to interviewee ASR, the idea of having cross ventilation is, "to have cross ventilation from the North side of the house to the South side". Therefore, the houses were oriented toward the North or West. In addition, the house's biggest window and main rooms were facing the North or West side to give access to the incoming positive airflow and exhaust this negative airflow and odours from the South side. As a result, the spatial organization in the traditional houses locates the service rooms' windows facing the South side elevation to exhaust the odours.

8.3.3.2 passive ventilation benefits

Using the passive ventilation elements or combining them with air conditioning will help to design a house that advantages from the Jeddah microclimate and reorganizes the different indoor spaces (Feist et al., 2005, Morrissey et al., 2011). Consequently, as most of the interviewees mentioned, the expected changes in the spatial organization are highly expected to enhance the resident's social interaction. In addition, Hughes et al. (2012) Karava et al. (2012) and others show evidence that combining the passive ventilation elements with the air conditioning will reduce the power consumption by nearly 30% in the residential buildings.

8.3.3.3 experience how it works

Currently, there might not be effective alternatives for the house residents that provide them with thermal comfort if the air conditioner stopped working. In addition, there might be a lack of knowledge of how to benefit from the available passive ventilation solutions. Interviewee TAN mentioned that he might leave the house and stay in a hotel if the air conditioning stopped working. Another example is what interviewee SAS mentioned, "The problem is that we have the Manwaar in the centre of the house, from where can I ventilate it?". Moreover, interviewee AAT mentioned that while he was building his house, "My brother recommended to me to have one big window from end to end. I told him that the sun would be too strong. Also, there will not be any privacy, and the air conditioning will be always on and if the air conditioning stops then you cannot use the room". On the other hand, there might be an effective passive solution, but the lack of how to use them might limit their function. Interviewee MBB highlighted that, "When I built my house before I installed the windows, there was a nice airflow in the house. Nevertheless, after the windows and curtains are installed, we are not opening the windows in order not to have dust in the house. So, we missed the nice airflow".

8.3.3.4 confident to use passive ventilation

The interviews with Jeddah house residents were exploring if they were comfortable to use the three popular passive ventilation elements inspired by Jeddah traditional houses in their contemporary houses which are the courtyard, Manwaar and Mashrabiyyah.

Two main conditions of accepting the use of these elements were pointed out. Interviewee AMB and others agreed on the first condition which is, "these elements are better to be used, but in a contemporary way". The other condition is that the passive ventilation elements need to be secure especially to prevent, "the animals such as cats or rats so they could not come into the house through them".

Courtyard

Interviewee ALH pointed out that besides the courtyard thermal and environmental performance it, "provides a good view and an enjoyable space". In more detail, it provides a private indoor spot for the house residents to interact in. In addition, interviewee AAT supported interviewee ALH's opinion and added, "You are sitting in the house beside the courtyard having lunch, you have indirect lights that lights all of the spaces in the house". On the other hand, although some of the interviewees were unconvinced with the idea of having a courtyard, they changed their mind after they saw contemporary solutions for the courtyard and they were more comfortable to apply the idea in their houses.

Manwaar

The Manwaar is still used in contemporary houses because it is required by Jeddah municipality. Unfortunately, its use in the contemporary houses is different from its use in the traditional houses mainly because of its location and size.

Some of the interviewees such as AML, WAY, SAB and others agreed that if the Manwaar’s location could be changed and combined with the family daily used rooms it would be much more functional. Because, as the interviewee's highlight, it will provide better indoor ventilation and a better view. Consequently, the interviewees show a high intention that if the Manwaar was modified, they might change the location of the living room and the bedroom from facing the setback or the street to facing the Manwaar. Also, they might change the location of the service rooms from viewing the Manwaar to viewing the street.

Moreover, some of the interviewees suggested some modifications, such as removing the piping and the air conditioner compressors from the Manwaar. Interestingly, another suggestion was to add shutters on top of it in order to control the incoming airflow and to protect it from dust, insects and animals.

Mashrabiyyah

The Mashrabiyyah helps to control the incoming airflow and provide privacy for its user as interviewee HOT highlighted, “I can call the kids from the yard without being seen. It can also provide me with the shade.” However, because of the limited designs of the Mashrabiyyah, its application is limited. The most similar contemporary solution to the Mashrabiyyah could be the double façade wall, see Figure 110.

Suddenly, one of the interviewees did not accept having a double façade in their house because, as they claimed, it could be a place for a lot of dust and insects. On the other hand, the majority of the participants accept using the double façade solution more than the Mashrabiyyah. Nevertheless, using the double façade (as one of the passive ventilation elements) could change the use and size of the window behind it which might result in having better airflow and more natural lighting. Moreover, interviewee YQR mentioned that if he used the double façade wall, he could change the location of the living room from one of the side elevations to be in the main elevation. Using the double façade in the house could have two extra benefits than the other passive ventilation solutions. The first benefit is that it could be used in all the elevations of the house. The second benefit is that it could be one of the best solutions for Jeddah houses that have its main elevation in the southern side.

Figure 110 traditional Mashrabiyyah (left) double façade (right)

8.3.4 intention

The attitude, subjective norms and perceived behaviour control are the three predictor variables that help to shape individual intentions and to predict if the individual will apply the behaviour or not. Figure 111 shows the three predictor variables with the different themes under each variable. In addition, an example statement from the interviewees. The different predictor variables help to clarify the individual intention of using the passive ventilation system (alone or combining it with the air conditioning).

The participant's attitude toward using the passive ventilation system and elements are extremely positive. The positive attitude is because using the passive ventilation system will help to have better spatial utilization and reduce the waste area in the house. Another reason is that the passive ventilation system will help to provide the indoor with thermal comfort and fresh air. Finally, the participants believe that combining the passive ventilation system with air conditioning will help to reduce the power consumption at different times of the year.

The subjective norms come from different human and non-human factors that create social pressure on the individual that affects their intention toward using the passive ventilation system. Although the municipality building regulations required the Jeddah Higazy style to be reflected on the residential building, the reflection is mainly aesthetic without any functions from using the elements. Another municipality regulation that affects the individual decision of using the passive ventilation system is requiring building only 60% of the residential lot. In addition, is the requirement of having a Manwaar inside the building and a setback surrounding it. Although the individuals show the intention to use the passive ventilation system, the building regulation limits them from using and benefiting from the passive ventilation and its elements.

Moreover, there are a number of human factors that affect the individual intention toward using the passive ventilation system. The first factor is having a waste area to reflect the social status of the residents that have passive ventilation elements in the different residential buildings. The second factor requires the house residents to be flexible in their requirements while discussing the house design with the architect. Thus, this will help the architect to be more creative in their designs and to advantage from the outdoor microclimate. On the other hand, the architect must advise their client how to best benefit and dwell in their residential building. Finally, the house residents that have the chance to personalise their residential building design have better opportunities to use the passive ventilation system and elements than the house residents that buy ready built houses.

The perceived behavioural control shows Jeddah house residents' knowledge and confidence in the use of the passive ventilation system. Jeddah house residents, to a high extent, have past experience of using the passive ventilation system and elements in their traditional houses and some of their contemporary houses. Moreover, using the passive ventilation system in contemporary houses will help to design houses that function in conjunction with the Jeddah microclimate, have better spatial organization and consume less power.

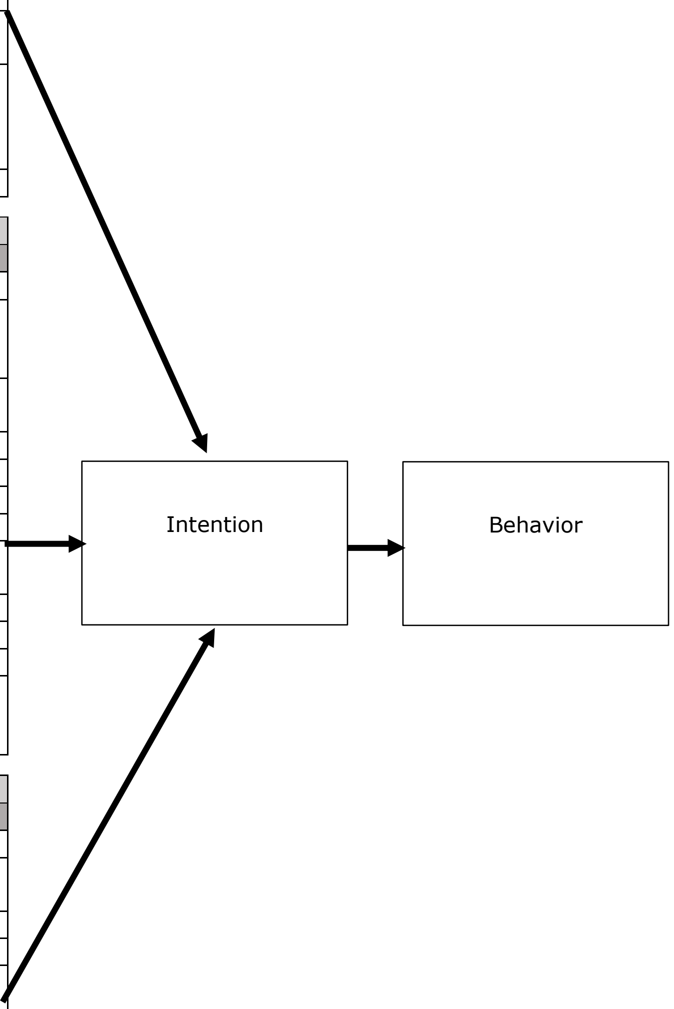
Furthermore, although the research data shows that there was a lack of knowledge of how the passive ventilation system works and how to benefit from its elements, the data also shows that there is an increase in Jeddah house residents' knowledge of how passive ventilation works. Additionally, nowadays, the residents are more aware of how to benefit from the existing passive ventilation elements such as the windows and Manwaar.

Finally, although there are a number of conditions that the participants require to use the passive ventilation system and elements, the findings show high confidence in the use of the different passive ventilation elements in the contemporary houses.

Attitude	
Theme	**Example of a statement from the interviewees**
It is good	"It is very good to have such an area on the ground floor"
	"The rooms surrounding the courtyard have access only through it"
	"The Manwaar could be used as a wind-catcher if you have it in the living room. Because it will link the house from top to bottom and can ventilate the house."
Better utilise the spatial organization	"You are setting in the house beside the courtyard having lunch, you have indirect lights"
	"the courtyard and Manwaar provide three things that make a difference in the space which is the lighting the planting and the water"
	"The Manwaer could be modified and used in ventilation. If it is modified and cleaned and has some plantings. I could open my window on it instead of having my window on the street. Besides, it is shaded for most of the day and allows natural lighting. I think if we improve it will be more accepted"
Power saving	"it is important to provide the indoor with fresh air"
	"using the passive ventilation element helps to save money at different times of the year".

Subjective norms	
Theme	**Example of a statement from the interviewees**
The municipality requirements	"The municipality also required that the minimum size of the Manwaar is 1.5M by 1M"
	"The site will be $200m^2$ or $250m^2$, and the building area is, for example, 50% or a maximum 60%. Then you need to have a guard room and a car parking. This will result that you won't have enough area for the passive ventilation elements"
	"Frankly speaking, we are using the Manwaar because it is a requirement from the Municipality, but we are not thinking how to benefit from it"
	"I can use the Mashrabiyyah if the municipality requires"
Social statues	"The most important thing is that the rooms are big".
	"one of the most important things in the house is to have a big welcoming entrance".
	"In my house, half of the ground floor is a visitor room, dining room and toilets"
	"We are concerned about the visitors and give them a big space in the house and from the family entertainment that we might use daily"
	"most of the built area is used in the bedroom instead of using it to have gathering areas".
The architects	"the person how designed this house does not know our required" "
	"The residents were not really thinking about the weather when they were designing their houses"
	"The people are now buying ready-built houses, they are searching for the best thing that fits them, but the others who are designing their house have a better chance to design a house that reflects their needs and lifestyle."

Perceived behavioural control	
Theme	**Example of a statement from the interviewees**
Past experience by other	"to have cross ventilation from the North side of the house to the South side"
	"the courtyard provides me with good weather, therefore I and my family are staying in it regularly. Even some of the visitors I meet them in the courtyard"
Experience how it works	"If the air conditioning stops working, we will open the windows. We can use a manual fan, or I leave the house"
	"The problem is that we have the Manwaar in the centre of the house, from where I can ventilate it?"
	"When I built my house before I installed the windows, there was a nice airflow in the house. Nevertheless, after the windows and curtains are installed, we are not opening the windows in order not to have dust in the house. So, we missed the nice airflow".



Confident to use passive ventilation	“these elements are better to be used, but in a contemporary way”
	“If we can change its place and integrate it with daily use areas”
	“if I had known about the double façade wall, I would use it because it will help me to have bigger openings and allow more indoor airflow. Also, it will help me to have a better living room that views the double façade from one side and the courtyard from the other side”

Figure 111 the three predictors that will help to predict Jeddah house residents will use the passive ventilation system

8.4 Recommendations

The researcher tried to reflect on how combining the passive ventilation system with air conditioning could affect the spatial organization and the house resident's social interaction. The researcher used the Alfaridah case study because it is an existing building that was built based on Jeddah municipality building regulations (see section 5.3.3 Contemporary case study for more details). Also, to a high extent, it is one of the most bolder prototype designs in Jeddah city (Konooze.com, 2016, kinan.com.sa, 2016). Moreover, it was important not to make massive changes in the footprint of the building to ensure the municipality building regulations were adhered to. However, the minor changes on the footprint also follow the building regulations based on the researcher's experience. The reason for having different proposals is to explore how combining a different set of passive ventilation elements with the air conditioning could differently affect the spatial organization and the house resident's social interaction.

The two suggested proposal designs need further investigation and testing to discuss in depth their advantages and disadvantages. Thus, the investigations and testing could be, at first, with the local architects to explore their effectiveness in terms of their spatial organization, social impact, thermal performance and if they are passively designed to benefit from Jeddah's microclimate. Following that, a set of guidelines and regulations of how to apply the passive ventilation system or some of its elements in the contemporary residential buildings need to be provided to the local authorities, such as Jeddah municipality and the ministry of housing, to approve it and include it within the building regulations.

This section has two subsections that show the two different design proposals. The first proposal is called 'the breathing design' and the second proposal is called 'the airwave design'.

8.4.1 The breathing design

This proposal mainly depends on using the courtyard as a passive ventilation element. The idea is to feed the house with the incoming airflow from the centre of the house through the courtyard and to exhaust the air through the air ducts and the windows (see Appendix 7 for full drawings)

8.4.1.1 The spatial organization

Adding the courtyard in this proposal affects the spatial organization of the different spaces and the room orientations. Figure 112 and Figure 113 shows that after applying this proposal to the Alfaridah house case study the rooms are more indoor oriented, i.e. have an indoor view. Furthermore, Figure 112 shows that nearly one-third of the ground floor is public zones and has mainly indoor views to the courtyard. In addition, the living room on the ground floor is at the centre of the house. Unlike the original design that locates the living room mainly on the first floor, the public and semi-public areas in this design proposal are more flexible to being combined together. The flexibility of combining the different rooms could help the house residents to change the room use based on their needs. Moreover, the semi-public area on the first floor is at the centre of the house and all the private rooms have access through it.

Moreover, besides the outdoor view, using the courtyard led to the living rooms in the ground and the first floor having a better indoor view and more natural air and lighting. Finally, although the footprint of the proposal is similar to the footprint of the case study, using the passive ventilation element led to reorganizing the different spaces on the first floor and led to having more rooms. In other words, using the courtyard with air ducts led to having an extra bedroom.

Figure 112 breathing design proposal ground floor (Author, 2018)

Figure 113 breathing design proposal first floor (Author, 2018)

8.4.1.2 The passive ventilation system

The courtyard, Manwaar and the windows are the main set of passive ventilation elements used in this proposal. Using these elements led to having more indoor openings between the different rooms (see Figure 112 and Figure 113).

Besides using air conditioning in the different rooms, the section in Figure 114 shows that the different spaces in the house are ventilated through the courtyard (in the centre of the house) and the windows (on the Northern elevation). Equally, the indoor air is exhausted through the air ducts and the windows.

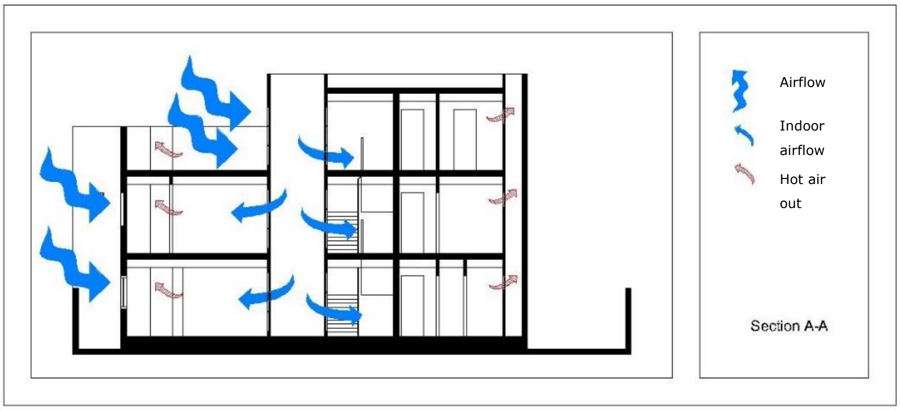


Figure 114 breathing design proposal section A-A (Author, 2018)

8.4.2 The airwave design

Using the double façade walls is the main passive ventilation element used in this proposal design besides the windows and the Manwaar. The double façade wall is added on the Northern and Western side of the house to face the incoming airflow. The incoming airflow is expected to wave through the different spaces and exhaust from the Manwaar and the windows (see Appendix 8 for full drawings).

8.4.2.1 The spatial organization

Using the double façade affects mainly the first floor because the setback walls surrounding the ground floor affects the incoming airflow quality (see Figure 115). As a result, apart from having a Manwaar in the centre of the staircase, there were not many changes to the ground floor spatial organization.

On the other hand, the spatial organization on the first floor changed such as the orientation of the different rooms, i.e. the living room and bedroom have mainly an outdoor view (see Figure 116). Additionally, combining the passive ventilation system and air conditioning led to organizing the different privacy zones, i.e. having the private zone on one side of the house and the semi-public zone on the other side. Moreover, the semi-public area size on the first floor is nearly one-third of the floor area. In addition, although the living room is not between the public and private area, it has a bigger size and prime location facing the main street. Unfortunately, not having the semi-public area between the public and private areas could, to some extent, affect the family social interaction because although the residents have the chance to view who is in the living room, some of the residents might prefer to go directly to their private room without passing through the living room. Nevertheless, having the living room in a prime location with high-quality air ventilation and an outdoor view could encourage the house residents to interact in it.

Figure 115 airwave design proposal ground floor (Author, 2018)

Figure 116 airwave design proposal first floor (Author, 2018)

8.4.2.2 The passive ventilation system

The double façade wall, the windows and the Manwaar are the main set of passive ventilation elements used in this proposal. Figure 117 shows that the double façade wall is used in the Northern and Western side of the house to face the cold incoming airflow. As a result, using the double façade led to having bigger openings behind it. Also, the double façade wall provides shade and privacy for the opening behind it. Excitingly, the double façade wall could be a modified version of the Mashrabiyyah. Furthermore, although the openings between the different indoor spaces are fewer in this proposal, having big openings in most of the rooms led to having airwaves in nearly all the different spaces in the house (see Figure 117).

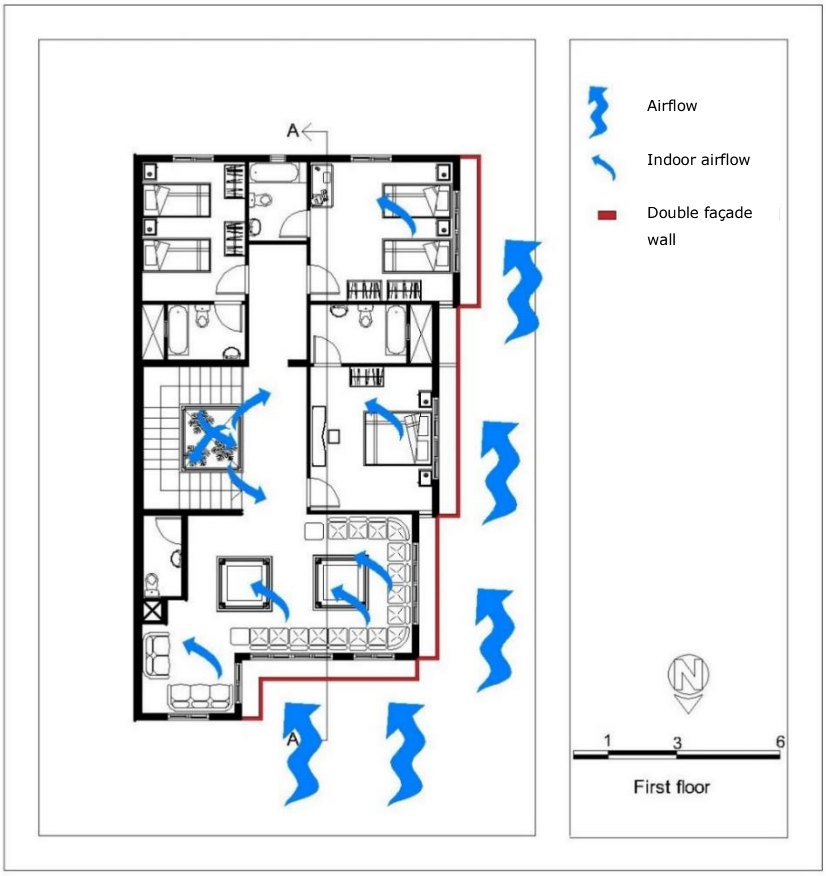


Figure 117 airwave design proposal first floor (Author, 2018)

The section in Figure 118 shows that the two indoor air providers are the openings behind the double façade and the Manwaar. In addition, the air is exhausting mainly from the air ducts and the smaller openings.

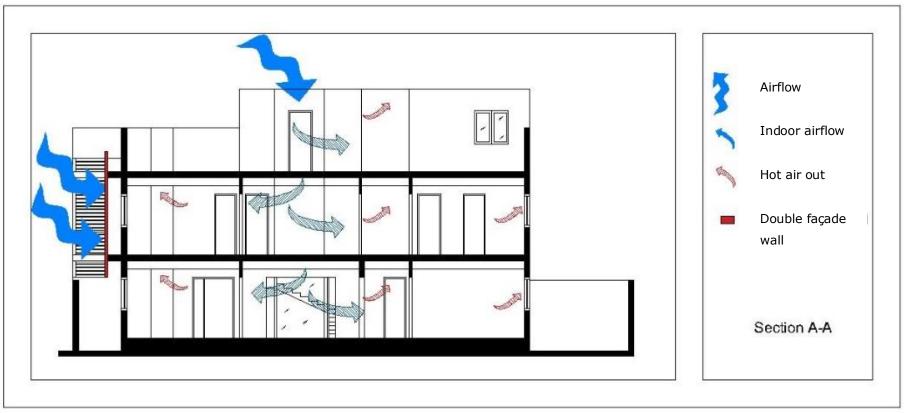


Figure 118 airwave design proposal section (A-A) (Author, 2018)

8.5 Conclusion

Based on the theory of planned behaviour, Jeddah house residents' intentions toward using the passive ventilation system are, to some extent, weak because of the many municipality building regulations requirements. On the other hand, because the individual's attitude and perceived behavioural control are highly positive, the intentions toward using the passive ventilation system alone or combining it with air conditioning are also highly positive. In other words, it is very much expected that the research participants will use the different passive ventilation systems in their contemporary residential buildings.

The different passive ventilation systems affect the spatial organization differently because they do not depend on one element but are a set of elements working together. Additionally, using passive ventilation elements in contemporary Jeddah houses could help to reorganize the different spaces in the house. Consequently, these changes could help to reduce having waste areas, save power and enhance the family social interaction because they provide private areas for the family to meet in, good natural airflow and lighting and an enjoyable area in the house. In other words, it could provide a dwelling for Jeddah house residents.

Chapter 9 Conclusion

9.1 Conclusion

To the best of the researcher's knowledge, this research made a new and original contribution to the existing knowledge by demonstrating that there is a link between the spatial organization, the resident's social interaction and air conditioning and passive ventilation systems used in the house by exploring them. In addition, how the link between the three areas could lead to reflecting the house residents' identities, improve quality of living and reduce power consumption in the house. Finally, identifying links between the three research areas with a view to making improvements not only in Jeddah city, but elsewhere in Saudi Arabia and possibly worldwide.

A review of the literature revealed that there was a lack of evidence linking the three research areas. In addition, there was further limited evidence regarding how the link between the cause and effect of the air conditioning or passive ventilation systems used in the house and the house resident's social interaction. In other words, how a house as a technical space is connected to a house as a social space. In more detail, if the spatial organization is changed, it will affect the air conditioning or passive ventilation systems used in the house and the family social interaction. On the other hand, if the environmental technology or systems used in the house is changed, it will mainly have an effect on the spatial organization and consequently on the resident's social interaction. Nonetheless, the effect of the air conditioning or passive ventilation systems on the house resident's social life could be through the spatial organization (see Figure 2). Thus, the aim of the research was to explore the link between the three research areas through combining the passive ventilation systems with the air conditioning and how this combination could affect the spatial organization and the house resident’s social interaction. In addition, to ascertain to what extent Jeddah house residents could accept using the passive ventilation system.

One of the main differences between Jeddah traditional houses and Jeddah contemporary houses is the replacement of the passive ventilation system with air conditioning. Besides that, the urban design of the city and the building regulations are other factors that had a massive impact on Jeddah building typology through time. These factors changed the house design from indoor-oriented to outdoor oriented. In contemporary Jeddah houses, being dependent on air conditioning led not to use the different sets of the passive ventilation elements. As a result, not having the passive ventilation elements affected the spatial organization, the location of the different rooms and their views. Consequently, the house resident’s social interaction was affected. Furthermore, although the different aged residential buildings in Jeddah have the same three privacy zones, the mass of these zones, their locations and the different focal points has changed.

The quantitative finding revealed that, in Jeddah contemporary residential buildings, air conditioning is the main technology that must be available in all the rooms at different times of the day. In addition, the findings confirm the link between the three research areas and how changing to using air conditioning affects the other two areas. Yet, using the air conditioning led to discarding some of the spaces and having fewer functional passive ventilation elements. Furthermore, the quantitative findings also reveal that having air conditioning in different rooms helps to have new room functions and different multi-function rooms. In addition, besides being dependent on air conditioning, importing western designs (architectural factor) and the change in the number of family members (social factor) also affected the three research areas. Finally, the finding shows that there is an acceptance of using the different passive ventilation systems.

The qualitative data revealed that Jeddah contemporary residential buildings are not designed to benefit from Jeddah's microclimate because of being dependent on air conditioning. Consequently, to a high extent, none of the available passive ventilation elements function well. In addition, although the air conditioning provided extra area for the house residents, it led to dispensing with some of the passive ventilation elements. Furthermore, not having the passive ventilation elements inspired from Jeddah traditional houses led to not having eye contact between the different house residents in the different spaces and not having enjoyable interaction areas alongside their function as ventilation elements. Likewise, it affected the house resident's privacy.

Moreover, the qualitative data also revealed that it is important to increase the house resident's knowledge of how to use and benefit from the passive ventilation systems and their effect on the spatial organization, the family social interaction and power consumption. Finally, the qualitative findings show high acceptance to combine the passive ventilation systems with air conditioning but with different conditions. The conditions are mainly to have the passive ventilation elements in a contemporary design to match with the house design and to combine the passive ventilation elements with the daily used rooms.

This study suggested that there is a link between the three research areas of spatial organization, house resident social interaction and the air conditioning and passive ventilation systems used in the house. Furthermore, this study concluded that Jeddah house residents are willing to accept and combine the passive ventilation systems with air conditioning and its effects on the spatial organization. This is in light of individual attitudes, subjective norms and perceived behavioural control factors of the theory of planned behavior.

9.2 limitation

A limitation of this research is that the number of the interview participants is relatively moderate which might impact the generalisation of the qualitative findings. In particular, the number of female participants is lower than the male participants in both interview stages. This is because of the high level of privacy of the Saudi community. However, the interview data provides a rich and in-depth information regarding the participants' perceptions and views. Also, the qualitative data collection method aimed to clarify the range rather than generalise, thus, there is no specific role of the sample size as long as the data is rich to the saturation (as indicated in section 4.6.2).

This research could have utilised physical experimental designs or longitudinal study. However, because the passive ventilation system inspired by Jeddah traditional houses is not commonly used nowadays, it was important to understand the house resident perceptions on reusing the passive ventilation system, whether they could affect the spatial organization and resident social interaction or not. Consequently, an exploratory research including a cross-sectional questionnaire was more appropriate than using another approach. Moreover, while a longitudinal study could have offered better opportunity to explore the changes participants experienced over time and the resulting impact on beliefs about passive ventilation (though it is not widely used), the practical limitations of time also assisted in the decision of this research to conduct a cross-sectional questionnaire study. These limitations are highlighted in the following section for future recommendation.

9.3 future research

The present study lays the groundwork for future research to be carried out by simulating and examining how using the different sets of passive ventilation elements could reduce power consumption of the residential building. In addition, further investigation is required with the architect and house developer to explore how using the different sets of the passive ventilation systems could affect positively or negatively the spatial organization and the resident's social interaction.

Following that, a set of modified building regulations that could help to reach the Saudi vision 2030 by focusing on designing a passive house need to agree from the Saudi Council of Engineers. Subsequently the agreed regulations must be provided to and approved by the local authority, which are Jeddah municipality and the ministry of housing, in order to modify the current building regulations.

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Appendix 1

This Appendix illustrates the questionnaire questions.

<u>Start of the questions</u>

1. How old are you?
    a. 20-30
    b. 31-40
    c. 41-50
    d. 51+
2. What is your gender?
    a. Male
    b. Female
3. What is your education?
    a. High school
    b. Bachelor degree
    c. Masters
    d. Other
4. In which city do you currently live?
    a. Riyadh
    b. Jeddah
    c. Dammam
    d. Other
5. What type of residential unit do you currently live in?
    a. Apartment
    b. Standalone villa
    c. Duplex villa
    d. Roof villa
    e. Others
6. Approximately how old is the building you live in?
    a. Less than 10 years
    b. From 11 to 15 years

    c. From 16 to 20 years
    d. Other
7. Which rooms are most commonly used at home?
    a. Male guest room
    b. Female guest room
    c. Living room
    d. Dining room
    e. Bedroom
    f. Outdoor annex
    g. Courtyard
    h. Kitchen
    i. Bathroom
    j. Storage
    k. Other
8. What are the rooms that can be dispensed with?
    a. Male guest room
    b. Female guest room
    c. Living room
    d. Dining room
    e. Bedroom
    f. Outdoor annex
    g. Courtyard
    h. Kitchen
    i. Bathroom
    j. Storage
    k. Other
9. In your opinion, what is the most important reason for changing the spatial orgnization in the house?
    a. Climate changes
    b. Technology changes
    c. Modernising the house designs
    d. Increase in family members

e. Decrease in family members

10. Do you need to add new rooms to the house?
    a. Yes
    b. No
11. If yes, what rooms have you added to the house?
    a. Male guest room
    b. Female guest room
    c. Living room
    d. Dining room
    e. Bedroom
    f. Storage
    g. Others
12. Did you make any changes to the house?
    a. Yes
    b. No
13. What are the changes you made?
    a. Changing the room function such as from a dining room to a sitting room
    b. Changing the room size
    c. Adding new technology such as the lighting systems
14. What are the rooms you made changes to?
    a. Living room
    b. Dining room
    c. Bedroom
    d. Visitor's room
    e. The kitchen
    f. Others
15. What are the changes you are intending to make?
    a. Changing the room function such as from a dining

room to a sitting room

b. Changing the room size

c. Adding new technology such as the lighting systems

d. Other

16. What are the rooms you are intending to apply changes to?

a. Living room
b. Dining room
c. Bedroom
d. Visitor's room
e. The kitchen
f. Others

17. How many people live in the house?

18. What activities do you do jointly in your home?

a. Drinking tea
b. Playing cards
c. Chatting
d. Reading
e. Studying together
f. TV Watching
g. Playing with the children
h. Meeting visitors
i. Playing computer games such as PlayStation, Xbox, Wii
j. Others

19. In which room/s does the family usually meet?

a. Living room

b. Dining room

c. Visitor’s room
d. Kitchen
e. Bedroom
f. setback
g. The roof
h. Other

20. In which room/s do you prefer to have most of the family activities?
    a. Living room
    b. Dining room
    c. Visitor’s room
    d. Kitchen
    e. Bedroom
    f. setback
    g. The roof
    h. Other

21. In your opinion, what is the most important reason for changing social activities in the house?
    a. Climate changes
    b. Technology changes
    c. Modernizing the house designs
    d. Increase in family members
    e. Decrease in family members
    f. Other

22. Is there a room with a specific function that the family has different social activities in, for example, chatting in

the kitchen or studying in the dining room?

a. Yes
b. No

23. What are these room/s?

a. Living room
b. Dining room
c. Visitor’s room
d. Kitchen
e. Bedroom
f. setback
g. The roof
h. Other

24. What are the multiple activities that happen in these rooms?

a. Drinking tea
b. Playing cards
c. Chatting
d. Reading
e. Studying together
f. Watching TV
g. Playing with the children
h. Others

25. What is the most important technology that must be used in the house?

a. Environmental Systems such as air conditioning
b. Media Technology such as the TV
c. Appliances technology such as the kitchen appliances
d. Other

26. To what extent do you depend on technology in the house?

    a. Do not depend

    b. Neutral

    c. Depend

27. What are the technologies that must be available in the following rooms?

	TV	CCTV	PlayStation	Internet	Computers	Kitchen gadgets	Laundry gadgets	AC	Fan	No need
Living room										
Visitor's room										
The kitchen										
Bedrooms										
Bathrooms										
Dining room										
The roof										
The setback										
Others										

28. Which of the following gadgets you can dispense with in the house?

    a. Mobile phones

    b. TV

    c. CCTV

    d. PlayStation, Xbox, Wii

    e. The internet

    f. Computers

    g. Microwave

    h. The oven

    i. Fan deodorization

    j. Laundry gadgets

    k. Air conditioner

    l. Fan

    m. Cannot dispense with any gadget

n. Other

29. In acceptable outdoor weather such as in winter or spring, could you depend on any alternative to air conditioning such as opening the windows to have fresh air?

a. Yes

b. No

30. Is it possible to rely on artificial lighting only and dispense with natural lighting?

a. Yes

b. No

31. Is it possible to partially dispense with modern kitchen appliances and go back to the traditional ways of preparing food?

a. Yes

b. No

32. What is the best way to gather the family members in one room?

a. Watching TV

b. Playing computers

c. Playing games

d. Chatting

e. Others

33. If you had the opportunity to redesign your house, what would you do differently?

End of the questions

Appendix 2

This appendix illustrates the interview questions and figures.

<u>Start of the questions</u>

1- The following figure (Figure 119) shows a traditional house in Jeddah city that was built nearly 100 years ago and a contemporary house in Jeddah city. As you can see the ground floor is mainly used for the guests and the first floor and the following ones are used for the family. The rooms on the first floor and above are mainly the living rooms, bedrooms and service rooms. It might be clear that the living room is the biggest room on the floor because all the family members socially interacts there and have different activities. Also, it has the biggest window facing the main street to allow the natural airflow in and to build a connection between the indoor and outdoor users which is reflected in the elevation. On the other hand, the spatial organization has been changed in the contemporary house, for example, the living room is much smaller, and it faces one of the side setbacks. Also, the windows are smaller, and are mainly closed all of the time, and the air conditioner is used to control the indoor thermal temperature. These changes led to a decline in the family social interaction and the relation between the indoor and outdoor users. In my research I am assuming that the air conditioner is the reason for these changes and I am discussing if it is possible to use alternative ventilation options that might help to enhance the family social meeting and reorganize the spatial organisation, but let me ask at the beginning,
    a. What other changes have happened to the house designs?

b. How have these changes affected the living patterns of the house residents?

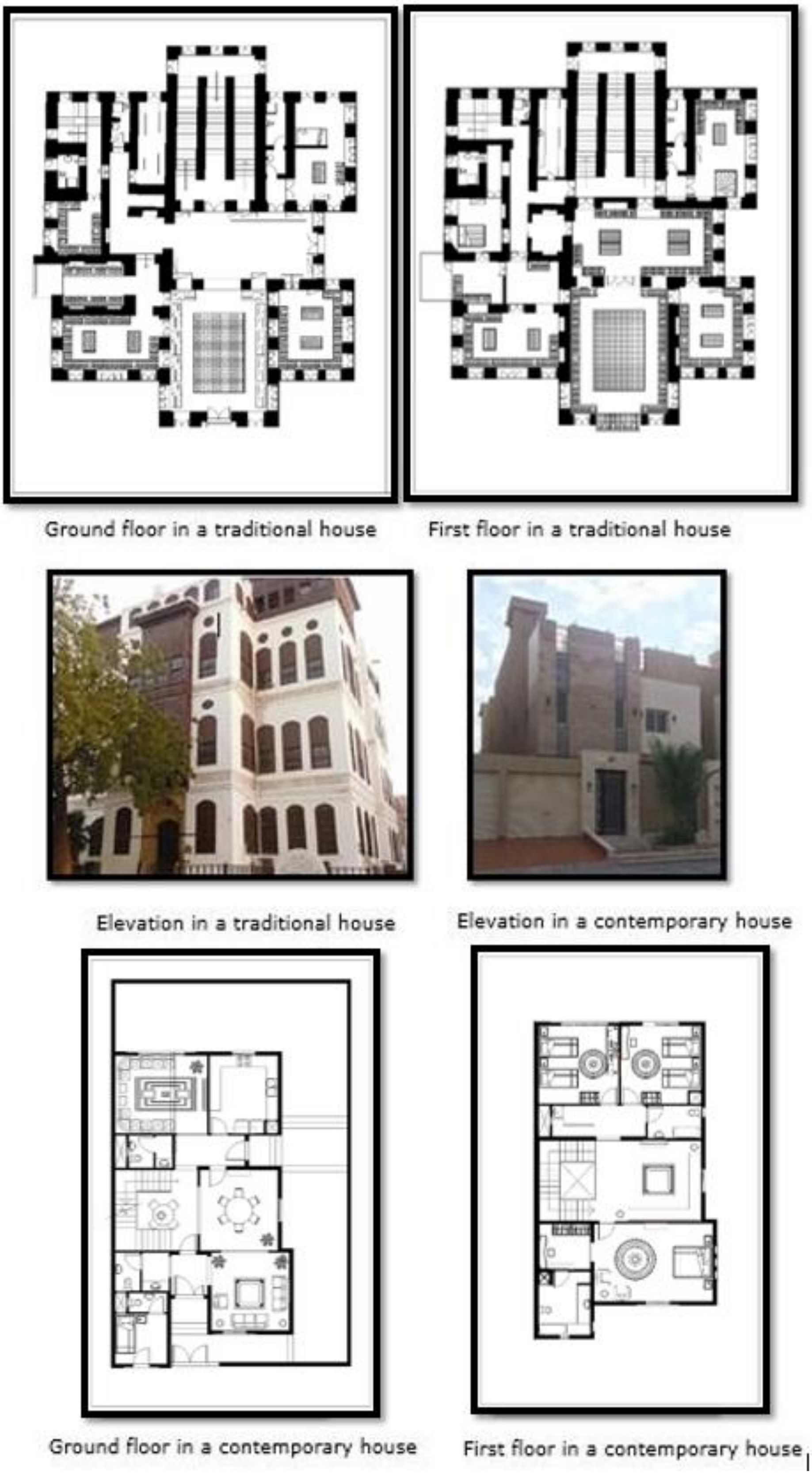

Figure 119 a traditional house and a contemporary house

2- What is the reason that led to not using the traditional spatial organisation such as the room location and size in the contemporary houses? For the following rooms living room, bedroom and kitchen.

3- Figure 120 shows a traditional courtyard, wind catcher, thick walls and a Mashrabiyyah. These elements were the available technology to control the indoor thermal environment and to maintain the resident privacy so the family could gather. Although there are alternative technologies that can provide similar functions, is it acceptable to use these elements nowadays?

   a. How could these elements be used?
   b. Could they be developed to benefit from their functions?

Figure 120 courtyard and a Mashrabiyyah

4- Figure 121 are photos of a setback and a Manwaar in a contemporary house which are usually not used effectively, how can we benefit from them?

   a. Can the Manwaar be used as a passive ventilation element?

b. If yes, could it be a social interaction area for the family?

Figure 121 a setback and a Manwaar in a contemporary house

5- Developing and using the traditional elements such as the courtyard and the Manwaar or the passive ventilation solutions could reduce electricity consumption. Also, it could provide the residents with a sociable space; is it possible to use them in the contemporary houses?

6- How do you spend your day in the house? (working day and vacation)

  a. What rooms do you mostly stay in?
  b. How long do you stay in the different rooms?
  c. Who gathers with you in the different rooms?

7- Figure 122 illustrates a Manwaar which has been modified to be a courtyard, do you think that this modification could make the Manwaar more sociable?

  a. What other spaces could be changed to create a more social house?
  b. Could having bigger living rooms help to change the family living patterns and to meet more?

c. Are the rooms that have a better view (either to the street or to the garden) more sociable?

d. What are the social needs missing in the house nowadays?

Figure 122 modified Manwaar

8- What new spaces do you require in the house?

   a. Do these rooms have any social uses?

   b. Why do you think these rooms are important?

9- Using the air conditioner led to providing thermal comfort for all the rooms at the same time. Also, it led to having closed doors most of the time, could it be the main reason that affects the social life of the house residents?

   a. If there is one air conditioner in the house, in which room might you locate it?

10- Besides the air conditioner, what other ventilation solutions would you prefer to use in your house?

   a. What might happen if the electricity cut off and you cannot use the air conditioner?

   b. Is using passive ventilation solutions acceptable?

11- If we modify the Mashrabiyyah as illustrated in Figure 123, is it possible for it to be reused?

   a. Do you think it will have a social use as it had before?
   b. Do you think that it might be used as a ventilation element?

Figure 123 modified Mashrabiyyah

12- Figure 122 shows a Manwaar that is used as an internal courtyard that is expected to help the family to socially interact in it or around it. However, is it possible to add a use to the Manwaar and cover it as shows, to benefit from it as a contemporary wind catcher?

   a. Is it possible to have some opening to the Manwaar for the rooms surrounding it (see Figure 125)?

Figure 124 covering the Manwaar

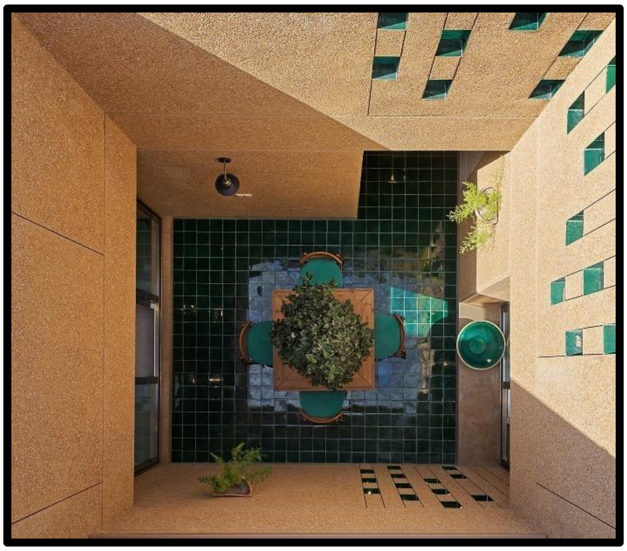

Figure 125 having openings to the Manwaar

13- Another passive ventilation solution is using the double façade as illustrated in Figure 126. The front façade can absorb the heat and provide privacy to the room behind it. Could this solution help to change the spatial organization?

   a. If we locate the double façade facing the street, what rooms could be behind it?
   b. Is it possible that the rooms behind it could have bigger openings?
   c. Could we locate the living room behind the double façade?
      i. If yes, where will the bedroom be?
      ii. If no, what room will be there?

Figure 126 double façade wall

14- Is it possible to depend on the passive ventilation solutions or to combine them with the air conditioner?
    a. Why?
15- Could the size of the house be a limitation in the use of the alternative passive ventilation elements?
16- While designing your house, what is the most important aspect that you consider, is it the pattern of living in the house, the spatial organization or the environmental technology that you will use in the house?
17- Finally, after the discussion we had, what is the future of Jeddah houses?
    a. In relation to its design
    b. In relation to its social use

<u>End of the questions</u>

Appendix 3

This appendix shows the full drawing of Nassif house which is a traditional residential building in Jeddah city.

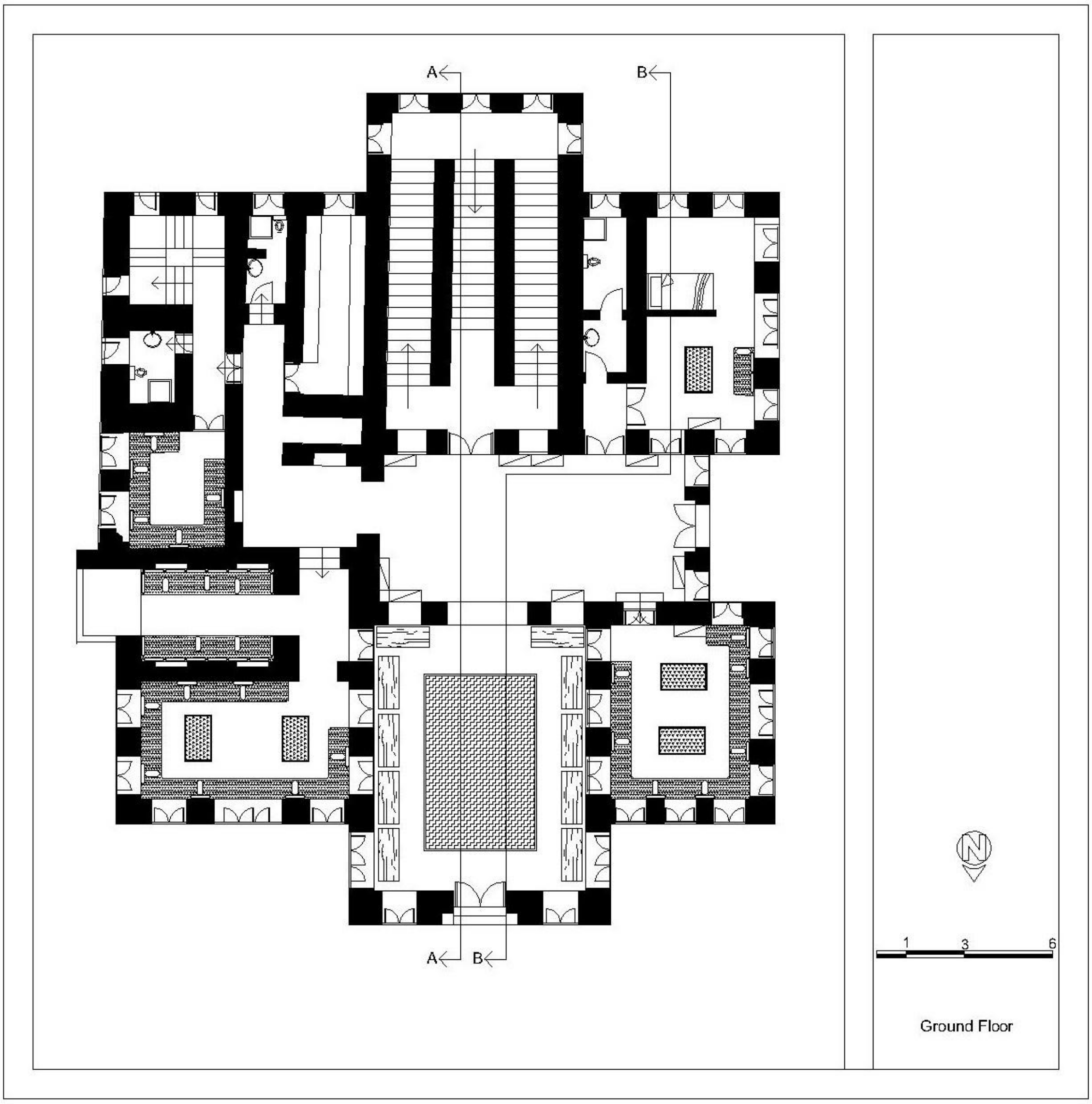

Figure 127 Nassif house ground floor (Author, 2018)

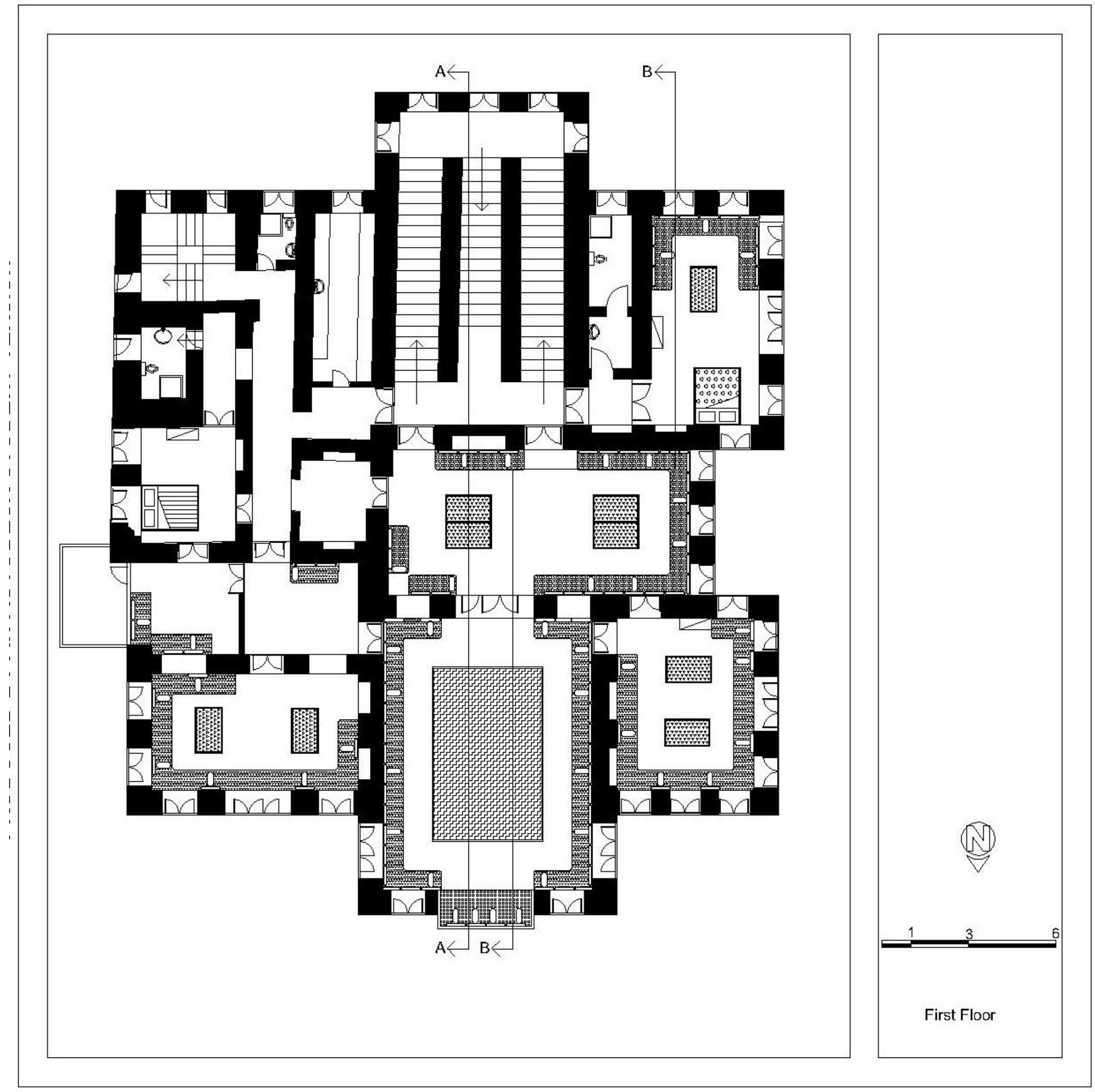

Figure 128 Nassif house first and second floor (Author, 2018)

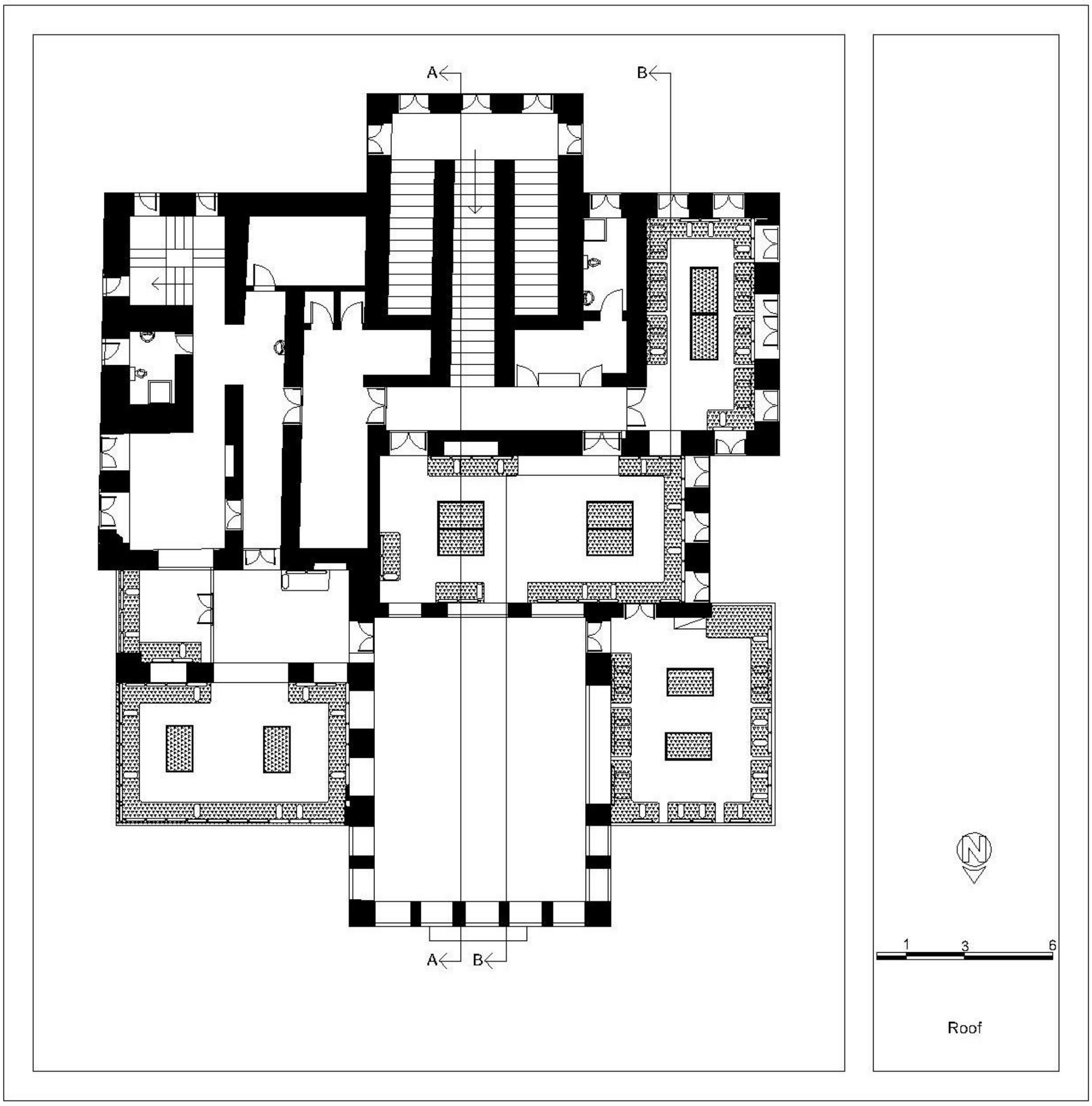

Figure 129 Nassif house roof (Author, 2018)

Figure 130 Nassif house elevation

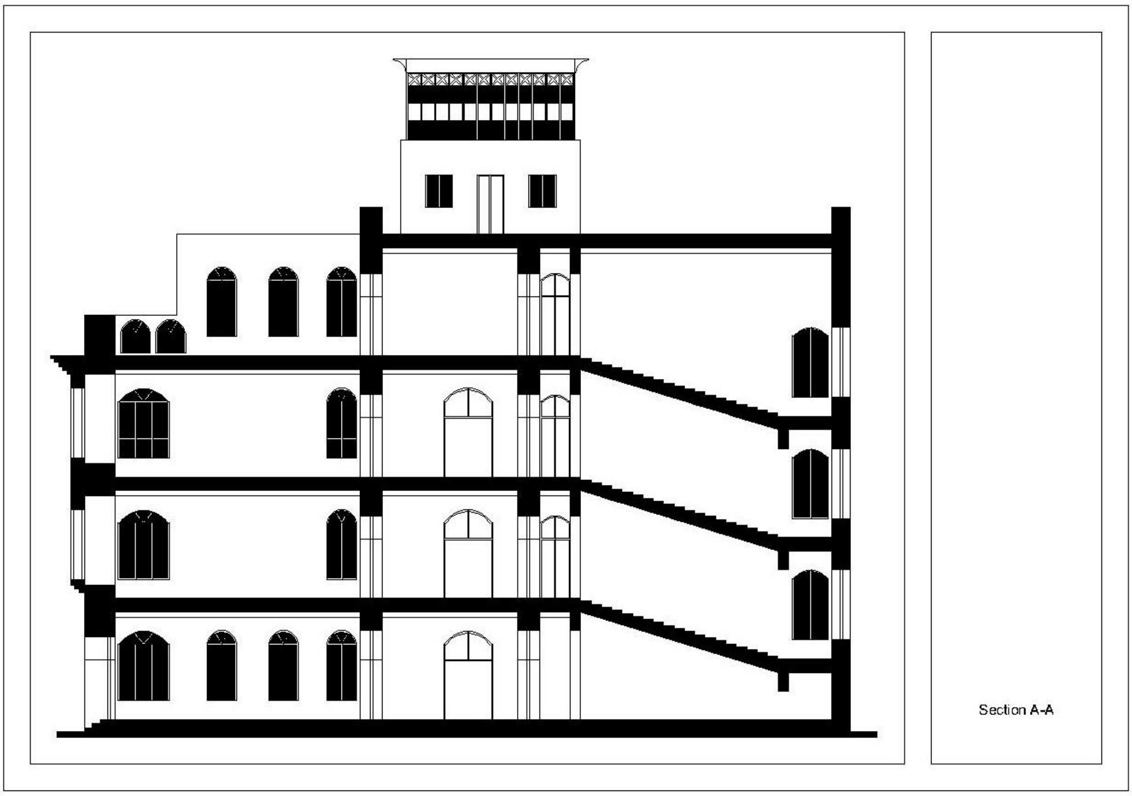

Figure 131 Nassif house section A-A (Author, 2018)

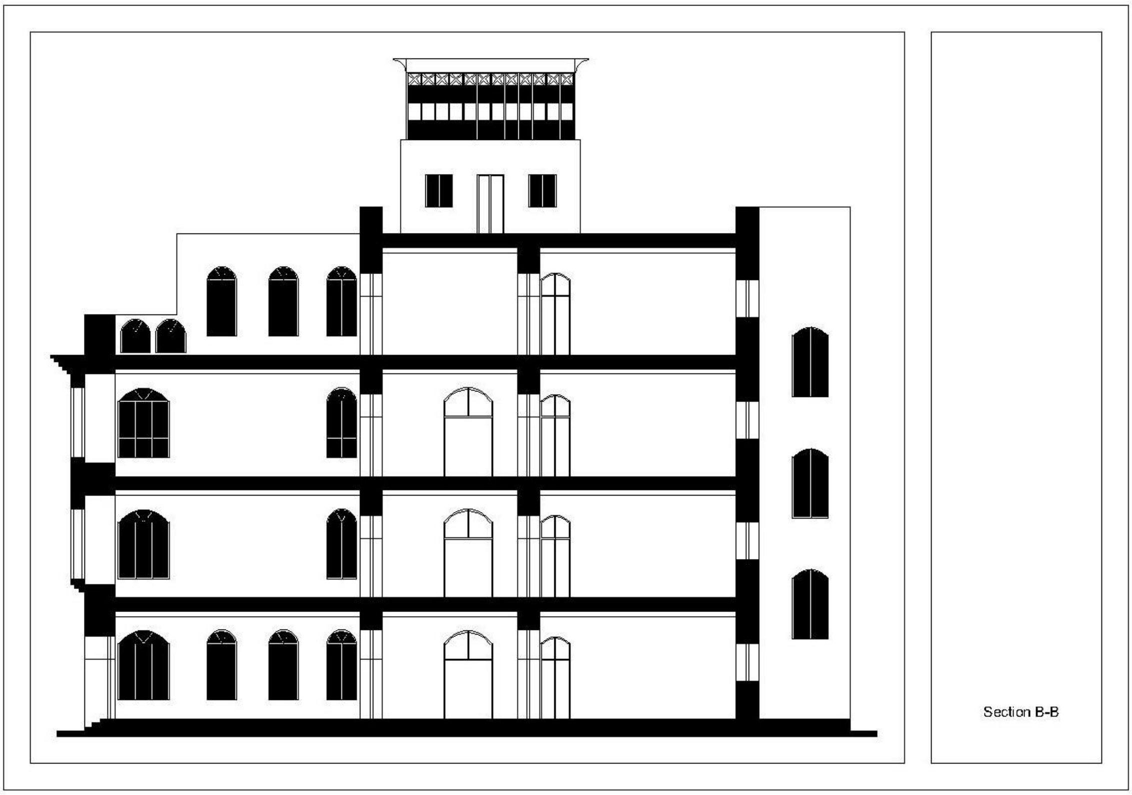

Figure 132 Nassif house section B-B (Author, 2018)

Appendix 4

This appendix shows the full drawing of Alfaridah residential building which is a contemporary residential building in Jeddah city

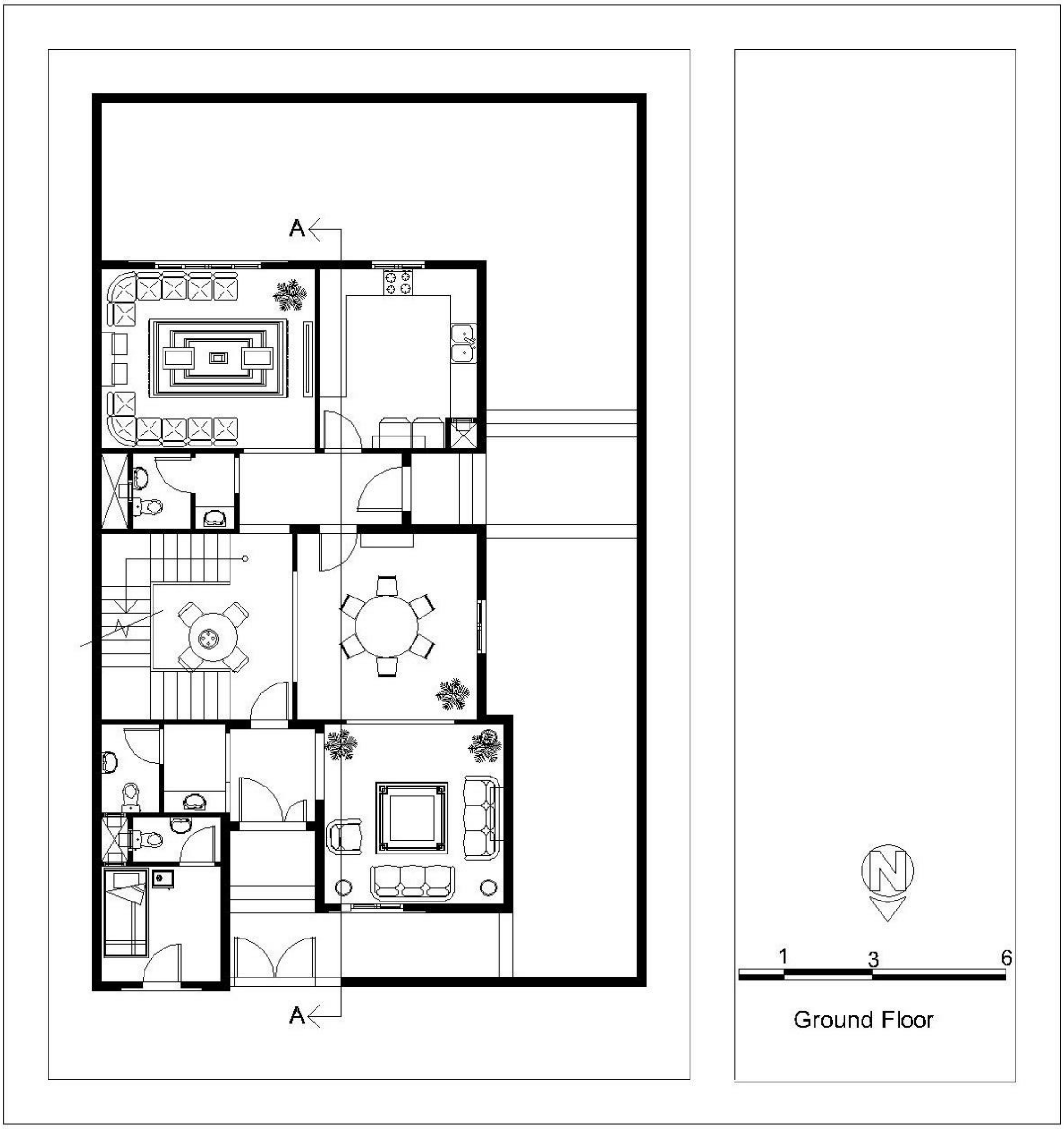

Figure 133 Alfaridah residential building ground floor (Author, 2018)

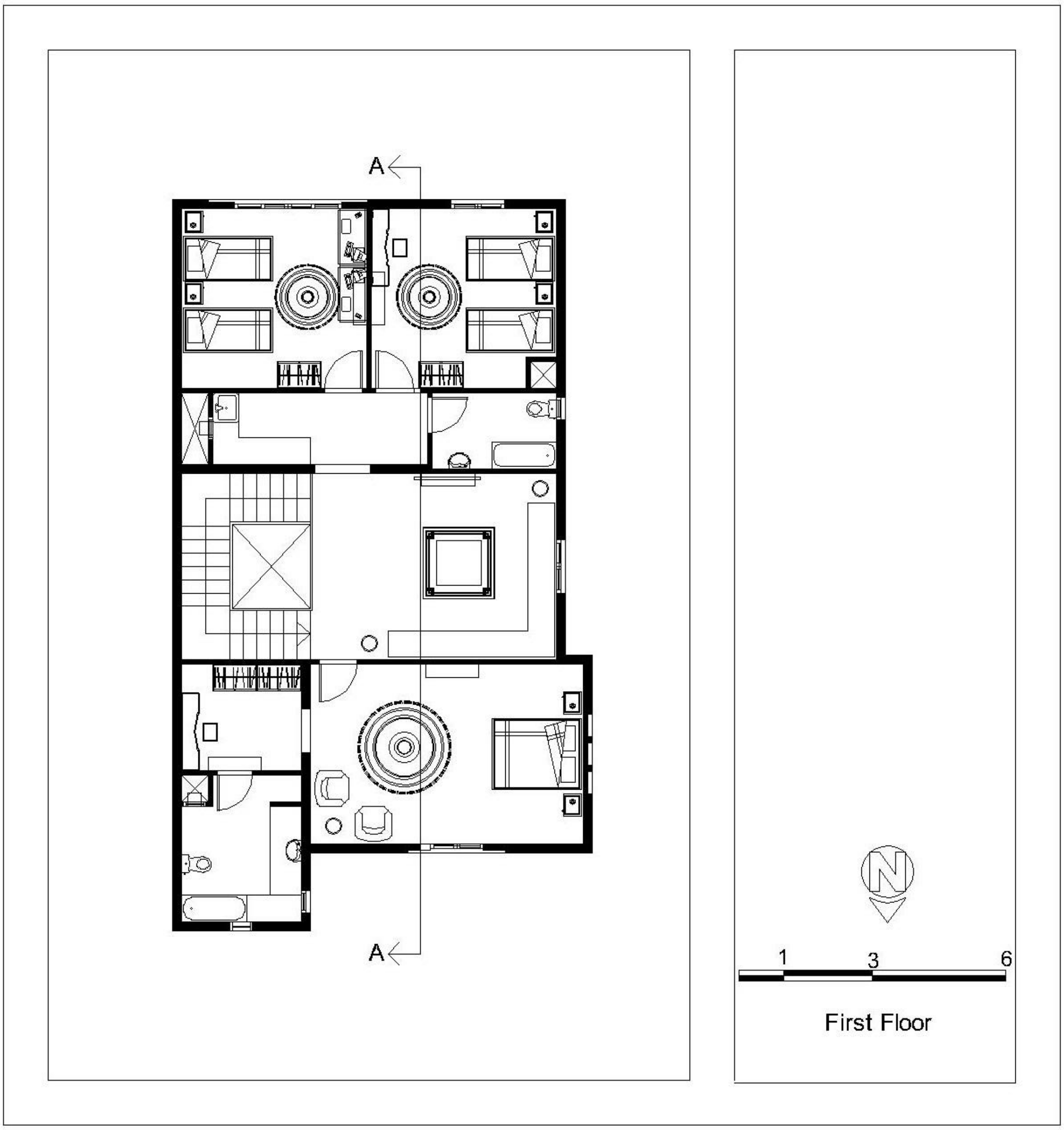

Figure 134 Alfaridah residential building first floor (Author, 2018)

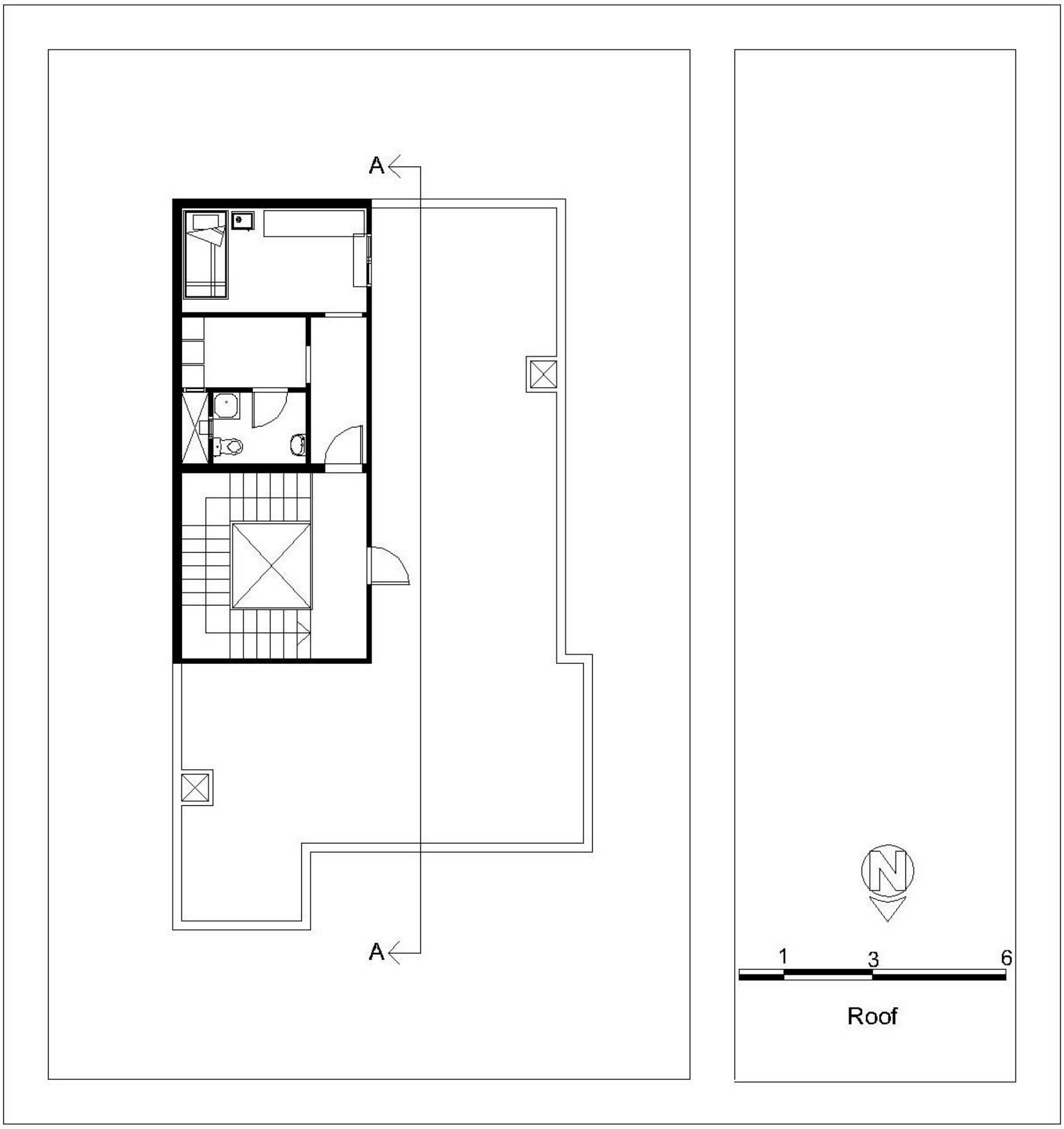

Figure 135 Alfaridah residential building roof (Author, 2018)

Figure 136 Alfaridah residential building elevation

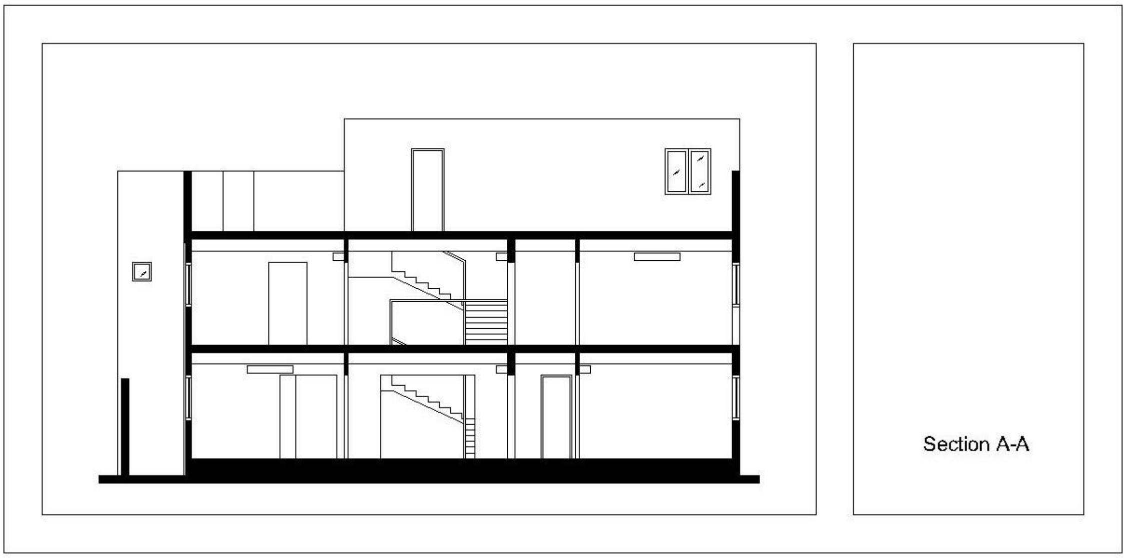

Figure 137 Alfaridah residential building section A-A (Author, 2018)

Appendix 5

The table below show the different interviewees professions, residential type and category.

	Interview stage	Name	Gender	Residential type	Category
1	1	AAM	Male	Villa	General
2	1	AAS	Male	Villa	General
3	1	AJD	Male	Villa	General
4	1	ALH	Male	Villa	General
5	1	AQD	Male	Villa	Architect
6	1	FLS	Male	Villa	General
7	1	HDT	Female	Villa	General
8	1	ISK	Male	Villa	Architect
9	1	MBB	Male	Villa	General
10	1	SAB	Male	Villa	General
11	1	SAS	Male	Villa	General
12	2	ABQ	Male	Villa	General

13	2	AML	Male	Villa	General
14	2	ASK	Male	Villa	General
15	2	ASR	Male	Villa	Architect
16	2	ATR	Male	Villa	General
17	2	GDG	Male	Villa	General
18	2	HOM	Female	Villa	General
19	2	OQB	Female	Villa	General
20	2	TAN	Male	Villa	General
21	2	TSQ	Male	Villa	Architect
22	2	WAY	Female	Villa	General
23	2	YQR	Male	Villa	General

Table 28 the interview participants gender and background

Appendix 6

This appendix is a sample of one of the interviews transcriptions.

<u>Start of the interview</u>

Researcher: At first, thank you for your time, and I would like to ask your permission to record the interview.

Interviewee YQR: Ok on problem.

Researcher: Just want to inform you that you can stop this interview at any time, and if you like I can delete the recording, it might go up to 40 minutes.

Interviewee YQR: Ok.

Researcher: My research is about the Higazy houses, recently we hear a lot that the family member is not interacting a lot, and everyone is in his or her room. The reason might be the use of modern gadgets such as TV or phones. But for me, I think that the air conditioner is the main reason.

At the beginning, let me give you an idea of what changes happened between the old and new houses in Jeddah. This figure (figure 104 in appendix 2) is for Nassif house. On the ground floor were the visitor's room and the storage. The first floor we have the living rooms and the bedrooms. As you can see the living room is facing the street and have the biggest openings in the floor. They allow the airflow to come in and to be exhaust from the backside of the house where the kitchen and the bathrooms are located, and this allows the bad smell to go out. In the new houses, the situation has been changed. The living room and the

kitchen area on the ground floor; the first floor is mainly for the bedrooms. And the master bedroom is facing the street. The living room becomes smaller and in the middle of the house and facing the side setback or the Manwaar. At the same time, the windows are smaller and always are close. What other changes had happened?

Interviewee YQR: In the design

Researcher: Yes, and as a lifestyle inside the house

Interviewee YQR: I think that the financial and the aaa social side in the community changed a lot of things. Before they were aaa as you said they love to gather together and open the windows to allow ventilation. But what is clear now that everyone is closing on their windows, it is privacy, and no one must see us. So, this is one of the reasons that led to changing the social life and led to having a close house. I believe that this is so negative. I believe it has a psychological effect if the windows were small.

From the financial side, having small houses led to renounce a lot of things that were available in the old houses. So, the design of the house has changed, and the spatial organization have been totally changed. As you said the kitchen is in the middle of the house, the bedroom is on the main elevations. The living room is on the back. All of this is because of the small size of the houses and their design.

If someone is thinking to save money and provide privacy, they must change the design of the houses and the air conditioner.

They said the air conditioner is an alternative and there is no need to open the windows to allow the airflow. They did not think about the cooking smell and how it will spread in the house, they think that the air conditioner is the solution. And this led that the family does not interact much. Everyone is in his room relaxing. But still I think that there are some residents do care about the living room but unfortunately, the living room is now in the medal of the house.

Researcher: You highlight a number of reasons such as the cost that led us to concede some space, what are these spaces?

Interviewee YQR: Aaaaa mmm most of the built area are used in the bedrooms instead of using it to have gathering areas.

They believe that if the bedrooms were small, it means that I narrowed myself because this is the space (personal space) that I should relax in.

Another thing we cared about is the visitor's room more than the family room. Why? Because the people are now thinking about how I can meet my visitors in a small room. They did not think they are not really using the visitor's room for less than 20% in a year. Sooo they sacrifice the living room area to use the area in the bedroom and the visitor's room that is used for less than 20% from my personal experience.

Researcher: In this figure there is some of the traditional architectural elements, the Mashrabiyyah, Manwaar, thick walls which are nearly 70cm and the courtyard they were the available technology to cooling and ventilating the house. Can we in the contemporary houses use the same technique?

Interviewee YQR: From my personal point of view, it might be hard, but we can use them. Because first it is so costly to have

70cm walls unless if we use the new technologies such as the cool iron or the bricks. Then I can reduce the size, and the wall will be more effective. How thick are the bricks? (20CM), We can use it. Trying to gain space from having small walls and to save money.

In relation to the Mashrabiyyah, it is so dutiful, and I am trying to have them, but I might modify them to be more aesthetic than functional in ventilation.

Researcher: Why?

Interviewee YQR: Because the environment surrounding us have a lot of air conditioners and hot steam around the house, so this limits me from benefiting from the natural air. To be more effective the concept could be done in an area that all of the houses are following the same concept but if I was the only one that is applying this solution, I don't think I will really benefit. So, I can use the Mashrabiyyah as a decoration element.

Researcher: Besides the ventilation they were providing privacy, they use to be free behind it and viewing the street without being seen ….

Interviewee YQR: Regarding the point of viewing the street, it has been changing with time. Aaaa. Because the residents are no longer interested in viewing the street and knowing who is using the street. Everyone now is globalized and in their house. No one cares who is in the street. So, this point has totally changed, and it is no longer important to know who is on the street or even viewing it.

I told you these things need to design an area that follows the same concept.

Researcher: The Manwaar as you know they are used to exhaust the bad smell and also the setback, these areas are nearly in every house, and they are misused how can we reuse them for the ventilation?

Interviewee YQR: Ventilation what?

Researcher: The house

Interviewee YQR: I can see two types of the Manwaar, (no, this is the Manwaar and this is a setback).

Ok, the setback is different from the Manwaar aaaa as much as possible, if I can avoid having a Manwaar and instead have it as an external setback is much better, because I cannot benefit from the Manwaar, or I do not know how to benefit from it. I feel that I cannot benefit from it because having the air conditioners in it will lead to generating heat and having a hot area. For this reason, I cannot open the window; this is first

But for the setback, it is very appropriate if we change the decoration of it to look like a small garden instead of being a solid space. Having any natural things such as planting. It could be also covered. Even the air conditioner units I try to keep it away from these gardens in order not to generate heat, so I won't benefit from it.

A lot of people are having these things (the air conditioner) in the setback, and this will be so bad if it has a lot of air conditioners.

Researcher: Ok instead of having these areas for ventilation, can we make them attraction areas for the family to interact in?

Interviewee YQR: This will lead to another thing. I must ventilate the space; this will cost me to have outdoor air conditioners and to cover the area because as I told you we care about the privacy in our culture, so I do not think that I can leave it uncover and if the buildings surrounding me are high this will make a lot of effects. I do not think that I will be relaxed while I am sitting outside.

So, I do not think that it will be a good alternative unless these setbacks are in the centre of the house so the surrounding walls aaa if the house residents are the only one that can view it, I might accept it.

Researcher: The house reflects its resident statues, how do you evaluate the status of the house resident from his house?

Interviewee YQR: Aa I did not understand what do you mean?

Researcher: I mean the social status, if you see the house how can you judge the financial situation of the residents, or if the residents are open-minded and so on?

Interviewee YQR: Of course, the house reflects a lot of the house resident personality, if he is an environmentally friendly, he loves planting. You can see a lot of people that are caring for their gardens and it reflects the resident culture, how he can make the house a place for relaxing more than just a close house.

Yes, the house can reflect a lot, but we must bear in mind the budget, most of the residents, are now buying readymade houses. So, they do not have full control to make changes in the house, they might make some external decorations that show that the house resident care. Also, the house resident can add some touches that make his house looks much better than his neighbours although they have the same house design. But you can feel the difference.

For example; if you have a number of villas, 10 next to each other, nearly 50% looks the same, 20% of the residents are careless, and the house does not look like the way they bought it and 30% you feel that they added some things, decorations, planting aaa made some improvements because they are saying that this is my house and I must care about it.

The pre-built houses might have some boundaries that stop the residents from applying their personal touches in the house. Especially if they cannot afford to make some changes in them.

Researcher: Ok but they are already paying 1 to 1.5 million, why do they pay on a pre-built house, why they do not build their own houses as they like?

Interviewee YQR: The time is important, the 1.5 million is the cost of a full house that includes the site, building costs. While building a house yourself costs 1.5 million and does not include the site, you need another half million to find a site in a good area.

So, it is important; I can pay 1.3 million in a house in a good area. But if I will build, I need to divide the 1.3 million to 800 thousand for building and 500 thousand for the site. So, I might not really build a full house.

Some people have the idea of building the house in stages, so they can do what they want, but it is highly expected that they won't continue building the house. As you see, we found a lot of houses built on the ground floor only and did not continue building the other floors.

Researcher: Usually where is the best room that the family members are meeting in?

Interviewee YQR: It depends on the family but mainly in the living room. I care a lot about the living room. I prepare it to be comfortable for the gathering. Even when I feel tired, the living room is where I relax, I prepper it with all the ways to be a good relaxing place.

Researcher: What are these ways?

Interviewee YQR: The theatre, the TV aaa a coffee machine, relaxing sofas this is the main thing I need.

Researcher: What about the room view?

Interviewee YQR: The view here in Saudi, I do not really care because as I told you, I do not care who is in the street. What I care about is not the view but the sunlight. I love the natural light.

Yes, this point is important, I do not like my living room to be in the middle I prefer it to be on the sides so the windows can have sunlight and I prefer the windows to be big and to have a balcony.

Researcher: If we have a Manwaar and we modify it and its ground floor and use it as a courtyard as in the figure, could this be much better, i.e. could it enhance the family to gather in the space around it for more time?

Interviewee YQR: How can I benefit from this Manwaar? Could it provide airflow?

Researcher: Yes, it could allow the airflow in and the natural lighting. It could be a focal point instead of being a

rubbish area; it could be a good area for the family social interaction.

Interviewee YQR: Yes, it depends on how you will use the space, or how you will use the Manwaar. If you are from the people that won't use it and you will neglect this area and locate the air conditioner units in it, then it will be a hot place.

Researcher: What if we remove the air conditioner units from it?

Interviewee YQR: Yes, yes it will be a very good idea. I told you the natural lighting is very important for me. I am not from the people that love to have small windows. I prefer it to be as big as much as we can.

Yes, it is a very good thing. Even in my father's house in the first floor, because he purchased a pre-built villa and in the second floor we extended the ceiling on the first floor, so we have a small roof area that we were not really benefiting from it.

Researcher: So, do you gather there?

Interviewee YQR: Yes, before we were gathering on the ground floor because it had a view of the setback. But now we are meeting upstairs. This depends also on the ages of the house resident s if they can use the stares or not. So, the change that we made. Led to make a lot if changing such as the residents psychological has improved. We felt that the house had expanded.

In my house, I do not have a Manwaar and the only Manwaar we had, we change it to a lift. That's the way we benefit from it. It was a place to dry the clothes, a very hot place that you cannot be there for 10 minutes.

Now the Manwaar is changed to a lift.

Researcher: The contemporary houses had new room uses, can you give me some of the rooms that showed up or that are no longer used?

Interviewee YQR: New rooms aaaa nothing is in mind now before the living room was in the intersection of the house, i.e. the point that all the rooms are viewing. The living had 4 or 5 doors, each door is for a different room.

But now this room is changed. The dining room is linked with the kitchen and the internal isolated room is the living room. Because the residents are not really feeling their privacy in the living room, but they feel it is a closed room.

Researcher: One of the new uses you mentioned is having a theatre in the living room. Also, the playroom is a new room that shows up

Interviewee YQR: Well the playroom depends on the resident budget. Aaa

Researcher: Is it really important?

Interviewee YQR: It is normally located in the living room. Usually, it is not separated in a different room unless you have special games that you need a room for them.

Yes, I recognise an example, my relatives love watching movies and also love preparing for it. When he was married, one of his requirements, while he was looking for a house, is to have more room because he wants a room for cinema. This is what he really loves. So, what the residents care about is reflected in the house.

I am one of the people that dispense with the visitor room and change it to a photo studio. Which is something new now but what is happening now is that the residents want to benefit from their houses and reflect their habits in it. The fact that I changed the visitor's room to a photography studio is a social risk. But because I have no problem that the visitors use my living room, so there is no problem and the living room I had was so big. The only limitation is that the building and room areas.

Researcher: The air conditioner consumes up to 80% of the house energy. On the other hand, the air conditioner is the fastest way to cool the house. More than that every house member is going to their rooms and closing their door to have faster cooling. Could this be the reason the led to weakening the family relations?

Interviewee YQR: Sometimes. Yes, this could be the reason, but for me how the people were raised in the house will be the thing that specifies if they will socially interacts or no. i.e. if the house was cold, the living room also is cold, so it is not the air conditioner that affects the family social interaction.

Researcher: Ok what if I give you only one air conditioner to use, in which room you are going to have it?

Interviewee YQR: My bedroom.

Researcher: So, the rest of the house residents will come to your room?

Interviewee YQR: No, I don't think so

Researcher: Do you think they will stay in their rooms without air conditioners? Because there is only one air conditioner in your bedroom.

Interviewee YQR: It is not acceptable that anyone uses my bedroom. I don't think that I will have only one air conditioner in the house.

Researcher: What if the electricity cuts off? How will you ventilate the house?

Interviewee YQR: I think I will use the windows, I will open the windows. The old solutions are not functional because the houses were ventilated. Having the Mashrabiyyah or butting a wet piece of a curtain on the window to have cold air into the house is not really functional or acceptable. Because aaa there is no air circulation because of the surrounding houses. That's why opening the windows is the only thing that I can do.

We can use manual fans.

Researcher: The passive ventilation solutions are functional, and some are really using it, but the others may not really trust such solutions. One of the current examples is the Sami Al-Angawe house. These solutions could not really replace the air conditioner, but they could reduce the uses of it. However, old architectural solutions could be used nowadays. For example, the Mashrabiyyah has two functions providing privacy and ventilating the air. The Mashrabiyyah could be used as it was or could be modernised and give you similar functions. So, if we redefined the Mashrabiyyah, could we use it?

Interviewee YQR: What is important for me is that the people's awareness. Some do not really know what the functions of the Mashrabiyyah are; they think it is just a decorative element.

If you want to apply this concept, you must first increase the awareness of the residents of what is the real functions of these elements. The awareness is so important because the house resident will not risk and pay for something that might not function.

The other problem is that the hot air around the house that is generated from the other air conditioners. The examples you used might be built-in more open areas. I support using these new techniques, but at first, you must increase awareness.

Researcher: Ok, in the figure, this Manwaar has the piping, small windows and air conditioners. The function of the Manwaar is it takes the indoor air and excuse it. What if we remove the air conditioner and improve the Manwaar, cover it with one of the shading elements such as in this figure to allow the air in and ventilate the house and the excusing from the other side. Is this solution acceptable?

Interviewee YQR: Yes. One of the things that annoyed me is the bacteria in the Manwaar. You can find the bad smell. But if we can function from it, it will be a very good solution.

Researcher: Ok could this lead to changes in the spatial organisation, i.e. instead of having the kitchen or the bathroom facing the Manwaar, you locate the bedroom or the living room facing it?

Interviewee YQR: I do not think it is appropriate to face the bathroom and kitchens to the street. Unless if I have different functions on different floors. For example, I will locate the kitchen on a higher floor so you will avoid having the kitchen on the same floor of the living room or the bedrooms and I could have a small service. But locating the kitchen in the elevations that have a street view, I do not think it is a good idea.

Researcher: Ok but there are some rooms that must have a view to the Manwaar, either the kitchen or the living room, so what do you prefer to face the Manwaar?

Interviewee YQR: I prefer that the bedrooms have a Manwaar view. We have four elevations, one of them is for the kitchen. I thought about it; the rear elevation could be for the kitchen. Aaa and the other elevations are for the other rooms.

Researcher: Ok these are the solutions that were available from the old times, there are new solutions such as the double façade elevation, if we use this technique what rooms on the first floor you prefer to face the street? Is it still the master bedroom or the living room?

Interviewee YQR: You are talking about a house that can have more than one space on its elevation. It is not important that all the elevation is a living room, it could have more than one room facing it. We can have the master bedroom and the living room on the main elevation. I think this is a good solution. But I nominate the living room has a street view and from the other side have a view to the Manwaar.

But there are some will require to have privacy in the living room, i.e. if you have the TV on one side and the reading area on one side there will not be internal privacy. It depends on the residents need

Researcher: Behind the double façade, would you enlarge the window size?

Interviewee YQR: Yes, as big as possible even if I make the window as big as the wall. It will be very beautiful, the natural lighting inside, not annoying, provide me with good ventilation, provide me with the privacy, but is it costly. I must think if I will do it how much it will cost, is it from the basics that I must pay for? Is it worth paying for it?

Researcher: Well, in every project there are two types of costs; construction cost and operating costs. Yes, it might cost you nearly 200 thousand while constructing the building, but in the long range, it will save from your running cost. This will help you to less use the air conditioner.

Ok, when we started, you highlighted that using natural ventilation is hard because of the environmental conditions, but after we discussed the different solutions that could solve a lot of the disadvantages. Do you still insist that it is hard, or have you changed your mind?

Interviewee YQR: No still from my understanding the air conditioner is important because it is annoying if I think that my house does not have an air conditioner. I do not feel comfortable. But you cannot increase the awareness of the residents in a day it needs time. I lived out for nearly two years, and there weren't any air conditioners, but the weather was cold. Even in summer, it was very hot in the houses but some houses that have big windows it was acceptable and colder.

I wish I can do this, but the problem is with the cost of it. The budget could be the limitation of a lot of things. I am paying anyway, so that way I do not pay for something that solves my needs directly, such as the air conditioners.

Researcher: If you have the money and the site to build a house, the first step is to go to an architect to design the house. You will give him your requirements, but do you accept his design directly or do you negotiate with him?

Interviewee YQR: No no no, of course, I will negotiate.

Researcher: What are the things that you insist on having in the design?

Interviewee YQR: It is so important for me to have internal courtyards. Aaa, I am not really interested in a swimming pool. I want big windows. This is one of the most important things for me. Because I want to have natural lighting. The living room should not small, and it should be opened to all of the rooms.

While I was searching for accommodation for my marriage. I searched more than half of Jeddah houses. I found a very great accommodation, but unfortunately, the house was like corridors with a lot of rooms on it. However, I took an apartment after all that have three rooms that have a well-designed living room. Although my relatives did not like the idea of having three rooms after they see the apartment, they felt the difference.

They believed how the living room could change the image of the house. You never know what is in the bedroom, also the visitor's room does not give an impression of what is in the house. But when you improve the intersection of the house which is the living room, the others can judge the house resident way of living.

Researcher: Do you mean social status?

Interviewee YQR: Yes. Social status. But if I have the money and the opportunity to make changes, of course, I will do these solutions. I will reduce the use of the air conditioner, but I cannot have rooms without an air conditioner. Frankly speaking, I might have the living room without an air conditioner but not the other rooms.

Researcher: When you want to design your house, what is more important for you; is it how you will organize the rooms or how you will use the rooms?

Interviewee YQR: As I told you most of the houses that I found are a corridor that has rooms facing it. This is a thing related to how I will move between the rooms. Aaah yes, it is an important point. That is how I will move between the rooms. It is not good to have rooms like a maze. I might build a villa that the rooms on the first floor view the living room on the ground floor. To have a big opening. For the bedrooms, I accept to have them as a corridor viewing another living room.

Researcher: How do you see the future of Jeddah houses?

Interviewee YQR: The nature of the people that they change. The awareness is increasing. Before the contractors were limited, the designs were typical, and they did not think of changing. But now the younger generation is improving. Even the new housing projects, they design it in a more contemporary way. There will be a big change even that the building size is smaller; you will see changes. But I do not think that they are thinking about the air conditioning topic.

<u>**End of interview**</u>

Appendix 7

This appendix shows the full drawing of Alfaridah villa after modifying it and use the breathing design proposal as discussed on the recommendation section.

The different privacy zones drawings

Figure 138 breathing design proposal, privacy zone, ground floor (Author, 2018)

Figure 139 breathing design proposal, privacy zone, first floor (Author, 2018)

Figure 140 breathing design proposal, privacy zone, roof floor (Author, 2018)

The passive ventilation solution and the airflow drawings

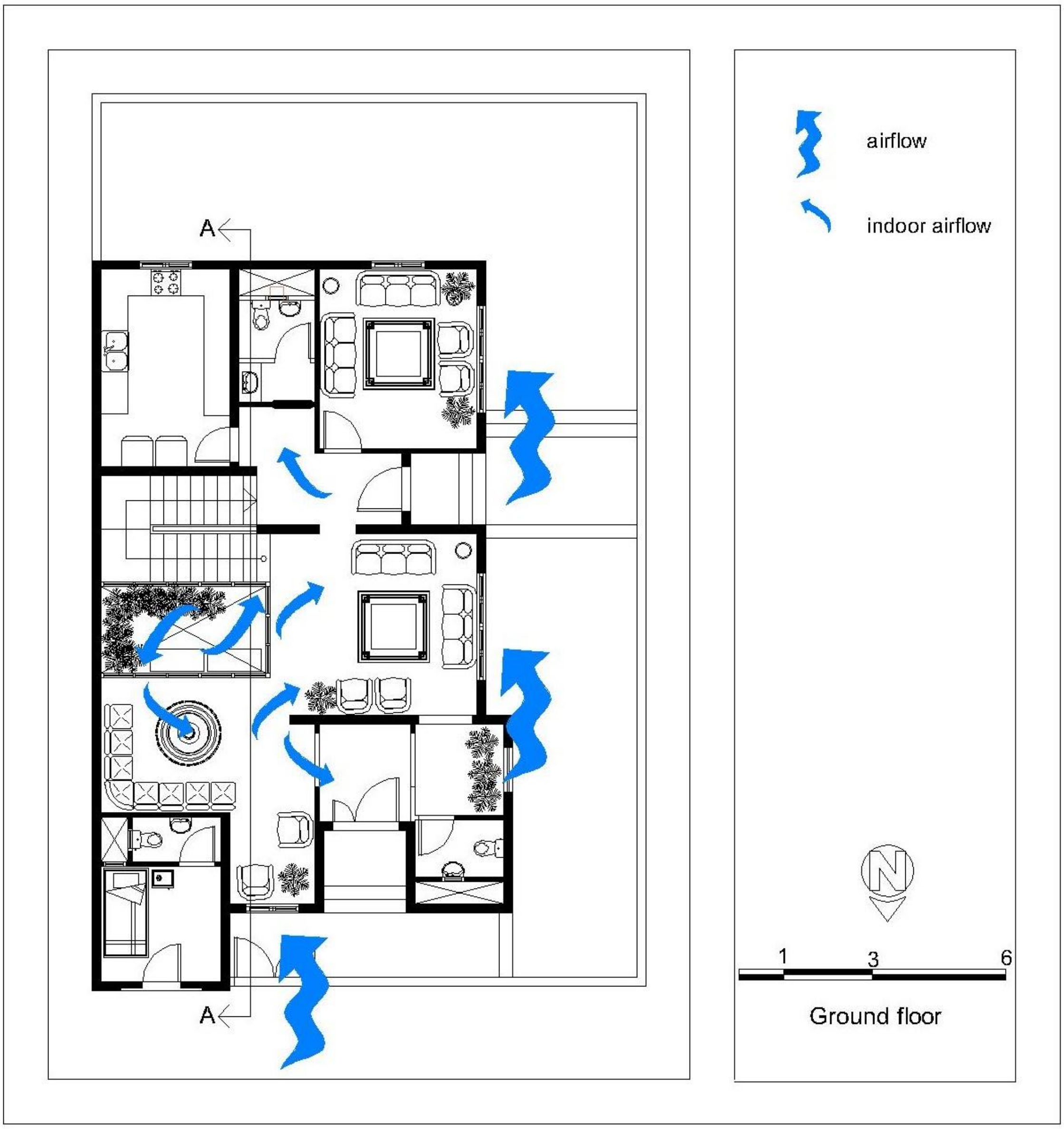

Figure 141 breathing design proposal, airflow, ground floor (Author, 2018)

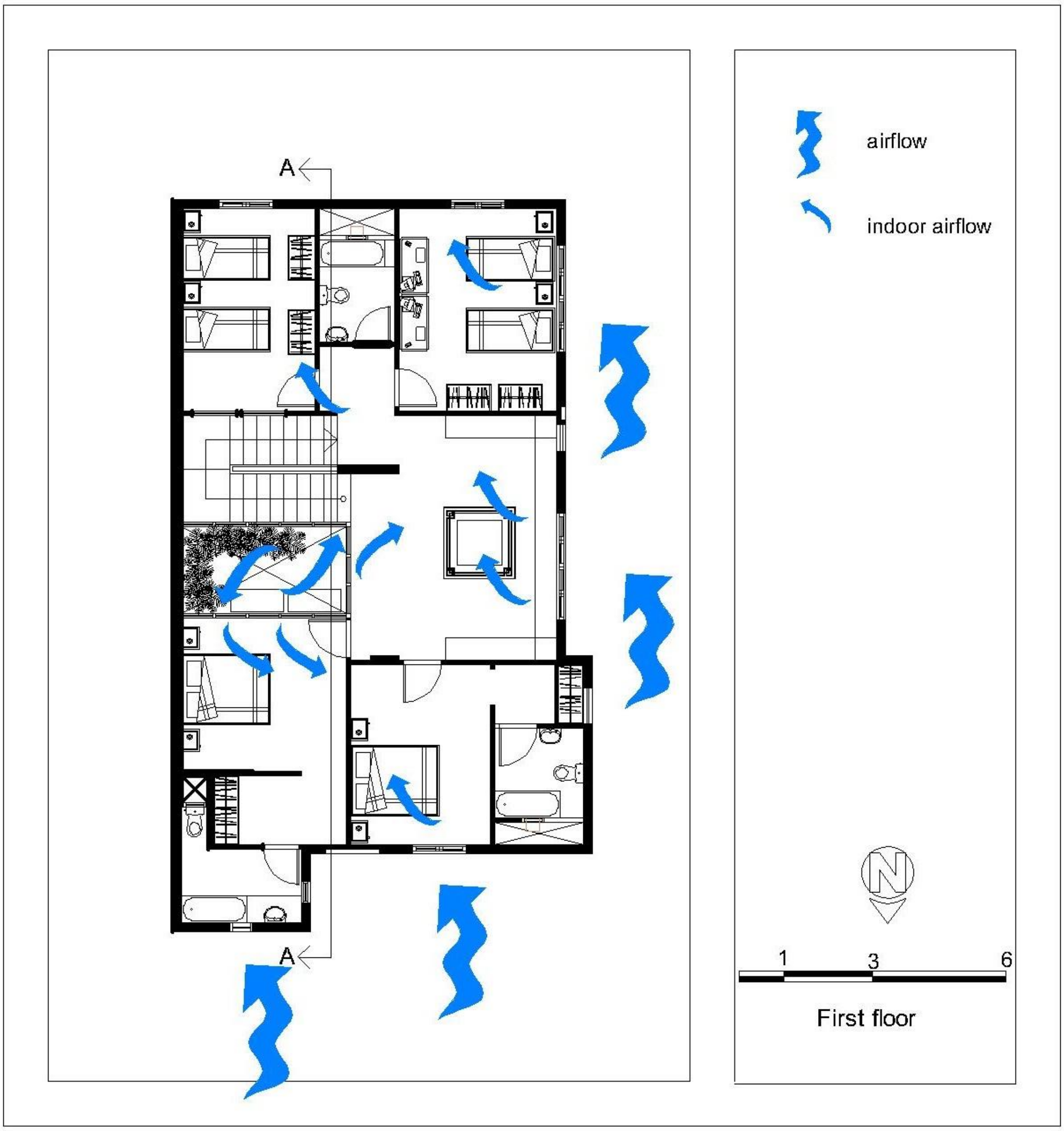

Figure 142 breathing design proposal, airflow, first floor (Author, 2018)

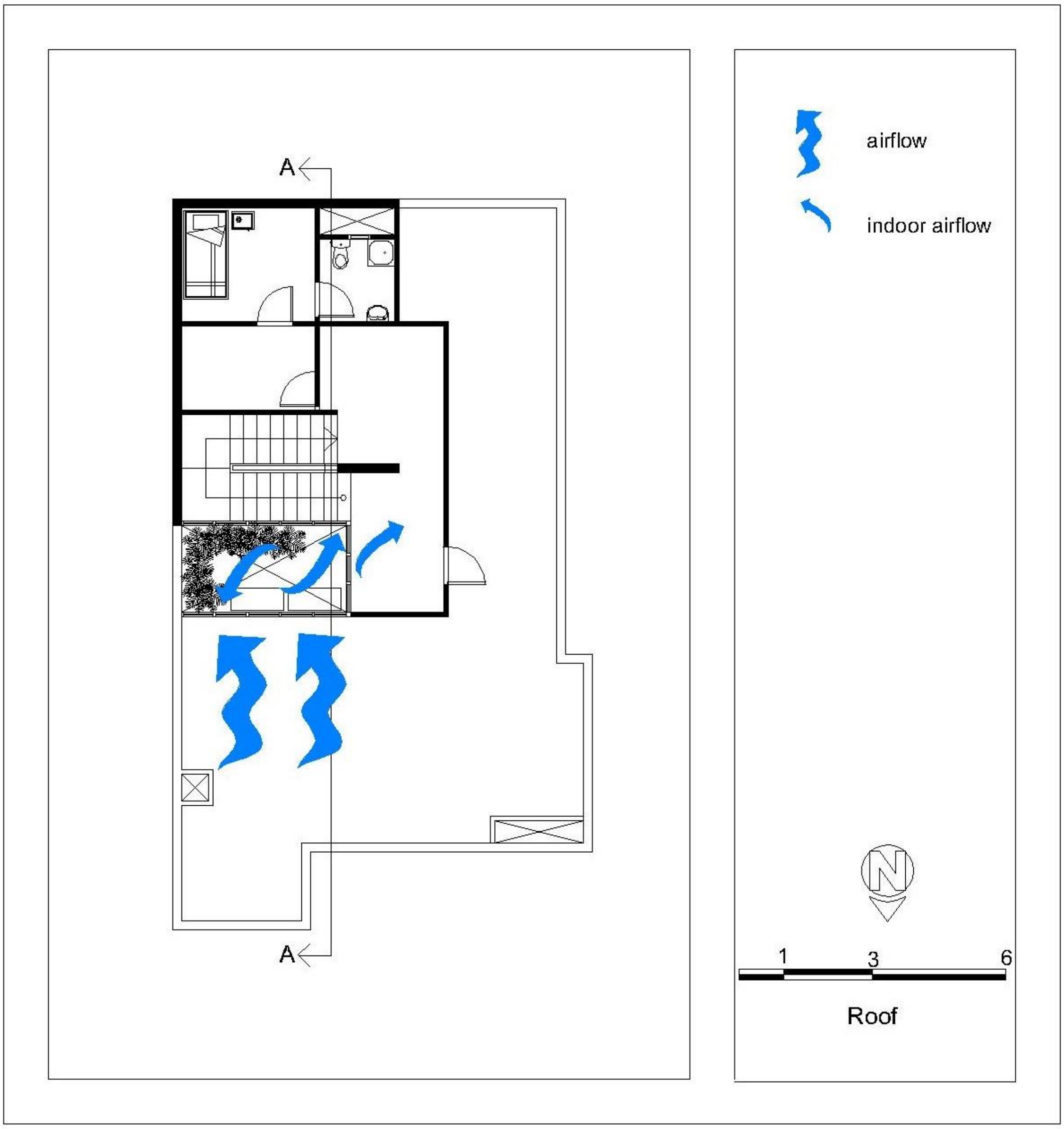

Figure 143 breathing design proposal, airflow, roof floor (Author, 2018)

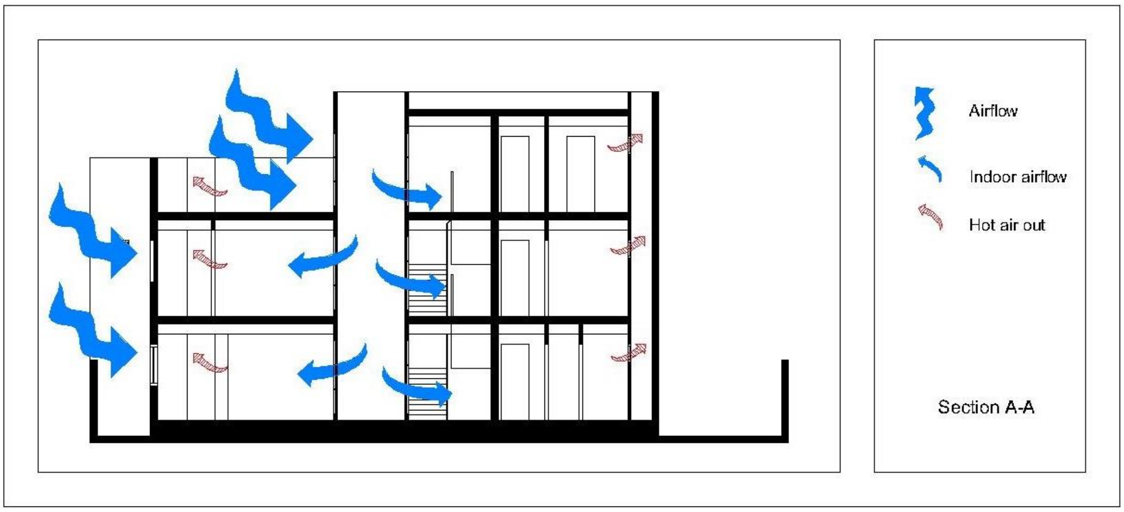

Figure 144 breathing design proposal, airflow, section A-A (Author, 2018)

Appendix 8

This appendix shows the full drawing of Alfaridah villa after modifying it and use the airwave design proposal as discussed on the recommendation section.

The different privacy zones drawings

Figure 145 airwave design proposal, privacy zone, ground floor (Author, 2018)

Figure 146 airwave design proposal, privacy zone, first floor (Author, 2018)

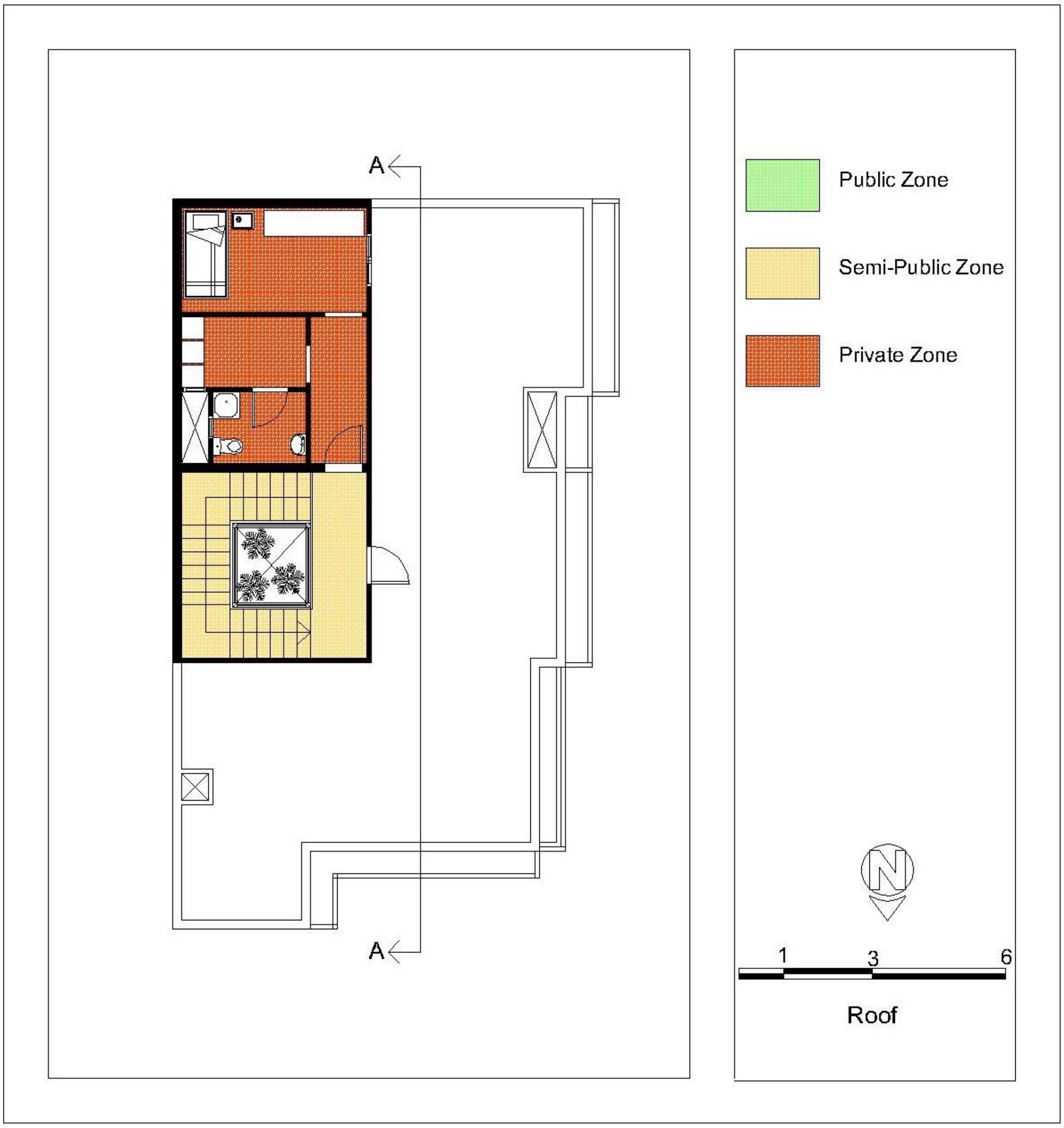

Figure 147 airwave design proposal, privacy zone, roof floor (Author, 2018)

The passive ventilation solution and the airflow drawings

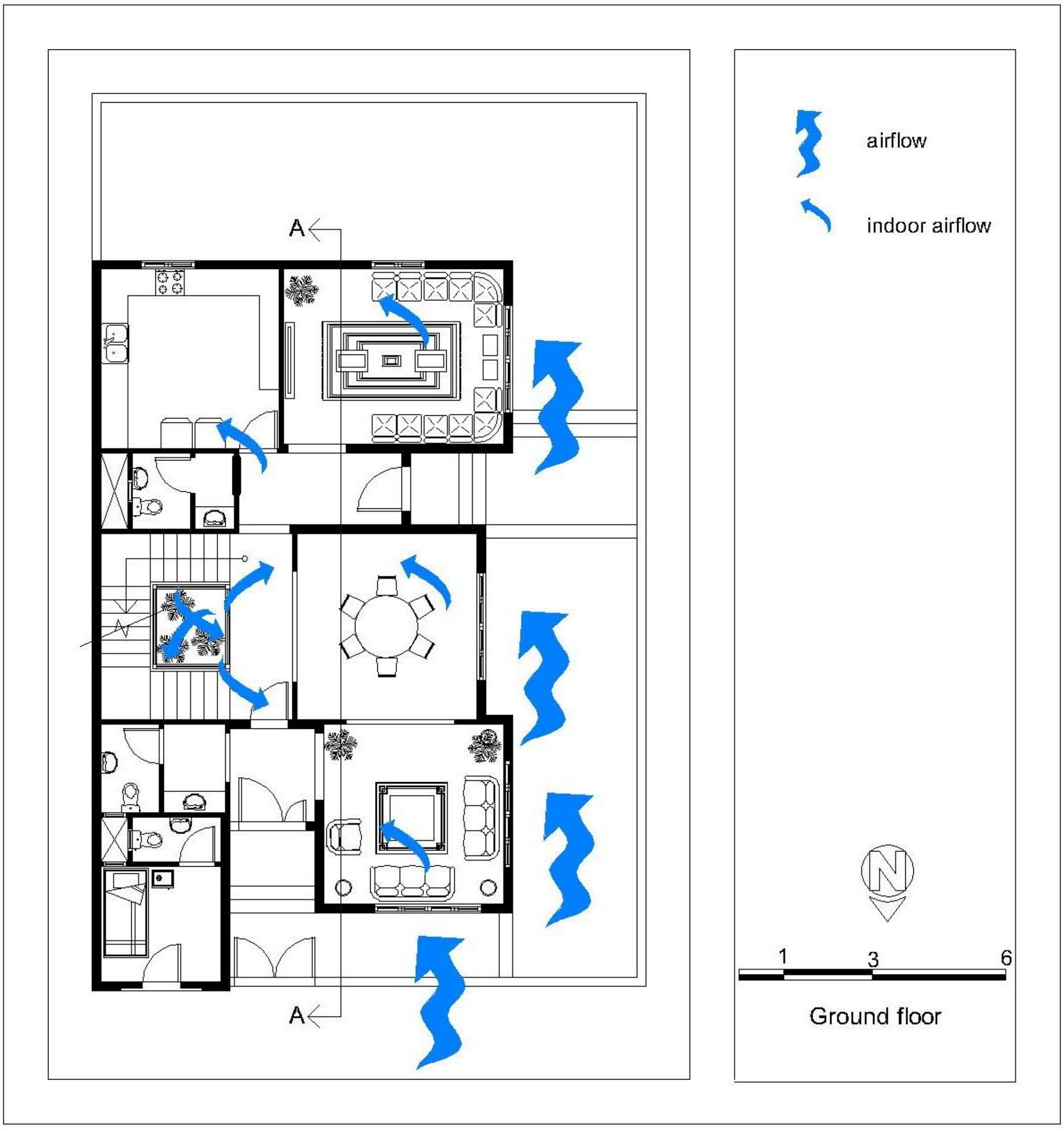

Figure 148 airwave design proposal, airflow, ground floor (Author, 2018)

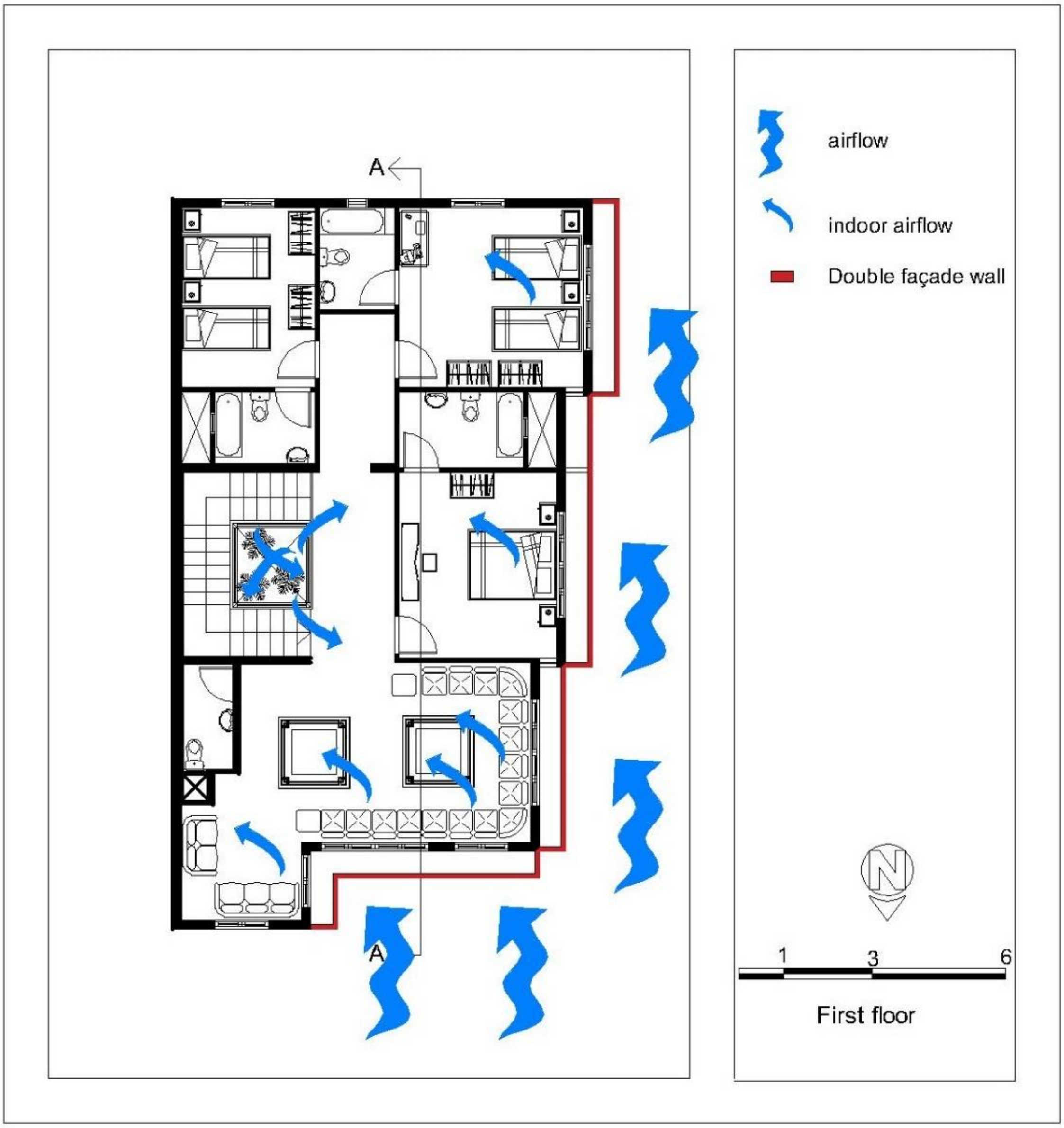

Figure 149 airwave design proposal, airflow, first floor (Author, 2018)

Figure 150 airwave design proposal, airflow, roof floor (Author, 2018)

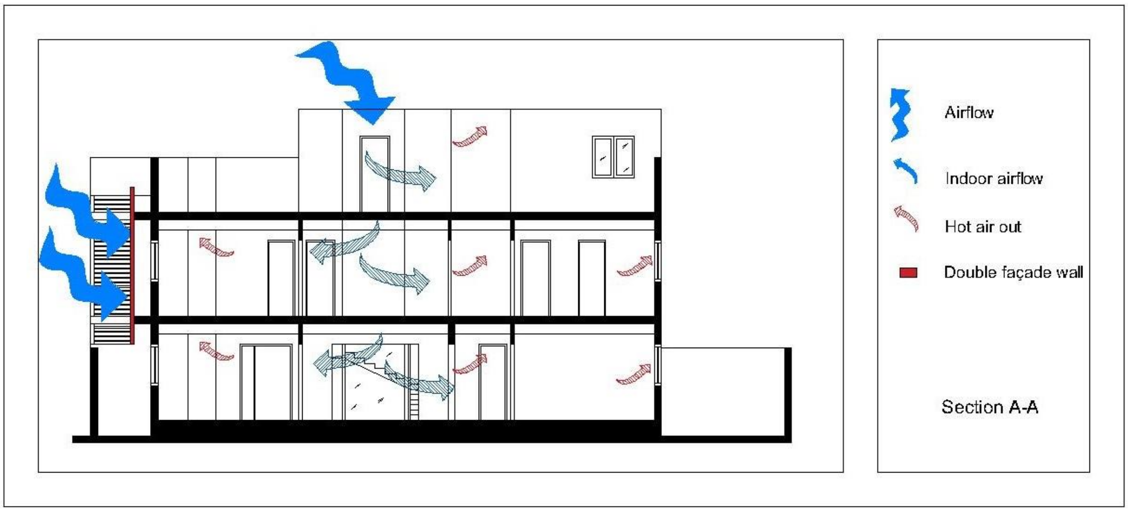

Figure 151 airwave design proposal, airflow, section A-A (Author, 2018)

CD copy of the research