ENERGY-EFFICIENT, REGIONAL BUILDING DESIGN APPROACH: LESSONS FROM DAMASCENE VERNACULAR ARCHITECTURE

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ABSTRACT

ENERGY-EFFICIENT, REGIONAL BUILDING DESIGN APPROACH:
LESSONS FROM DAMASCENE VERNACULAR ARCHITECTURE

Ghaid, Atik

Architecture Master's Program

Supervisor: Assist. Prof. Yiğit Yilmaz

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The emergence of advanced technologies, globalization and modernization policies has affected architectural and urban practices negatively. Nowadays, buildings are considered the major source of greenhouse gas emissions and global warming. The urgent need to reduce energy consumption and design more self-sufficient buildings have made some countries comply with the Kyoto protocol. The directive of building's energy performance (EPBD, 2002) that was published in 2002 has emphasized two aspects: reducing energy consumption and improving energy efficiency in buildings. Moreover, the published recast of the directive (2010) has decided that all buildings after 2020 have to be self-sufficient 'nearly-zero energy' buildings. Nevertheless, the building sector in Syria is accounted for 50% of total energy consumption. Furthermore, Syria is relying on fossil fuels to generate energy since the country has yet to develop renewable energy capacity. Nowadays, the energy sector is in chaos due to political conflict. Therefore, architects should enhance building performance and design energy-efficient buildings that can be achieved by referencing vernacular, regional strategies and understanding the dynamics of the region's inhabitants to achieve environmental sustainability goals and to create meaningful places.

This dissertation is drawing on damascene houses, accordingly, a comprehensive analysis of the vernacular architecture and modern architecture of the city is conducted to propose an energy-efficient, regional design guide for the hot-arid climate of the region. Hence, the dissertation starts with discussing a brief contextualization of the

previously done literature, it continues with the second chapter, which is providing a comprehensive analysis of the vernacular dwellings in Damascus in terms of the early settlements and the implemented regional, passive strategies. The third chapter is discussing regionalism in architecture, architectural identity, and the socio-cultural aspects that are affecting energy consumption. Thus, the chapter is investigating the tangible and intangible dimensions of Damascene buildings, besides; the abandoned vernacular strategies are discussed. After the first three chapters, the data is collected to propose design strategies in chapter four that could cope with the user(s) and the climate. Finally, a new design that is relying on an existing representative case is proposed. Thus, the dissertation aims to provide an energy-efficient, regional guide model for architects to follow.

Keywords: Energy-efficiency, Regional architecture, Vernacular dwellings, Damascene houses, Architectural identity.

ÖZ

ENERGY-EFFICIENT, REGIONAL BUILDING DESIGN APPROACH:
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Ghaid, Atik
Architecture Masters Program

Supervisor: Assist. Prof. Yiğit Yilmaz

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Gelişen teknoloji , globalleşme ve modernleşme politikaları, mimariyi ve kentsel uygulamaları olumsuz etkilemiştir. Günümüzde binalar, sera gazı salınımı ve küresel ısınmanın en büyük kaynağı olarak değerlendirilmektedir. Enerji tüketimini azaltma ve daha fazla kendi kendine yeterli binalar tasarlamaya yönelik acil ihtiyaç, bazı ülkelerin Kyoto protokolüne uymasını sağlamıştır. 2002 yılında yayınlanan Binaların Enerji Performansı Direktifi (EPBD, 2002) iki adet konuya vurgu yapmıştır: Binalarda enerji tüketimini azaltmak ve enerji verimliliğini arttırmak. Ayrıca direktifin yeniden yayınlanan düzenlenmiş hali (2010), 2020 yılından sonra Avrupa Birliği'ndeki tüm binaların kendi kendine yeterli 'sıfır enerji binaları' olması gerektiğine karar vermiştir. Bununla beraber, Suriye'deki inşaat sektörü ülkedeki toplam enerji tüketiminin %50'sini oluşturmaktadır. Ayrıca, ülkede henüz yenilenebilir enerji üretimi olmadığından dolayı, enerji üretimi fosil yakıtlara dayanmaktadır. Günümüzde enerji sektörü siyasi çatışmalar nedeniyle kaos içerisindedir. Bu nedenle mimarlar, çevresel sürdürülebilirlik hedeflerine ulaşmak ve anlamlı yerler yaratmak için yerel, bölgesel stratejileri ve bölge sakinlerinin dinamiklerini anlayarak bina performansını arttırmalı ve enerji bakımından verimli binalar tasarlamalıdır.

Bu tez Şam evlerine dayanmaktadır, buna göre, bölgenin sıcak-kuru iklimi için enerji verimli, bölgesel bir tasarım rehberi önermek için şehrin yerel ve modern mimarisinin kapsamlı bir analizi yapılmıştır. Bu nedenle, bu tez, daha önce oluşturulmuş literatürün kısa bir tartışmasıyla başlar, Şam'daki yerel konutların tarihsel gelişimi ve uygulanan bölgesel, pasif stratejiler açısından kapsamlı bir analizi ileikinci bölüm devam eder. Üçüncü bölümde, mimaride yerelliği, mimari kimliği ve enerji tüketimini etkileyen sosyo-kültürel yönlerini tartışılır. Bu nedenle, bu bölüm Şam yapılarının somut ve soyut boyutlarını incelemektedir. Ayrıca, terkedilmiş yerel stratejiler tartışılır. İlk üç bölümden sonra, dördüncü bölümde kullanıcı(lar) ve iklim ile başa çıkabilecek tasarım rehberi önermek için veriler toplanır. Son olarak, şu anda var olan temsili bir konut yapısı üzerinden sunulan tasarım rehberi uygulanarak enerji verimli bir tasarım önerilmiştir. Böylece tez, mimarların takip etmesi için enerji bakımından verimli, yerel kaygılar taşıyan bir tasarım rehberi ortaya koymaktadır.

Anahtar Kelimeler: Enerji Verimliliği, Bölgesel Mimari, Yerel Konutlar, Şam Evleri, Mimari Kimlik.

In loving memory of my father, Dr Salah Atik who was fascinated by Damascus and its vernacular architecture “you will always be remembered and in my heart’. Words cannot express how grateful I am to my mother Dr Bayan Abdulmunem, whose love and prayers surrounded me, without her encouragement and support I would not become what I am today. I hope I have made you proud

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Chapter 1

Introduction

1.1 Motivation

"Do you know how a human can live in a bottle of perfume? Our house was that bottle…Those who lived in Damascus, and strolled around the narrow lanes and alleys know how paradise could open its arms for them without waiting…" (Our Damascene house, Nizar Qabani)

Arab countries are known for their architectural and urban legacy, where traditional vernacular architecture was common in the region. However, at the end of the 20th century, these countries have witnessed radical changes on several levels, as a result of the emergence of globalization policies, advanced technologies and oil exploration in many of them. These changes had a deep impact on the inhabitants and their relationship with the built environment.

Unfortunately, Damascus the capital of Syria is one of those cities that witnessed radical changes that affect the inhabitants' dynamics. Moreover, its vernacular regional houses were replaced with modern ones, which could not serve the users, arouse the sense of individuality, or respect the environment. Nowadays, the building sector is accounted for 40% of energy consumption (Cao, Dai, & Liu, 2016), the percentage urged developed countries to plan protocols that could reduce energy consumption which helps decrease greenhouse gases. Thus, the main aim of these protocols is to deal with the global warming issue by improving the energy performance of building stock through net-zero-energy buildings concept.

The main motivation of the study is, to investigate how the vernacular dwellings of Damascus achieved reflecting the identity of the region, cope with the dynamics of the inhabitants and be in harmony with the climate, topography, and used natural resources as the main source of energy. Moreover, how vernacular architecture evolved building strategies and techniques to serve the inhabitants and the environment; for instance, Al- Mashrabiya serves the traditions 'intangible dimension' the sense of privacy and the 'tangible dimension' passive design element since it reduces direct access to sunlight at the same time

Having discussed the motivation of the study, the thesis is seeking to connect the theory and practice of energy-efficient sustainable design, by investigating the tangible and intangible dimensions and strategies of vernacular dwellings in Damascus to propose a 'new design guide', which gathers the discussed aspects to present an energy-efficient, regional building that serves the user and evokes the sense of individuality.

1.2 Problem Definition and the Aim of the Study

Since the last third of the 20th century, the Arab world started to be negatively influenced on the architectural and urban level. The traditions, architectural identity and crafts started to fade in the region day by day. Besides, modernization and globalization policies have led to the emergence of inappropriate architectural and urban practices in many countries and historical cities, such as the case of the thesis "Damascus" under the name of modernity.

As a result, the vernacular dwellings in Damascus "the Damascene houses" and their main elements were mostly being replaced by more "modern" ones or neglected, such as the core of the vernacular Arab houses that used to link the interiors, and helped improve indoor environmental quality 'the courtyard'. However, with the absence of the courtyard in the new apartment houses, we can highly witness a large spreading of balconies all around the city, which could not function, or act like the courtyard did with reducing energy consumption or ensuring the required privacy. Therefore, the new damascene "copy, pasted" houses could not cope with today's needs of achieving thermal comfort, reducing energy, or reflecting the identity of the region and the users.

Consequently, the thesis aims to study the vernacular dwellings of Damascus in a hot arid region, its formation characteristics, elements and strategies to propose a new design approach "guide model" for contemporary architecture to help enhance building performance and reduce energy consumption. According to Hasan Fathy's saying, "Once you have mastered the craft, you can use it for whatever purpose you choose." Thus, the thesis is drawing on the 'traditional architectural practices' and 'the identity' of the region to produce regional buildings that reflect local values and evoke a sense of uniqueness. Finally, the dissertation aims to create a point of intersection where the theories of the region's identity, Syrian culture, and contemporary energy-

efficient design practices meet; as a contribution of the evolution of the vernacular to today's architecture.

1.3 Scope and Research Questions

This thesis is focusing on three main research areas while investigating the vernacular dwellings: Identity, site characteristics, and design practices, to achieve the thesis aims and propose a new design. Indeed, investigating the dynamic interaction of the mentioned research areas manage to reveal crucial points: Firstly, how the early settlements in old Damascus and the form of the vernacular house are directly affected by the traditions, identity and daily habits of the inhabitants. Secondly, how the mentioned effective elements would help to achieve contemporary energy-efficient buildings. Moreover, the Climate responsive design approaches of the house are analysed, to propose design solutions for contemporary buildings and reduce energy consumption. Thus, the dissertation hopes to foster the recognition of regional self-efficient buildings among the studied area, by bringing together diverse methodologies and concepts while studying it.

The chapters of the thesis focus on the mentioned research area and connect the concept of identity and theory of place with energy-efficient design practices *(Figure 1).* Besides, the study focuses on vernacular residential buildings in Damascus, Syria. Hence, settlement characteristics, building features, and passive design strategies of the vernacular architecture and a brief on the current architectural practices are highlighted, discussed and included to present a suitable design approach (an improved design model of vernacular architecture for the capital of Syria).

Research area in studying the vernacular architecture 'Damascene houses' to propose a new regional energy efficient-design

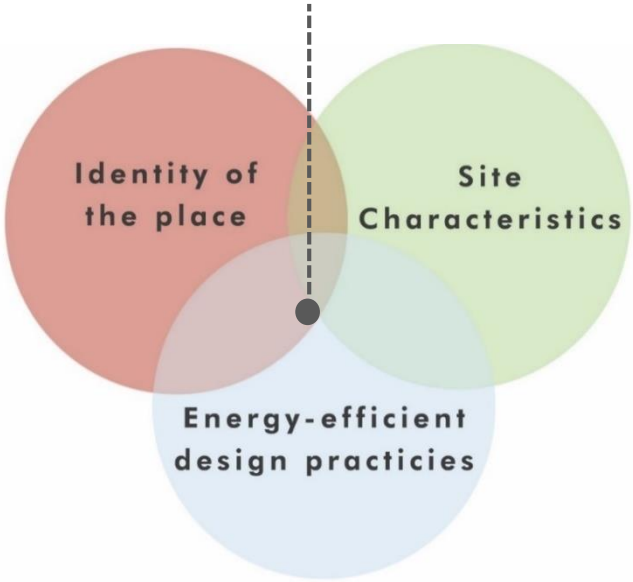


Figure 1. Research context (Author's own).

Achieving energy efficiency, relying on regional sources, reflecting the dynamics of the inhabitant, emphasizing the local identity, and the tactile dimension of a place are the main aspects to achieve "regional, net-zero energy buildings". Hence the main questions of the research are:

1. Can the vernacular architecture of Damascus present a model of sustainable design for contemporary buildings in the hot-arid climate of the city to enhance buildings performance, reduce energy consumption and reflect the local values?
2. What are the main elements and strategies from vernacular Damascene houses that contemporary buildings should evolve and follow?
3. How studying the identity and dynamics of the place "vernacular dwellings" could improve the process of achieving energy-efficient regional buildings?
4. How to link the identity of a place, the dynamics of the inhabitants and energy efficiency to propose new approaches for regional, energy-efficient residential buildings?

1.4 Methodology

This thesis employs a scientific, analytical, cultural framework that synthesizes vernacular architecture practices, energy efficiency, and cultural studies. The major goal of the thesis is to investigate the identity of Damascene vernacular dwellings and their climate-responsive features, which can be applied to enhance the energy efficiency of contemporary buildings, in particular the residential sector in a hot arid climate. Hence, the research methodology of the thesis relies on two main stages.

1. Damascene architecture analysis
2. Design guide and new design determination.

The first stage includes a comprehensive, analytical literature review on Damascene vernacular dwellings. Furthermore, energy efficiency in Damascene courtyard houses and a critical 'regional architectural' discussion on today's damascene dwellings are the main searched aspects of the analysis. Indeed, a review of the dynamics and the mechanisms of the mentioned aspects helps to provide a sensible framework to achieve thesis aims and tackle the problems. For the first step of Damascene architecture analysis, energy-efficient features in courtyard damascene houses are studied and investigated carefully. The second step of this stage discusses the concept of identity, regionalism in architecture and the tangible and intangible of home to criticize today's damascene dwellings and rethink vernacular abandoned strategies in the region.

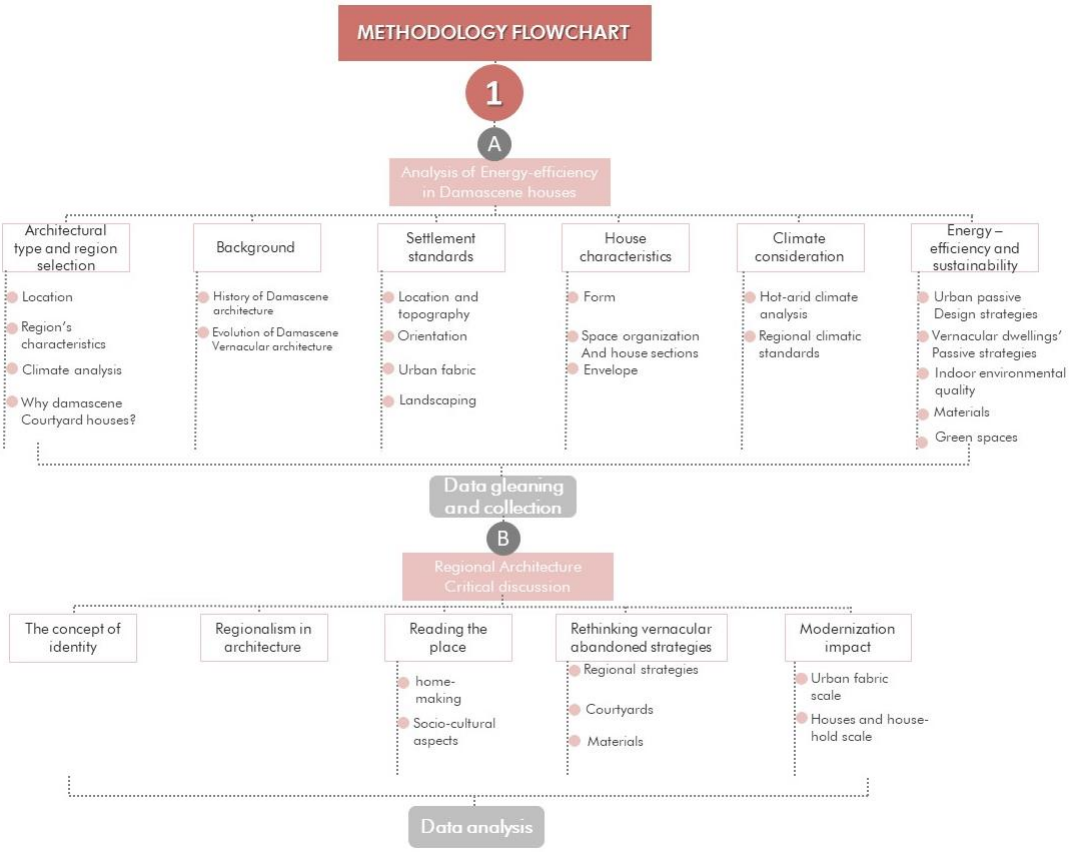
The second stage represents a new design proposal 'energy-efficient, regional building'. Thus, the thesis is suggesting a design guide that copes with the region's climate and traditions. Moreover, it is presenting a representative case study of a modern villa in Damascus and tries to tackle the problems in the case's performance in terms of (thermal comfort, visual comfort and privacy).

The design proposal part of the thesis includes:

1. Design guide: The first step suggests design strategies that could be implemented in the region to enhance the urban and architectural performance in hot arid climates. Furthermore, these strategies are proposed by taking into consideration the cultural background of the region.
2. Representative case study: this step presents a standard modern residential villa in Damascus), which reflects the situation of the dwelling building stock.
3. Representative case analysis: this step analyses the previously mentioned

modern, residential villa, in terms of the settlement, orientation, landscaping, materials, space organization, energy consumption, and envelope.

4. Re-using useful vernacular abandoned passive strategies: the discussed abandoned vernacular strategies in the first stage of the thesis (Damascene architecture analysis) are investigated in this step and re-used for the new proposed model to enhance energy performance and revive the identity of the region.
5. New design proposal: climatic vernacular features and the identity aspect are assessed in order to find the best solutions for a regional design, improve building performance, and reduce energy consumption. Drawings of the layout are provided. Furthermore, passive, and socio-cultural strategies are considered as a guideline for this step. The design proposal is based on the representative case's dimensions, spaces and heights to tackle the current problems in the house *(Figure 2).*



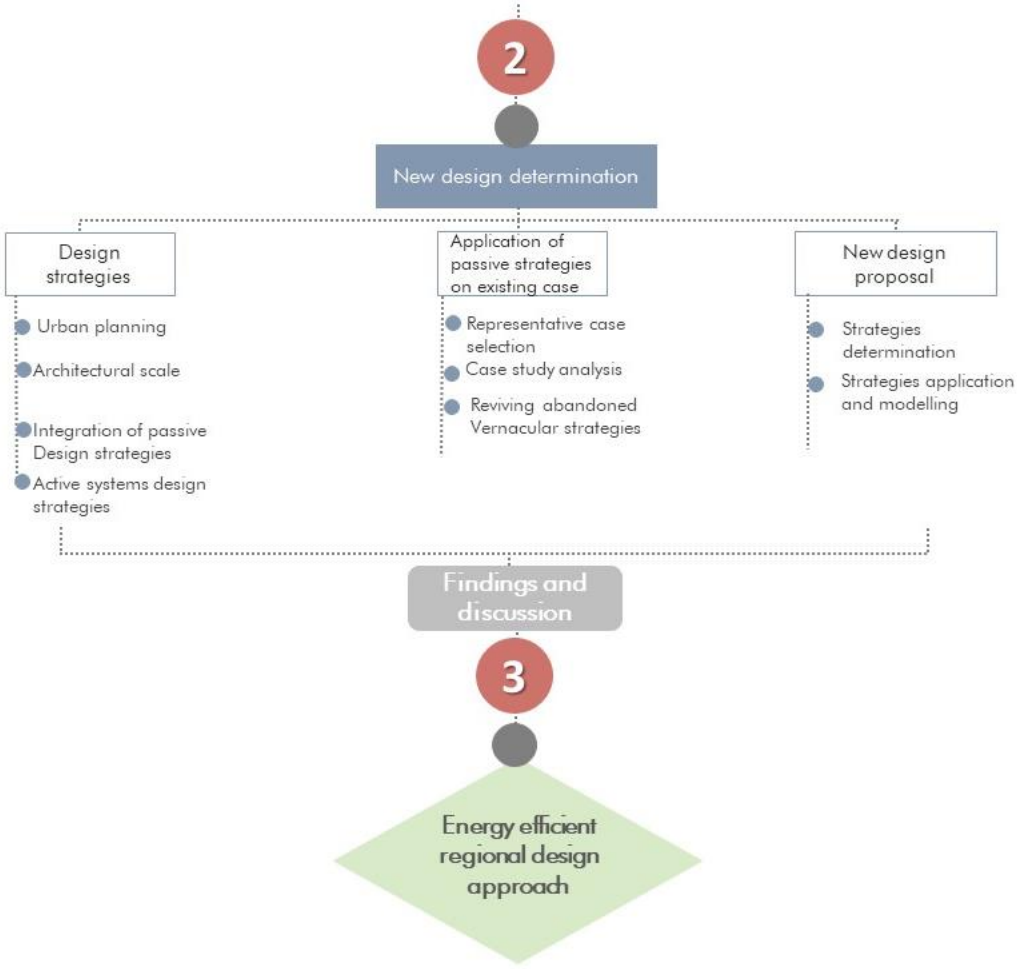


Figure 2. Research methodology flowchart (Author's own).

1.5 Thesis Outline

This dissertation starts with explaining the aims of the study, its questions, limitations, scope, the problem of the thesis and its methodology. Moreover, it highlights the main motivation behind choosing this topic. Then, it continues with a brief contextualization of the previously done literature. Hence, the literature review is presenting an introduction to the main discussed topics, which are (the concept of identity, regional architecture, vernacular architecture, and energy efficiency in buildings). The following chapters look closely at Damascus city and its vernacular dwellings in terms of the mentioned topics in the literature review.

The second chapter of the thesis provides a comprehensive analysis of energy performance in the vernacular dwellings in Damascus (Damascene houses). Moreover, early settlements standards, house characteristics, climatic

considerations, passive design, and materials selection are investigated and provided in detail in this chapter.

The third chapter discusses regionalism in architecture and vernacular architecture; besides, it tries to read the place (Damascene houses) by analysing the tangible and intangible dimensions of home. Accordingly, socio-cultural aspects are discussed in terms of architectural practises to critically rethink the abandoned strategies of the vernacular dwellings, and investigate the condition of today's Damascene houses.

The fourth chapter of the thesis presents a new design approach for hot-arid residential buildings in the region. Indeed, the new approach is relying on the literature review, vernacular architecture of the region, and the dynamics of the users to provide an energy-efficient regional home.

Finally, the fifth chapter presents briefly the findings of the whole study, furthermore, it provides a guide model for architects to follow and to design better energy-efficient, regional buildings in Damascus. Accordingly, the study helps to reduce energy consumption in a hot arid climate and to reflect the values of the region, based on a comprehensive analysis, theoretical and modelling applied studies.

In sum, the thesis is establishing an understanding of the meaning behind the architectural form, features and passive strategies of vernacular dwellings in Damascus, by investigating the architectural details in vernacular homes. This study reveals that there is a direct connection between energy efficiency and the socio-cultural aspects of architecture. Furthermore, the findings reveal the hidden identity and passive dynamics in Damascene homes, which are usually misunderstood or ignored. The thesis argues the bonding relationship between the region, inhabitants and the built environment to achieve energy efficiency. These aspects are proved and discussed in detail in the following chapters.

1.6 Limitations

Syria has been living under unstable political circumstances since 2011, which has affected the quality and quantity of research in many fields including architecture. As a result, a lot of data was not always accessible due to the lack of publication. Hence, some of the discussed topics in the thesis were hard to be found, such as the current energy performance in modern residential buildings. Therefore, the thesis relies on the found sources. In addition to the difficulties, the study has some limitations that must be taken into account and addressed in future studies.

First, the study focuses on investigating Damascene houses that are located on a flat site. Hence, it limits the generalizability of the study since residential buildings on sloped sites are not included. However, the suggested design strategies in the design guide chapter can be implemented in residential buildings in hot arid climate regions with flat sites.

Second, the study analysed the performance of singular family houses in Damascus including the vernacular and modern. Accordingly, some of the suggested design strategies and the findings of the study are limited to singular family houses in hot-arid climate.

Finally, more research data collection tools could have been used to add more credibility and reliability to the research. Simulations, questionnaires and surveys would have added a more authentic and understandable environment if they had been used, especially for providing a clear insight into the region and its inhabitants' desires.

1.7 Literature Review

Nowadays, we can witness the increasing desire in studying energy efficiency in architecture and the performance of buildings since consuming energy in buildings is playing a major role in causing climate change. However, there is a limited number of studies that are linking energy efficiency to regionalism and the identity of the region and its inhabitants. Accordingly, this section is discussing the done literature in the mentioned research areas to combine them in the study and to validate their effect on each other.

1.7.1 Introduction to the concept of architectural identity. “Only once have I been made mute. It was when a man asked me, who are you?” (Gibran, 1926).

What Identity is? What does it consist of? What forms it? How can we define someone/something? What are the aspects that distinguish someone/something from another? And What affects it? All these questions were asked and have been a subject of study by many fields for a long time. Indeed, Architecture is one of these fields. Where architects tried to define the identity, and solve its dilemma by finding the answers to the mentioned questions. Kevin Lynch has mentioned in his book the image of the city: “Identity is the meaning of individuality and oneness… Identity is a case where an object is unique” (Lynch, The Image of the City, 1960). Where others were linking it to the physical or spatial parts of the built environment, therefore, the built environment is considered as an important tool that reflects the identity of the region (Yilmaz & Maz, 2006).

Relph has mentioned that “The main characteristics which form spatial identity are the physical structure forming the space, the facilities it embodies, and the meanings created by users.” (Relph, 1976) However, there is a direct connection that links between people, identity, and the built environment. Hence, he stated that a ‘place’ is not just a location (Relph, 1976) . Furthermore, Juhani Pallasma redefined the house when he said, “A house, in fact, is a metaphysical instrument, a mythical tool with which we try to introduce a reflection of eternity into our momentary existence” (Pallasmaa, The Geometry of Feeling: A Look at the Phenomenology of Architecture , 1986).

Genius loci is another term that is used by authors to refer to the identity of a place. The term is a Roman concept that was defined by Christian Norberg-Schulz, the genius loci is ‘*what a thing is'* or what it *‘wants to be’.* (Norberg-Schulz, 1976). Thus, it creates the spirit of the place and transmits its meaning to the user and observer. Additionally, the built environment is the mirror that reflects the culture, the inhabitants’ dynamics, activities, and it clearly reveals the history, ethnic and religious settings of each region. Thus, it creates the hallow of ‘uniqueness’; which is the ‘essence’ of the concept of identity. Besides, architecture is the key element that transmits the cultural identity from one generation to another, to benefit from their tangible and intangible building

expertise to create sustainable self-efficient dwellings that arouse the sense of ‘placeness’, and being at ‘home’. The architectural identity of a place is both affect and can be affected by the local community and the geographical location in many ways (Yilmaz & Maz, 2006).

Consequently, it can be deduced that the architectural identity or the character of a place could be understandable through these three main elements: The physical form (patterns of the buildings), the social life of the users, and space organization *(Figure 3).* Furthermore, identity is a combination of the built environment physical and spiritual elements and their characteristics that distinguish it from other places. Hence, considering the mentioned elements together forms what we call ‘Regional Architecture’.

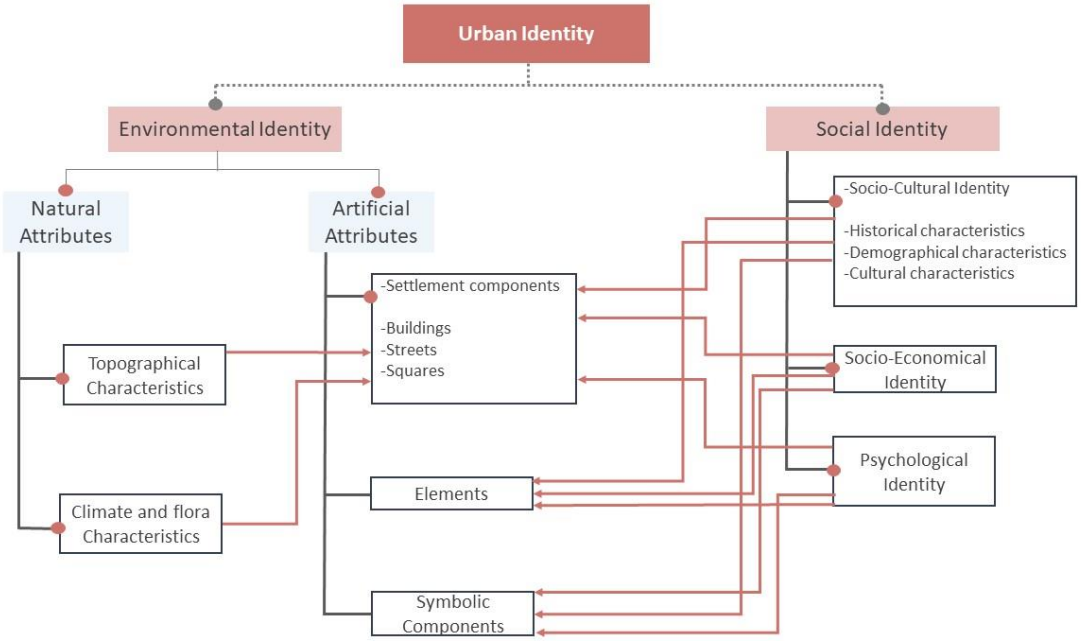


Figure 3. Urban and architectural identity components (ÖKESLİ & Gürçınar, 2012).

1.7.2 Regionalism and vernacular architecture. Regional Architecture is based on the strategies and techniques that were transmitted from the former generations that lived in the same region. Moreover, the formation and construction of a regional ‘dwelling’ or ‘place’ is depending on the: local materials, climate, physical characteristics of the region, the cultural structure and the dynamics of the inhabitants (Erarslan, 2018) . This harmonious combination has created sustainable dwellings that reflect the culture, and serve the user efficiently to provide a comfortable place and it has strengthened the relationship between the users and their homes. Thus, it is the purest architectural reflection of the region’s traditions, heritage patterns, and experiences (Erarslan, 2018). However, Vernacular Architecture is one of the most popular physical forms of Regional Architecture.

The word ‘vernacular architecture’ has appeared for the first time in 1861 (Collins, 1965). Vernacular as a term is defined in the Cambridge English language dictionary as ‘Local’, ‘Native’, or a ‘common thing’ in a particular ‘region’ or ‘place’ by a particular ‘group’ (Dictionary, 1995). Accordingly, vernacular architecture is the type of architecture that uses local materials, sources and construction techniques, while considering the inhabitants’ dynamics, traditions, and climate type; to create a bonding relationship between people, buildings, and their surrounding environment. Thus, vernacular architecture has succeeded in creating meaningful places that serve users social and physical needs ‘spatial and sensory’, evoke the sense of home and touch the earth lightly (Salman, 2019).

According to (ICOMOS, 1999) the built vernacular heritage is important; it is the fundamental expression of the culture of a community, of its relationship with its territory and, at the same time, the expression of the world's cultural diversity…vernacular building is the traditional and natural way by which communities house themselves. Furthermore, Paul Oliver wrote in his essay (Round the Houses): “There is something cosy about vernacular architecture…there’s not the craftsmanship anymore” (Oliver, Round The houses, 1983).

It is highly noticed that Vernacular dwellings have less embodied energy than modern and contemporary ones since it uses local materials, due to the lack of transportation capacity in the past and it is mainly depending on natural

sources (the sun is the main source of lighting, natural ventilation for cooling…). Indeed, each region has created a type of housing that fits with the local climate, topography and considers the activities, traditions and needs of the users as the main references for creating and organizing the spaces of the dwellings 'Human-centred design'. (Chandel, Sharma, & M.Marwah, 2016)

Unfortunately, modern architecture and modernists have prided themselves with the base element, or the foundation of logic that "form follows function" it was more sensible to them than following the former old techniques. However, "function" in modern architecture is more related to the structure and circulation of the building, where it rarely referred to the environmental (energy usage, climate-changing) or cultural issues as minor problems at best or it is not considered at all. As a result, energy consumption and climate change are among the most important issues that are facing the earth today (Lechner, 2014).

Nowadays, the increasing interest in reviving vernacular and regional architecture strategies and elements by architects and authors is highly noticed. Some has argued that contemporary architecture is unable to communicate with the users "No building today is capable of arousing feelings like the ones the Cathedral of Strasbourg did in the heart of the first Romantic Regionalist" (Tzonis & Lefaivre, Why Critical Regionalism Today?, 1990). Besides, the same authors (Tzonis & Lefaivre, 2016) believe that critical regionalism would help to reflect the culture and arouse the sense of individuality and oneness that universal architecture couldn't.

In some cases, regionalism and vernacular architecture were linked to environmental sustainability to learn from it while designing new buildings "Critical regionalism necessarily involves a more directly dialectical relation with nature than the more abstract, formal traditions of modern Avant-garde architecture allow" (Frampton, 1993). Additionally, Alexander Tzonis and Liane Lefaivre wrote that "this is the case of optimally composing buildings as shelters, respecting regional environmental constraints, and accepting regional resources" (Tzonis & Lefaivre, 1990).

Interestingly, we could notice that throughout history most architects or local builders have considered environmental controls in their buildings and designs. Moreover, the need for natural cooling, heating, and lighting has affected the form and the design of buildings (Lechner, 2014). Furthermore, the

usage of regional resources and renewable energy (energy efficiency in buildings) is an important common element between vernacular regional architecture and the goals to achieve net-zero energy buildings. which is discussed in the following section.

1.7.3 Energy-efficiency and passive design. In 2018, the proportion of the global population that has access to electricity has increased to 90%, but still, 789 million people lacked electricity; where most of them are living in rural areas (UN, 2020). Indeed, the continuing rising percentage of the global population urges countries to find solutions and access to cheap, clean energy. Unfortunately, in 2018 about 82% of the consumed energy came from fossil fuels (IEA, 2020). Furthermore, relying on fossil fuels as the main source of energy is harming both human health and the surrounding environment, where some of the countries like Arab countries have yet to develop renewable energy capacity which is 10% lower than the total average of the world's generated renewable energy which in 2018 was about 18% of the total consumed energy (IEA, 2020). The previously mentioned facts have urged countries and organizations to design and publish protocols in many fields that would reduce greenhouse gases and offer green energy for everyone.

The building sector is accounted for 40% of energy consumption in the USA and European countries, where this percentage may raise in some developing countries (Cao, Dai, & Liu, 2016). The urgent need to reduce energy consumption and design more self-sufficient buildings have made some countries comply with the Kyoto protocol. The directive of building's energy performance (EPBD, 2002) that was published in 2002, has emphasized two aspects: reducing energy consumption and improving energy efficiency in buildings (Rodriguez-Ubinas, et al., 2014). Moreover, the published recast of the directive (2010) has decided that all buildings after 2020 have to be self-sufficient 'nearly-zero energy buildings' (EU, 2010) . Indeed, this protocol is aiming at reducing energy consumption, greenhouse gases, and it encourages using renewable energy.

To achieve 'Net zero-energy buildings' or 'nearly zero-energy buildings', buildings must improve their performance and increase energy efficiency by reducing the consumption to zero or very low amount of energy which can be recovered by generating the energy that the users need from renewable sources

(Rodriguez-Ubinas, et al., 2014) Some of the recent researches are stating that considering the passive design and the climatic conditions of the region are the keys to achieving energy efficiency in buildings, where contemporary low energy buildings must consider hybrid energy systems to reduce energy consumption as shown in *(Figure 4)* (Edwin Rodriguez-Ubinasa, Rodriguez, Voss, & S. Todorovic, 2014).

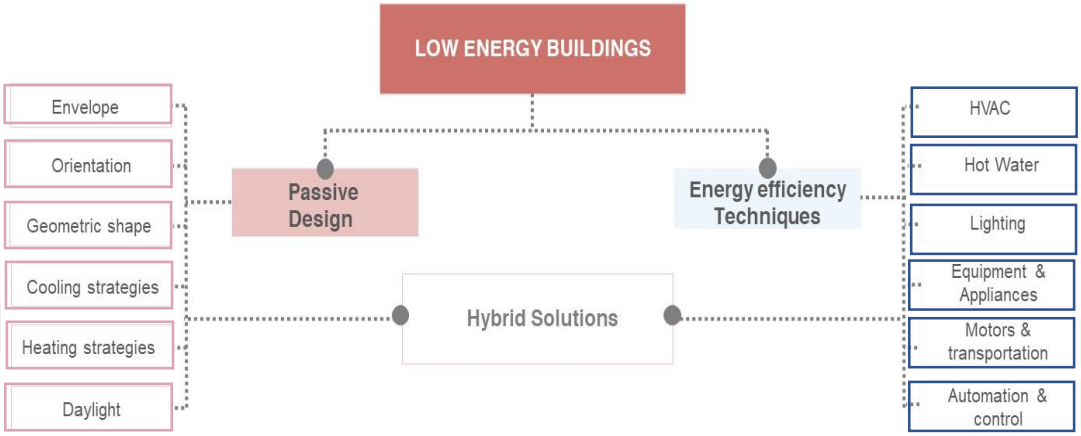


Figure 4. Hybrid solution for low energy building (Edwin Rodriguez-Ubinasa, Rodriguez, Voss, & S. Todorovic, 2014)

International Energy Agency (IEA) has mentioned in the Oil crisis & climate challenges book, most of the energy consumption is related to mechanical systems that would help to maintain a comfortable indoor environment quality and protect buildings from the outer climatic conditions (IEA, Oil Crises & Climate Challenges: 30 Years of Energy Use in IEA Countries, 2004). Additionally, optimizing the design process and enhancing building performance to minimize heating and cooling loads, is more influential than using HVAC systems (Todesco, 1996) . Hence, there is a direct connection between energy consumption, thermal comfort, and passive design.

Additionally, passive heating, cooling, and lighting can be more easily achieved through understanding the logic of the three-tier approach to sustainable design that Norbert Lechner mentioned in his book “Heating, cooling, lighting: sustainable design methods for architects” *(Figure 5)*,

1. The first tier is consisting of all the decisions that the architect makes while designing any building. When the architect makes the right decisions and considers reducing energy consumption this stage could help the building to accomplish about 60% of the heating, cooling and lighting by itself.

2. The second tier includes the use of natural sources and energies, such as passive heating, cooling, and daylighting strategies. Proper decisions at this stage can help to reduce energy consumption by about another 20%.
3. The third tier is consisting of the mechanical and electrical equipment and its collaboration with the previous tiers to be as efficient as possible. This important point can save another 5 % or so.

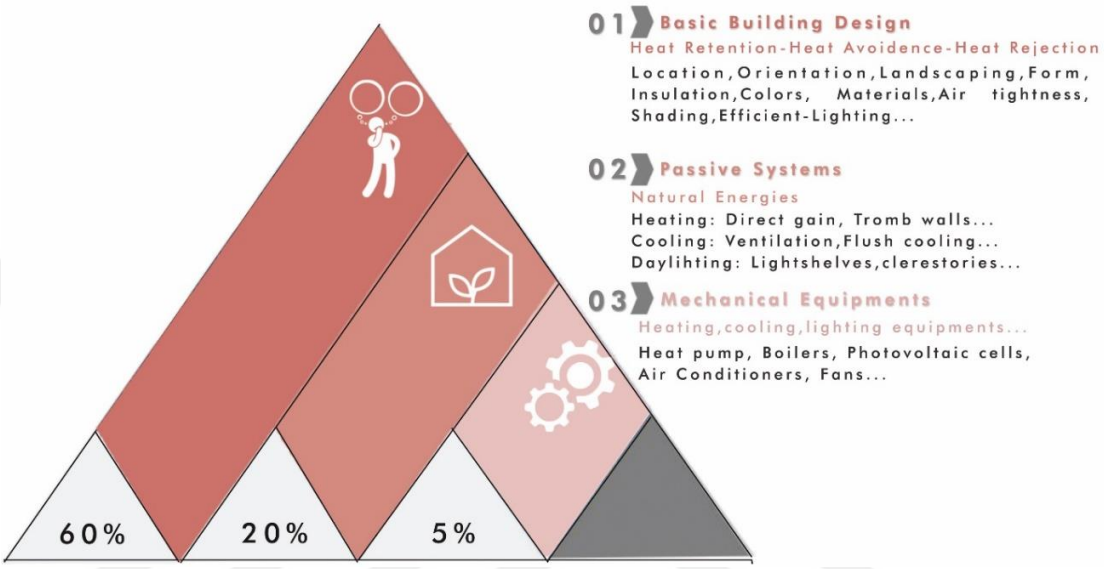


*Figure 5.*The three-tier approach to sustainable design (Lechner, 2014).

The heating, cooling, and lighting aspects of each building design always involves the mentioned three tires whether the architect consciously considered it or not (Lechner, 2014).

Unlike the hidden mechanical and electrical systems, passive cooling and heating devices can directly affect the form of the building and its envelope. Shading devices, for instance, are the visible part of the exterior aesthetics of the envelope, which is considered a very important part of the building, since the building could experience a very dynamic environment. Hence, the choice of the building envelope could affect not just the aesthetic part of the building, but also thermal comfort and energy consumption.

Accordingly, the building envelope is one of the main elements of 'climate-responsive design' or 'passive design' since it shapes the limits between the interiors and the exterior condition. Thus, selecting it carefully is one of the effective ways to help to minimize energy consumption (Rodriguez-Ubinas, et al., 2014). Moreover, the thermal performance of the building's envelope has to change according to the climatic conditions to make full use of the natural

sources, such as solar energy and wind to create a thermally comfortable indoor environment. Considering structures such as Trombe walls with control of the airflow or adding building components that could change the thermal performance with automatic or artificial controls such as moveable louvres are some effective additions to the building envelop which architects should consider for creating efficient climate-responsive buildings that would help reducing energy consumption (Xu, et al., 2020).

Nevertheless, designing for a certain climate is further complicated, because the needs and loads of heating and cooling change from one building type to another. For instance, houses need fewer cooling loads than office buildings in the same climate type (Lechner, 2014). Hence, understanding building use, its indoor comfort necessities, and the dynamics of a certain building that fit with the users can help design better places that facilitate people's lives and improve indoor environmental quality. Besides, considering thermal zones while planning and designing would manage to reduce heat loss, since interiors are divided according to their function, using ours, etc. Thus, it helps to reduce energy consumption (Gut & Ackerknecht, 2011) . It is very important to consider passive design's main elements (building materials, orientation, envelope, the geometry of the building…) while designing NZEB. Hasan Fathy wrote in his book Natural energy and Vernacular architecture, the recent sustainable, energy-efficient buildings are learning from vernacular architecture techniques. Moreover, they are referencing 'building upon climate-responsive strategy, since considering indoor environmental quality 'thermal comfort' and using renewable energy as the main sources for the house is the core of vernacular architecture (Fathy, 1986). Furthermore, to achieve thermal comfort within the building architects have to understand the environmental and cultural conditions that allow heat or cool to be lost,

1. Air temperature (°C).
2. Relative Humidity.
3. Air movement (m/s).
4. Mean radiant temperature (MRT).
5. Clothing pattern of the people in the region.

As have mentioned, insuring a thermally comfortable indoor environment would help to enhance building performance and reduce energy consumption. Hence, including efficient passive cooling and heating techniques help to achieve the goals of NZEBs. There are many strategies of passive cooling and heating each one of them valid for some climatic conditions (Rodriguez-Ubinas, et al., 2014). Moreover, these passive strategies help to avoid undesirable outer climatic conditions, by taking advantage of the available sources and techniques in the building's location such as getting advantage of solar radiation with thermal mass or benefiting from the wind by installing wind catchers to cool the building down in summers (Gut & Ackerknecht, 2011). Besides, the shape, usage or installation technique of passive cooling and heating strategies may change from one region to another depending on the dynamics and the needs of the inhabitants.

Consequently, to achieve thermal comfort in summers architects have to consider the three passive cooling tier design approaches (Lechner, 2014), these tiers are *(Figure 6):*

1. The first one consists of all the possible strategies that designers have to involve to avoid heat gain, the strategies at this stage may include (shading devices, vegetation, colours orientation, openings, natural light, insulation, control of heat sources, etc.)
2. The second tier is using passive cooling systems including the use of air movements such as 'wind catchers' to improve thermal comfort and the temperature of the indoors.
3. In some types of climates, it is not enough to just use the first and second-tier to achieve thermal comfort within the building. Hence, the third tier is required to maintain the temperature. The third tier is mechanical and electrical equipment. At this stage, the mentioned equipment has to cool what the first and second-tier could not achieve to minimize energy consumption.

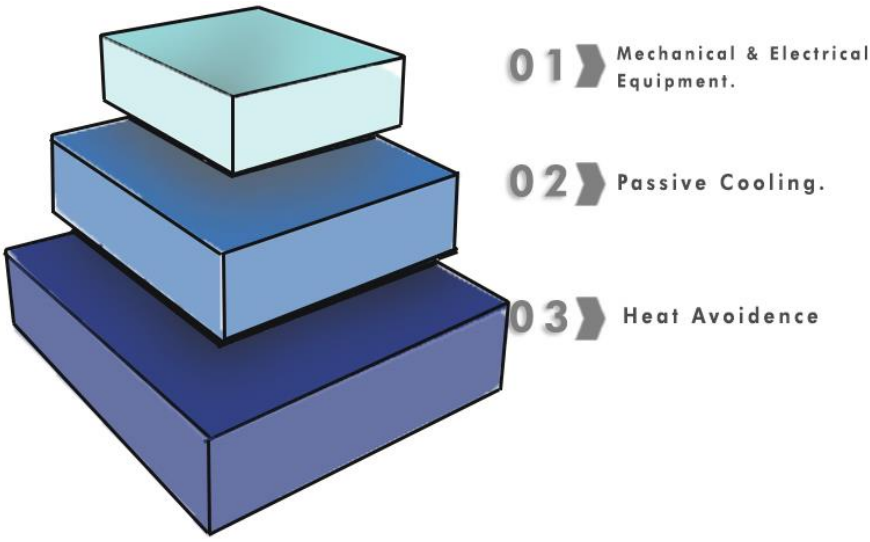


Figure 6. The three-tier approach for passive cooling (Lechner, 2014).

To achieve thermal comfort in winter we have to consider gaining solar heat. 'Passive solar' or 'passive heating' is a system function by collecting, storing and releasing solar energy to achieve thermal comfort without using any complex controls. It works by depending on the building elements to collect energy such as walls, floors, or windows (Gupta1 & N. Tiwari, 2016) . These main building components could function to satisfy the structural, architectural, aesthetics and energy requirements of the building, where walls may work to hold up the building and store heat at the same time. Additionally, there are many concepts for gaining heat such as:

- Direct gain (Southern windows)
- Indirect gain (Trombe walls)
- Isolated gain (Sun-rooms)
- Thermosiphon systems

Involving the three tiers of 'passive heating' or 'passive solar would help accomplish a sustainable design (Lechner, 2014), the three tiers are *(Figure 7):*

1. The first tier involves reducing heat loss in the building and its envelope by using proper insulation, calculating the area of total facade-to- the total volume, and considering airtightness. The better the designs are capable to keep heat, the less heating is required.
2. The second tier is depending on harvesting solar energy as possible with the help of passive heating elements.
3. The third tier is the usage of mechanical and electrical systems in some type of climates where the first and second tiers are not sufficient to heat the area.

In the USA, a passive well-designed building could save up to 80% of energy by just relying on natural resources. (Lechner, 2014)

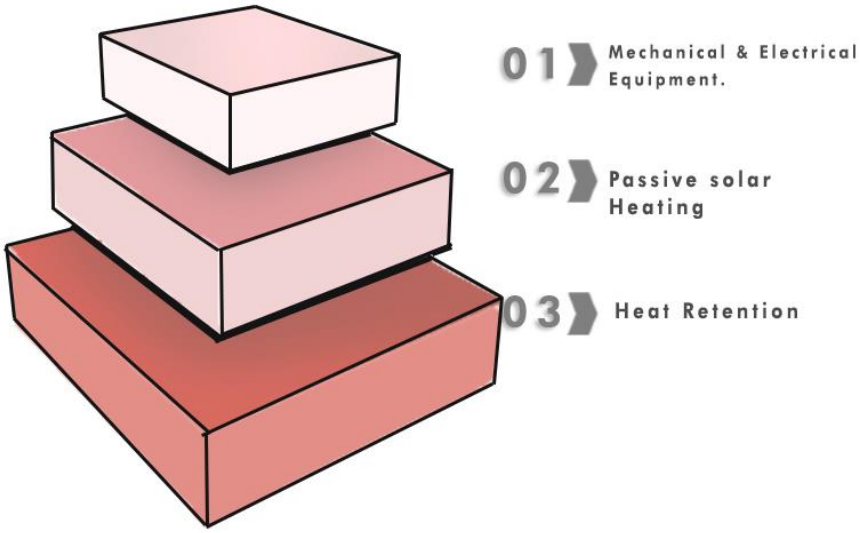


Figure 7. The three-tier approach for passive cooling (Lechner, 2014).

Indeed, it is important to predict indoor environmental quality in a built environment since thermal comfort models may enhance energy saving (Zhao, Lian, & Lai, 2021). However, lighting systems are responsible for 19% of global energy consumption (Han, et al., 2019). The energy efficiency of lighting systems varies depending on building type, lighting requirements and application strategies. In general, building lighting systems are divided into two separate schemes: passive lighting and active lighting. Whereas NZEBs are depending on natural light the most by simply using light guidance systems such as adding atriums in large buildings, benefiting from building's openings to collect the needed amount of light, or considering light shelves, etc (Han, et al., 2019). Moreover, architects must consider three aspects to achieve efficient lighting in their designs (Lechner, 2014) *(Figure 8)*;

1. The geometry of the design, and the colours of finishes
2. Daylighting
3. Artificial lighting

Sian Moxon mentioned in "Sustainability in interior design" book that, nowadays, there are many developed types of active lighting, which use less amount of energy than standard lightbulb does such as LEDs, or in some cases

like public buildings or shared spaces efficient lighting that is linked to movement, sensors would help minimize energy consumption (Moxon, 2010).

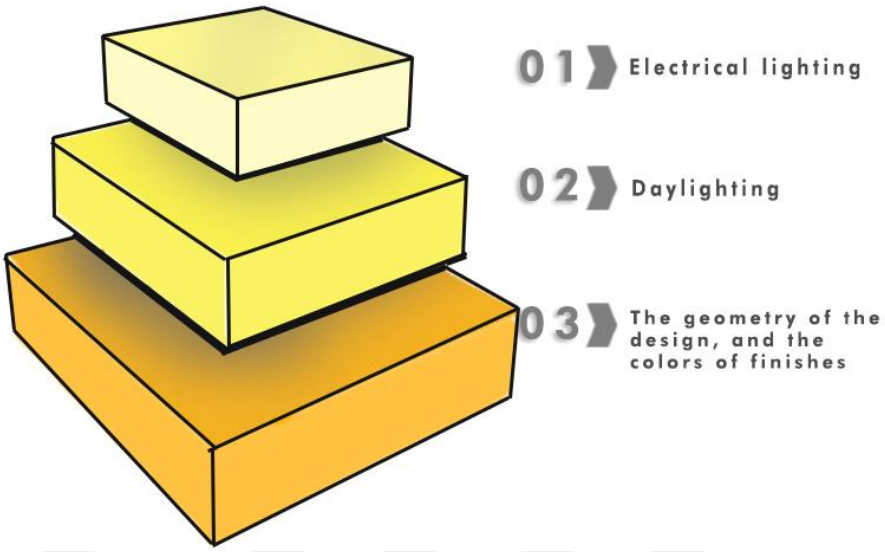


*Figure 8.*The three-tier approach for lighting (Lechner, 2014).

Having discussed the importance of reducing energy consumption, emphasized the identity aspect of the place and explained the main elements of vernacular and regional architecture. The following sections of the thesis are discussing in detail how we could achieve NZEB in Damascus while learning from its vernacular dwellings to reflect the cultural structure of the place while preserving the environment.

Chapter 2

Energy-Efficiency: Damascene Courtyard House Analysis

2.1 Damascus and Damascene Architecture Background

Damascus 'Dimashq' in Arabic, or 'Al Sham' which is the vernacular name of the capital of Syria, is located in the interior geographical zone of the country, 33º 30'to the north and rises 700 meters above sea level. The city is surrounded by a very fertile region called 'Al Ghouta', Qasiwn Mountain and anti-Lebanon mountains laying to the northwest. The mountains rise about 3000 m; as a result, it deprives Damascus of clouds and sea breeze to be considered as an arid region with rainfalls only during the months from December to February (Bosworth, 2007). Consequently, Damascus has a hot dry climate. Despite the dry climate of the city, it is blessed with the Barada River, which encouraged civilizations to settle and build their houses around it.

However, historians are not certain yet about the epoch when Damascus was founded, but according to UNESCO, excavations have revealed an urban settlement as early as 8000 to 10000 B.C (UNESCO, 2015). Historic Cities of the Islamic World book stated that the city is mentioned in Egyptian Pharos tablets as one of the cities that was conquered by them in the 15th century B.C (Bosworth, 2007). Thus, Damascus is considered one of the oldest continuously inhabited cities in the world. Moreover, the old city of Damascus has been listed as one of the world heritage sites by UNESCO since 1979 (UNESCO, 2015). Since Damascus is a very old city, it has been inhabited by many civilizations and became the capital and the centre of many. Hence, its architecture is influenced by the traditions and the dynamics of the people who lived in it.

Furthermore, the importance of the city comes from its rich history, layers of civilizations and its urban fabric. Mark Twain wrote that "Damascus measures time not by days and months and years, but by the empires, she has seen the rise and prosper and crumble to ruin. She is a type of immortality. Damascus has seen all that has ever occurred on earth, and still, she lives" (Twain, 1869) Consequently, the previously mentioned elements have shaped the very interesting urban combination of the city, which forms the collective

architectural identity of the region. For instance, the old city combines the narrow alleys of Islamic architecture and the grid system of the Greeks.

2.1.1 History of urban and architectural practices in Damascus (333 B.C- 1919). The complexity in the architectural and urban structure of Damascus is a result of millennia of building and shaping the image of the city. Indeed, the urban fabric of the city reveals continuity in the architectural evolution throw many eras that influenced the architectural practices from the Hellenistic till this day (Negila, 2012). However, the main difficulty that faced historians is to differentiate the architectural practices and the urban development in the pre-Islamic era due to the mutual practices and overlapping in the Greek and Roman periods. Indeed, this type of cultural interaction had a major role in creating the identity of the city.

Although Damascus was inhabited by old civilizations such as the Aramean and the Assyrian, archaeologists and historians never mentioned an architectural and urban development in that era. Thus, this section of the study starts with reviewing the history of Damascus from the beginning of the emergence of architectural and urban practices in the city (Hellenistic period) to the Ottoman period.

Greek 'Hellenistic' period (333 B.C). As cities are reflections of the dynamics of the inhabitants and they reveal the cultural structures, Damascus was firstly developed by Greeks following their urban and architectural style. The Greek city of Damascus is located within the walls of today's old city (Lababedi, 2008). In general, the roads network of Greek cities was developed following the planning methods of the Hippodamus of Miletus. Hence, Damascus had perpendicular straight streets intersecting with each other to create a semi-grid network, where each network included two main streets (Mansour, 2015). Furthermore, the width of the streets was half of the width of the vernacular houses. Greek cities' plans always had 'Agora' in the middle of the main intersected streets, which represent the city centre or a public place for gathering and shopping which is called in ancient Greece as seen in *(Figure 9*) (Burns, 2005). In Damascus, the regular size of the founded blocks was 45*100 m (Negila, 2012).

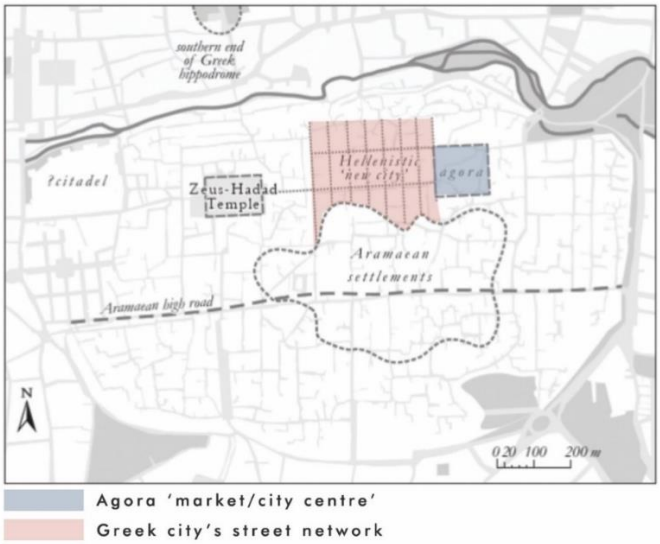


Figure 9. Hellenistic city in Damascus (Burns, 2005).

Moreover, vernacular houses were built in that era following the recommendation of Hippocrates to allow sun into the house (Waziri, 2004). Thus, Greek houses, in general, were built with a courtyard where it is divided into two types (Abass , Hakim Ismail, & Solla, 2016) *(Figure 10):*

1. The house with a central courtyard surrounded by house units (rooms), and opened to a corridor with columns.

2. Houses with courtyards/atriums near the street or in the back of the house.

*Figure 10.*Greek courtyard houses (Schoenauer & Seeman, 1962).

Roman period (64-B.C). The rapid increase in the numbers of the population in Roman Damascene city led to city expansion and urban development. Romans worked on improving the grid system of the Greeks, moreover, they shaped and built the walls of the city and its seven gates. The most important gates of the walled city are the eastern 'Bab Sharqi' and the

western ‘Bab Al-Jabia’, as a result of their location on the main axis street ‘Via Recta’ (Lababedi, 2008) *(Figure 11).* Furthermore, the first water supply system is considered one of the main important developed elements in the Roman city.

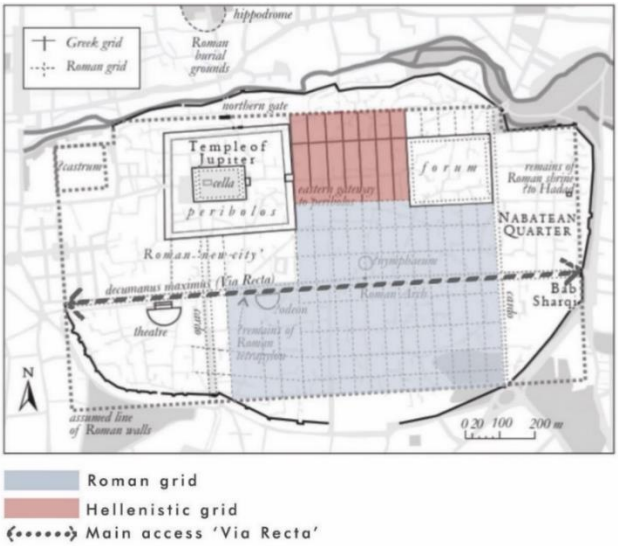


Figure 11. Roman city (Burns, 2005).

As for Roman courtyard houses, Romans inherited the techniques of the Greeks and the Etruscans. Thus, the houses were similar to the former Greek ones with some changes such as houses being inner oriented, the surrounded rooms windows were opened towards the courtyard area to provide more privacy *(Figure 12)*. Besides they developed the shape of the roofs from wooden Greek to arches and vaults (Bakeer, 2021).

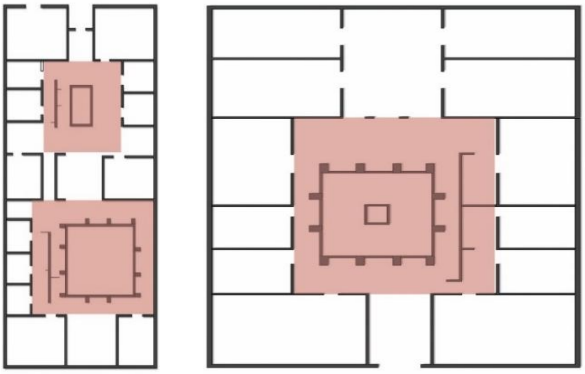


*Figure 12.*Roman courtyard houses (Schoenauer & Seeman, 1962).

In the Islamic period (661) Arab cities flourished and Damascus was one of them where caliphs worked on developing and expanding the city since it became the capital of the Umayyads. Hence, public facilities (hospitals, baths, markets and mosques) were established in that era. Public and worshipping buildings were ornamented and enormous, such as the Umayyad Mosque.

Generally, Damascus was developed following the compact organic pattern of growth, since architects in that era were applying climate responsive design strategies, houses were built in rows with deferent heights to prevent direct sun and create shadows (Lababedi, 2008). Moreover, the grid system of the city was developed to include narrow semi-roofed alleys to decrease the temperature and to create more shadowed areas. Yahya Waziri mentioned in his book that the percentage of the open space in Islamic cities was 11% whereas in Greek city was 27% and in Roman city was 31% of the total space (Waziri, 2004).

However, each house in that period had its own open private space (courtyards and atriums), these spaces provided the house with natural ventilation and lighting and it ensured privacy for the inhabitants. To decrease the noise within the city public facilities were located far from the residential neighbourhoods (Waziri, 2004). As have mentioned, courtyards were very popular, thus, they were considered in the residential and public buildings *(Figure 13).* Islamic Courtyard houses were more developed than Greek and Roman. Most of the courtyards had green spaces and a fountain in the middle to moisturise the dry air. Moreover, an additional section was considered called 'Al-Iwan'. Al Iwan or Liwan is a semi-opened area with a height of two stories covered by plants and oriental ornamentations or coloured stone 'Al Ablaq'. Al-Iwan provides a cool shadowed area for the users to gather (Bakeer, 2021).

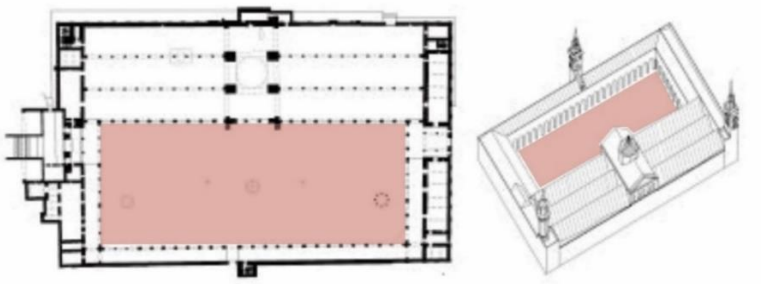


*Figure 13.*Great Umayyad Mosque of Damascus (https://yazargokcenur. wordpress. com).

In the Ottoman period (1516) Damascus added to its architectural layers a new one, the combination of the former architectural styles with the Ottoman created a unique urban fabric and architecture (Bakeer, 2021). However, Ottoman sultans were more interested in public facilities and mosques. Hence, they considered the Ottoman architectural style while building Al Tekkiya Al

Sulimania in Damascus, which is considered the finest masterpiece of ottoman architecture in Syria (Abdulrahman, 2008). Furthermore, public baths and palaces were very popular in that period *(Figure 14),* architects then worked on developing the interiors and courtyards. Hence, the interiors became more ornamented and larger, while outer facades remained very simple and humble. As previously mentioned, the urban plan of Damascus is a product of the lived settlers and their building strategies; however, according to Giulia Annalinda Neglia, the emergence of the final urban structure of Damascus was during the Ottoman rule (Negila, 2012).

Al-Tanzimat' of Damascus started in the last 60 years of ottoman rule. Thus, the city has witnessed several changes on the architectural and urban level, including the attempts to modernize the city and its master plan. The main aspects were considered during this period were,

1. Building new geometrical shaped suburbs.
2. Using stone material instead of wood while constructing.
3. Removing dead ends in alleys and widening main streets

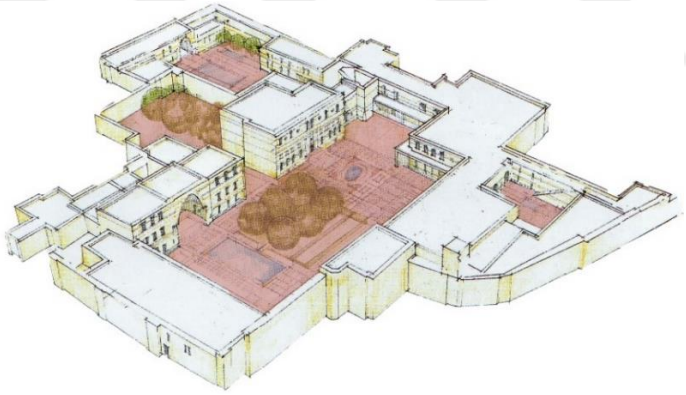


*Figure 14.*Al Azem palace (http://bornindamascus.blogspot.com/2020/12/).

2.1.2. Settlement standards. Human settlements are spaces or lands in which a group of people or a 'community' dwell, consequently, human settlements represent the relationship between people and nature; besides, they clarify their interaction with the surrounding environment (Cirella, 2021). The evolution of human settlements relies on both the built environment and the surrounding environmental elements (Tolba & El-Kholy, 2012). Many studies are focusing on the relationship between human settlements developments and energy (Hendry & Juselius, 2000) Accordingly, the human-built environment is responsible for consuming a considerable amount of energy annually.

Indeed, orientation, buildings type, materials, landscaping, urban fabric, building regulations and many other factors affect energy consumption and thermal comfort directly. Moreover, it is highly noticed that in most of the cities each neighbourhood creates its own atmosphere and local climate as a result of its built environment (Yahia & Johansson, 2013). Hence, some of these factors are discussed and analysed in the context of Damascene vernacular dwellings settlements in the following sections.

2.1.2.1. Location and topography. Indeed, the geography and the location of Damascus had a major role in determining the importance of the city. Damascus is situated in the south western corner of Syria, on a large plain about 700 m above sea level, at the eastern route of the Anti-Lebanon mountains, crossed by the Barada River (Rabbat, 2021) (*Figure 15*). With only an average of (178 mm) of precipitation annually, the Barada river and the strategic location of the city were natural attractions for early settlers. Thus, the early settlements appear to be in the western part of the walled city. Since the city is blessed with the river Barada, it is highly noticed that the name of Barada always accompanies Damascus in literature and studies.

Furthermore, Damascus started as a junction of a very important trade route and an important caravan centre as had mentioned in Egyptian and Accadian tablets. Besides, it is considered as an important node between Egypt (in the western road), Mecca (southern road), and Babylon (eastern road) (Lapidus, 1969). The early urban fabric form of the city started to be unfolded as early as 3000 B.C, where the walls of the city and its seven gates started to appear in the Hellenic era.

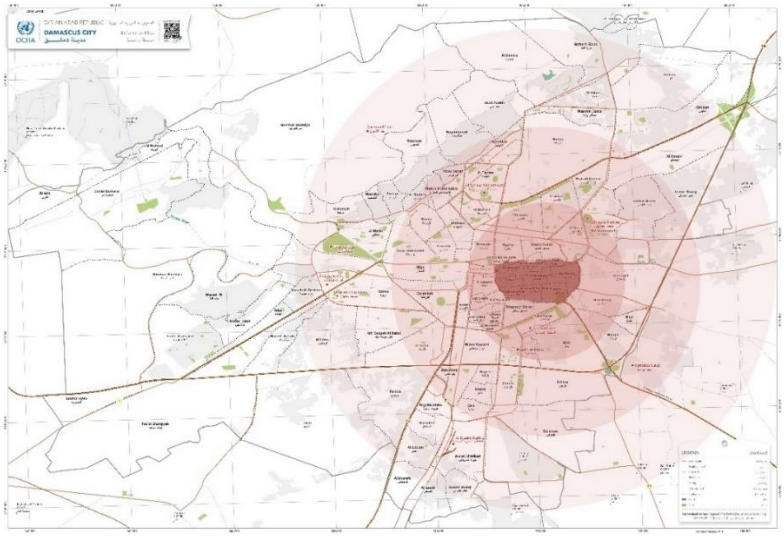


*Figure 15.*Map of Damascus. (https://reliefweb. int/sites/reliefweb. int/files/ resources/damascus_city_reference_map_20160922.pdf)

2.1.2.2. Orientation. According to Ross Bruns's book 'Damascus: A history', there is an early settlement in Damascus going back to 9000 B.C on a hill near the banks of the Barada River. However, there isn't a complete picture of how the settlements were, but it seems to be lightly populated then (Burns, 2005). Tell Ramand is the first site to be inhabited in the region and it is located in the southern hill (UNESCO, 2015). Nevertheless, Tell Al Salehiye which is located 25 meters above Damascus plain to the east, is the first site that has proven evidence to be inhabited going back to the bronze age. The hill of Tell Al Salehiye is a strategic location for the early settlers for defending purposes against enemies and natural conditions since it is located on the northern bank of the Barada River. Hence, it protects the inhabitants from undesirable desert sandstorms, where the location near the river provided moisturized breeze in the hot arid climate of the region (Burns, 2005).

However, the current walled city of Damascus is a little far from the early settlements on the hills where it is located on a plain on the southern bank of the river. The location of the walled city allows having moisturized fresh air from the river and Al Ghouta *(Figure 16).* Furthermore, the streets and the narrow-roofed alleys of the walled city are oriented towards 'north-south' and 'east-west' (Yahia & Johansson, 2013). The common architectural type of the old city's buildings is simple on the outside and rich on the inside, where all the sections of the building are oriented towards the inner courtyard or courtyards. Nevertheless, the modern buildings, which are located outside the walls of the

old city are mostly outside oriented towards the streets, where courtyards are absent and are replaced by balconies in these types of buildings.

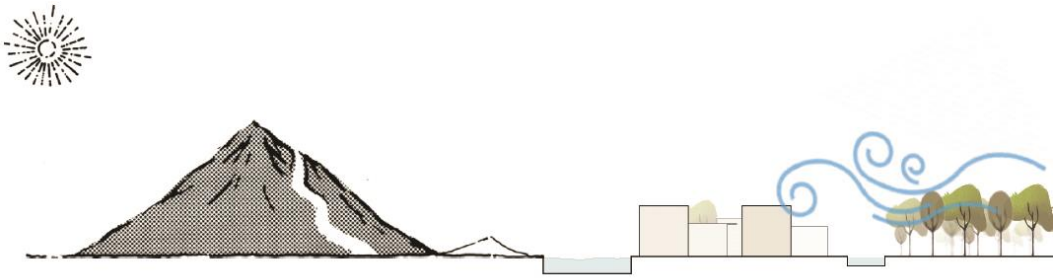


*Figure 16.*The geographical location and city's orientation (Author's own)

2.1.2.3. Urban fabric. The old city is located on a plain (flat region) with an oval shape, Medhat pasha street represents its long diameter which is about (1600) meters, and its short diameter is about (1000) meters extends from Al-Faradis gate to Al-Saghir gate. Hence, the city was limited by its rampart before the expansion towards the north-west and south (Al Sarouja souq and Al-Medan), where most of the buildings were located on the southern bank of the Barada river (Kabrit, 2000). As a result, oasis compact settlement was considered to reduce hot air and solar radiation (Gut & Ackerknecht, 2011). The city and its buildings were planned in a way that ensures shaded spaces in streets and alleys. Additionally, the fertile land that surrounds the city (Al Ghouta) and the Barada River are the two main geographical elements that represent the 'oasis settlement' of it; consequently, they provided the city with humid cool air.

However, the urban fabric of the city represents the physical components including buildings, streets, soft and hardscapes. According to Kevin Lynch's book "The image of the city", physical forms of the city can be classified into five main elements: paths, edges, districts, nodes and landmarks (Lynch, The Image of the City, 1960), each one of these elements is projected on the case of the old city of Damascus.

- Edges: the edges are the physical elements that prevent continuity. Hence, it represents the boundaries between two zones (Lynch, The Image of the City, 1960) the old city of Damascus is surrounded by ancient walls (rampart) and seven main gates that were built in the Roman era serving defensive purposes *(Figure 17).* However, these walls protected the city in old times from sand storms and it served the privacy aspect that was very important in Arab cities.

Inside the walls of the old city, edges and walls were absent in the alleys and quarters except for the grouped walls of the inhabitants' houses. Sometimes a big wall (edge) at the entrance of the main quarters (Al-harah) could be found. It can be distinguished with its arcades covering the beginning of the alley (Kabrit, 2000) providing it shade and the sense of transition to a new zone.

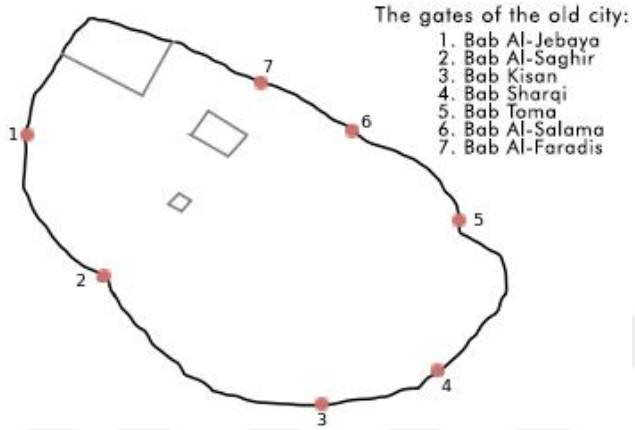


*Figure 17.*Old city's main gates (Translated and edited by the author).

- Districts: One of the main aspects that were considered while planning and building the old city is considering functional separation between residential quarters and commercial ones, since the city has a compact pattern, this aspect help to solve noise problems. Moreover, residential and commercial quarters could be distinguished by the design of their alleys (Waziri, 2004) Damascene districts (quarters) are connected, but independent. Each quarter of the city has its own facilities (mosques, baths, water distribution…) and the entrance of each one has a main huge door that could be closed in siege times (Kabrit, 2000) *(Figure 18).*

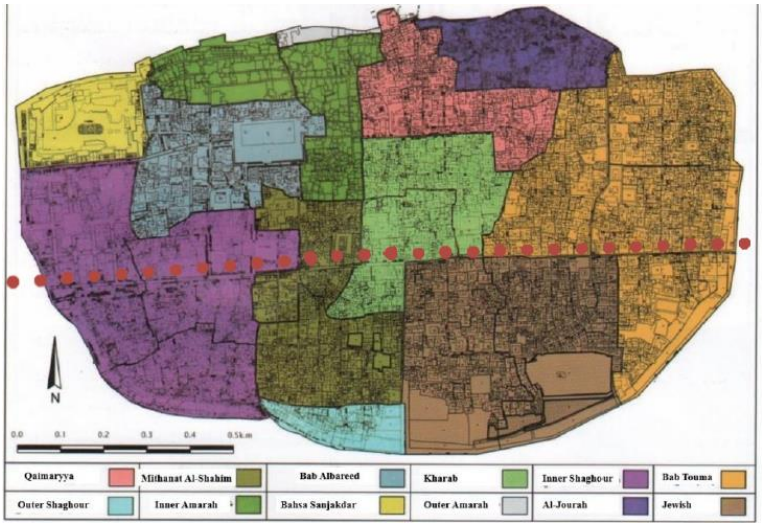


*Figure 18.*Districts of the old city (Bakeer, 2021).

- Paths: Paths are the channels that the inhabitants of the city use to move around it (Lynch, The Image of the City, 1960). The old city's paths evolved according to the evolution of the urban fabric of the city. Damascene-Roman city considered grid system oriented towards the east-west axis, which helped to minimize solar radiation that could occur in grid system cities in hot-arid climate. Moreover, it enhanced ventilation and air movement within alleys. However, in the Islamic era, the city expanded and evolved narrow, zigzagging, and dead-end alleys were considered to provide more shaded zones that help to minimize high temperatures in summers. Besides, such alleys reduce the stormy wind's effect (Gut & Ackerknecht, 2011).

Some parts of the alleys are roofed by a corridor that connects two houses called Sibat. The function of Sibats varies from one to another some are used as a bedroom for the new groom in the family others are functioning as a connecting corridor between two houses *(Figure 19).* Sibat helps to create shaded zones within alleys, besides; it improves air movement between the houses that are connected to it since it passes air from one direction to another (Waziri, 2004).

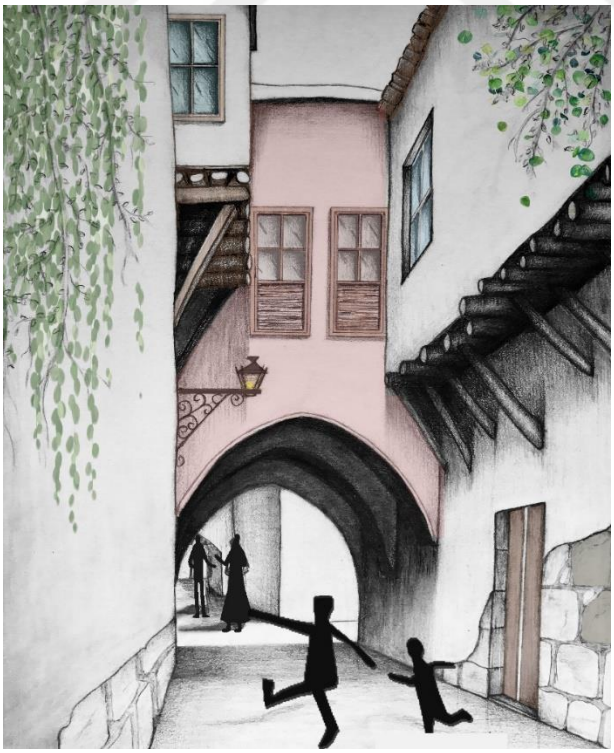


Figure 19. A sketch of sibat in old Damascus. (https://tr.pinterest.com /pin/ 373306256617933543/, edited by the Author).

Old Damascus has two main parallel streets that pass by it from west to east, the first one is Medhat pasha street and the second one is Souq Sarouja. All alleys leading from north to south are perpendicular to it. Paths or alleys of the old city could be categorized into three types according to the Damascene house book:

Al-Darb (The path): is the first one that represents the main passing node in the quarter. Al-Darb connects with the rest of the alleys from its ends.

Al-Zokak (The alley): is narrower than Al-darb and it is branching out of it to connect with another one.

Al-Qanah (Dead-end alley): It is very narrow about 130 cm; hence, it only allows two people to pass. Al-Qanah is branching from the alley (al-zokak) and it ends on the doors of houses. (Kabrit, 2000) *(Figure 20).*

Indeed, these types of paths (straight, parallel, and blocked ones) open the city to natural ventilation and prevent sudden temperature differentiation from day to night and from summer to winter.

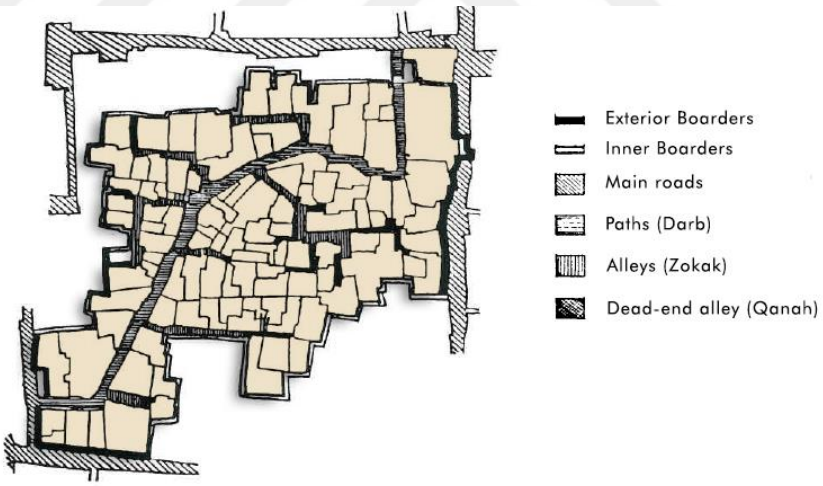


Figure 20. Paths and boarders in Al Nakashat quarter (Kabrit, 2000).

- Nodes: they are the strategic points of the city, which can change according to the inhabitants' daily dynamics and the node's function since it is the concentration point of the city. It is usually an intersection point between two main streets or paths. Thus, nodes can be square, street, corners, etc. There are two types of nodes in the old city of Damascus:
  1. Outer main nodes: these nodes are created by intersection between the path Al-darb the main street. These types of nodes are leading towards and out of the district quarter. Al-Miskiya square can be considered as an outer

node. Moreover, it is located near the main souq of the city Souq Al-Hamidiya and it contains some remains of Jupiter temple that dates back to the Damascene-roman city.

2. Inner nodes: it can be created by a little path widening where all others zokak and alleys are leading to it. As a result, it creates a small organic shaped square inside the quarter near to main public facilities (mosques, baths, etc).

- Landmarks: they are the main symbol of the city where people recognize the city by it, or give its name as a point reference for a location. Landmarks are physical objects (monuments, buildings, stores, mountains, etc.). In the case of Damascus, landmarks buildings can be distinguished from other ones by their huge size, ornamented elevations, and richly decorated interiors, hence, it gives the landmark building a monumental dimension. Moreover, it gives the city a unique touch since the outer elevations of Damascene houses are grouped and monotonous. The following sections are analysing the interiors and the exteriors of Damascene houses.
  The most important landmarks of old Damascus are presented in (*Figure 21),*

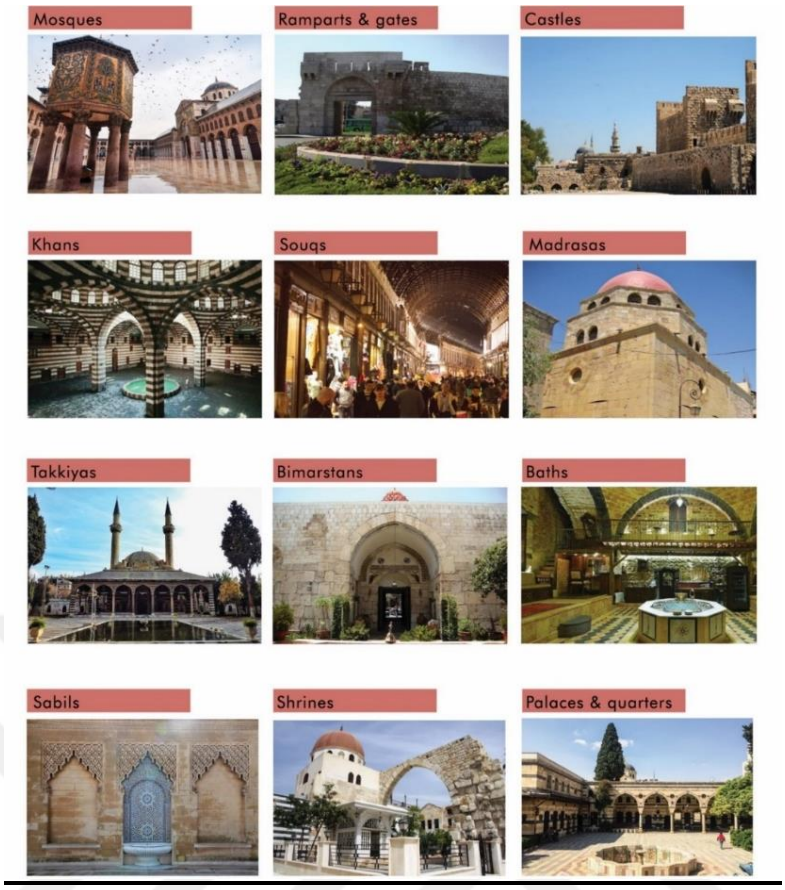


Figure 21. Main landmarks in Damascus (pictures were collected by the author).

2.1.2.4. Landscaping. The landscape of the city is considered one of the main tools that people use to enhance the surrounding environment and local climate. Hardscape and softscape are the two main pillars of landscaping design.

- Hardscape represents the unchangeable elements through time "mostly built environment" such as rocks, paths, streets, etc.
- Softscape represents the changeable elements through time "natural surrounding environment" such as trees, vines, plants, etc.

As have mentioned earlier, early settlements in Damascus were located near important geographical elements (oasis, green areas, rivers sea, etc.). Ross Burns mentioned that "if there were no Barada river there could be no Damascus" (Burns, 2005). Indeed, the river and the surrounding Ghouta attracted early settlers, since Al-Ghouta provides the city with vegetables, fruits and raw materials. Moreover, Al-Ghouta is known for its fruitful trees such as apricots, walnuts, peaches, cherries, berries etc. Ancient historians considered Al-Ghouta as "the paradise on earth" (Hafteh, 2012).

Evergreen and deciduous trees are common in public places around the city, which purify the air from dust, moisturize it and provide shading during summers. Where in winters, they prevent fast temperature dropping which could occur at night. The most planted trees in Damascus are: willow trees, palm trees, lindens, poplar trees, bead-tree, and bushes and in some areas outside the city windbreakers are noticeable.

Gardens and green open spaces are the setting of urban life in Damascus. Thus, damascene houses inside the walls of the old city are a small-scale version of Al-Ghouta. Unlike the modest alleys of the old city, Damascene houses were rich on the inside with their plants and decorations; each house has its own garden within the walls of the courtyard. Indeed, considering proper shading was the main aim for damascene houses to reduce direct sunlight in the hot arid climate of the city and to enhance thermal comfort around the house. Accordingly, they considered water surfaces in the middle of the courtyard "fountain" and different types of plants for aesthetic and thermal purposes. The plants inside Damascene houses can be classified as Woody plants (evergreen trees, vines), shrubs, bushes, and ground covers (Table1).

Table 1

Plants in the Courtyard of Damascene Houses (Author's own)

Number	Name	Example	Physical Characteristics	Function	Location
1	Woody plants "Evergreen trees"	Citrus trees (Bitter orange, Kabbad) and Loquat.	Evergreen trees remain green and they don't shed their leaves in autumn. Evergreen trees resist moisture loss in summers and cold in winters.	Evergreen trees and plants help to maintain appropriate temperatures throughout the year. Hence, it protects the house from cold winds in winters and high intense solar radiation in summers.	Evergreen trees and plants are usually located near the northern inner elevation of the courtyard. Sometimes it can be found in the east and west parts of the courtyard.
2	Woody plants "Vines"	Ivy, plants, Cissusstriata grapevines, and Wisteria.	Vines are climbing plants that could spread in different directions covering many hard surfaces to look like a soft one.	Vines plants are used in Damascene houses to control erosion, covering man-made structures (walls, windows, and pergolas) and protecting them from direct sunlight. Thus, it acts as a shading device when planting it near pergolas.	Vertical vines are usually found covering the inner eastern and western elevations of the courtyard. These vines ensure thermal insulation and shadow the inner windows of the house units that are opened towards the courtyard.
3	Shrubs	Damascene jasmines, roses, Angel's trumpets, Bougainvillea	Shrubs usually are no longer than 3m. Some are seasonal and others are evergreen.	Shrubs are usually used for aesthetic purposes; besides, they help moisturize the air, block low sunlight and it has positive psychological benefits for the dwellers.	Shrubs are usually located on the northern side of the courtyard facing the "Iwan".
4	Groundcovers	Spiderworts, Amaryllis, Bassia scoparia, Sprenger's asparagus.	Groundcovers usually reach 15-30 cm height.	They are planted to give aesthetic touches to the landscape. Moreover, they help eliminate erosion and ensure thermal comfort.	They can be planted in any area of the courtyard to fill the gaps between trees and shrubs.

2.1.3. Houses' characteristics. The Damascene vernacular architecture depends on creativity in the design and using natural materials smartly, to improve climatic conditions inside and outside the housing unit. Moreover, each Damascene house has developed its spaces to serve the users efficiently. It is highly noticed that damascene houses are very simple and humble on the outside except for the doors of some palaces. Additionally, the row of the houses shaped the alleys and the paths of the city. Indeed, there are common characteristics for these houses. Thus, the following headlines are discussing these characteristics in terms of form, space organization and the envelope.

2.1.3.1. Form. The courtyard house's design was inherited from the Roman culture and the nomadic gathering of Arabs tents, where they tend to locate their tents during their movement in the shape of a circle with a center in the middle to serve the privacy aspect and to ensure them shelter and security (Al Abidin, 2006). Therefore, the courtyard house fulfilled the deep-rooted need for an open area inside the house that connects people with the surrounding environment and the sky (God). Furthermore, the courtyard has a positive effect on the microclimatic level. In this respect, Damascene houses are the physical expression of the inhabitants' needs, beliefs and inherited cultures.

Damascene houses were evolved following the compact type of building to ensure security and privacy aspects of the home. Houses are built in the shape of a square, rectangle or sometimes overlapping squares. The units of the house are inner oriented towards the courtyard, where courtyards are usually built in a rectangular shape and the long axis of the rectangle is often oriented towards the east-west. Moreover, the ratio of the length to the width is usually 1:0.52, since Syria is lying on the (33.30) line of the equator (Salkini, Greco, & Lucente, 2017). Therefore, such calculations were used to guide architects with increasing the shaded area and improving thermal comfort in these vernacular dwells *(Figure 22).*

However, Damascene houses differ in their design, space organization and area according to the economic situation of the family and the number of its members. Some of the houses were built inside the walls of the old city and some outside. Damascene houses have five types:

1. Houses with multiple courtyards.

2. Houses with multiple courtyards and stories.
3. Houses with one courtyard and multiple stories.
4. Houses with one courtyard and one story.
5. The modern house.

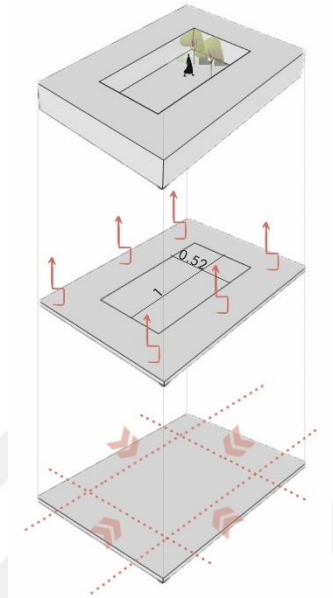


Figure 22. Damascene courtyard house form diagram (Author's own).

2.1.3.2. Space organization and house sections. The vernacular Damascene house is considered a centralized organizational type of shape since all the rooms are grouped around the central courtyard and oriented towards it. As have mentioned earlier there are several types of Damascene houses. Accordingly, in this section, the common house sections are discussed.

Some houses have a basement, which you can reach using stairs located in the kitchen or near it. The basement was used mainly to store food supplies and it acts as a thermal moderator (Al Abidin, 2006). The ground floor of Damascene vernacular houses is usually comprising,

1. the entrance section, the location of the entrance differs from one house to another, but it is usually located on the eastern or the southern elevation of the house. The entrance section has 2 main components which are: the main door, the house could be entered from the alley using a modest wooden door the width of the opening is about 80-90 cm, but some houses have a bigger copper-covered door called "Khoukha" which has a smaller door inside the big one where the user can enter (Kabrit, 2000).Al Dihliz is a small narrow corridor that separates the inner space (the courtyard) from the outer

one (the alley) which provide the users with the privacy they need since it acts as a transit space that reveals the rich well-ornamented interior of the house (Al Abidin, 2006).

2. Courtyard(s) section. The courtyard is considered as the main section in the house and the essence of it, besides, it is the main interactive section in the house. The courtyard of the house adds an aesthetical dimension to the house and it is a multipurpose space in the house, where families can gather, hold night events, and have dinner. Furthermore, it enhances the thermal condition of the house and its relation with the surrounding nature, which are discussed in other sections in detail. The courtyard contains one of the main sections in the house, which is; Iwan/Liwan is considered one of the most important architectural elements in the house. Al Iwan is a three-walled space located mostly on the northern elevation of the courtyard opened towards it. Iwans are raised from the courtyard with one or more steps; hence, it provides a platform for family gatherings and night events. Moreover, it is two stories in height with an arched ceiling where its walls are finely decorated and ornamented. Accordingly, Iwan is always shaded as a result of its location, where the moisturized breeze of the fountain and citrus trees improve the hot temperature of summers. (Kabrit, 2000).In some houses, more than one Iwan could be found.
3. Living section, each Damascene house has several living areas some are built for family members and others prepared to host guests. Additionally, in big houses (palaces) the ground floor is separated into two sections one for the family called (Haramlik) which includes housekeeping rooms (Khadamlik), and the other one is for guests called (Salamlik). Each one of these sections has a courtyard and Iwan. Consequently, these sections include the living rooms called, Al Qaah, which is a room or a hall that is prepared to host guests, hold events, parties, and family gatherings (Ferwati, 1992). There are two types of Qaah according to the season Qaah for summer and other for winter. The summer ones are usually located on the northern elevation of the courtyard next to Iwan to get benefit from the moisturized

breeze of the northern air (Kabrit, 2000). The other ones are located on the southern elevation to face winter's sun rays that ensure warm temperatures in winters (Bakeer, 2021). Al Qaah may include different levels to ensure airflow within the room. Besides, summer Qaahs has a fountain on the lower level of the room. Qaah is distinguished by its luxurious local decorations and materials, where its walls are covered with marble, wood and stone carvings and the ceilings are rich with its coloured ornaments (Kabrit, 2000) Some Qaahs have private doors that led to stairs for the second floor or to the Khadamlik room.

4. The kitchen, it is usually in the shape of a rectangle in some houses it has the shape of a square, where it is usually located on the dead corner of the house west or north-western part (*Figure 23*).

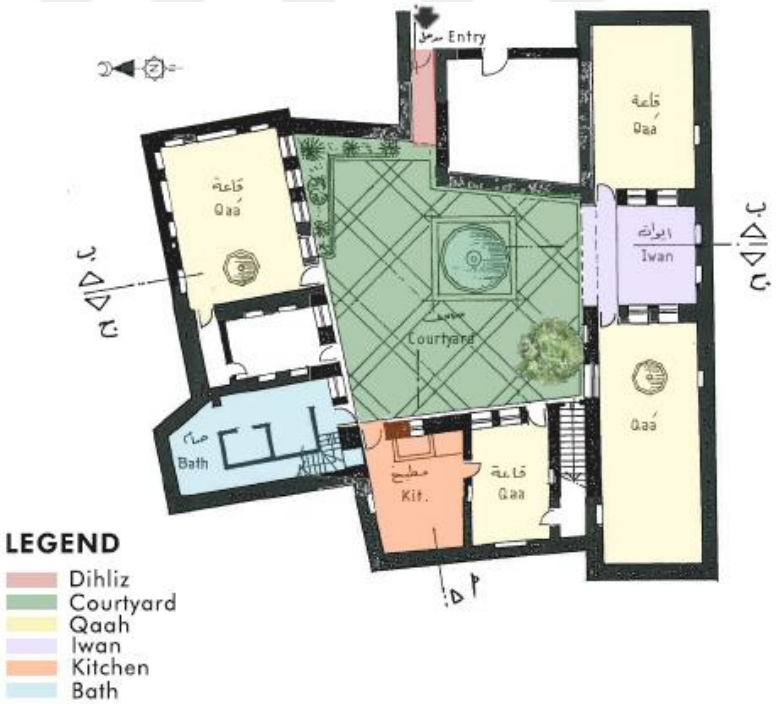


Figure 23. The ground floor of Al-Tabaa house (Kabrit, 2000).

The first floor. It is usually comprising private areas (Bedrooms), Bedrooms can be reached using stairs that led to a straight corridor, where bedrooms are located near each other on the northern or the southern part of the first floor. Bedrooms have big windows opened towards the corridor and the courtyard *(Figure 24).*

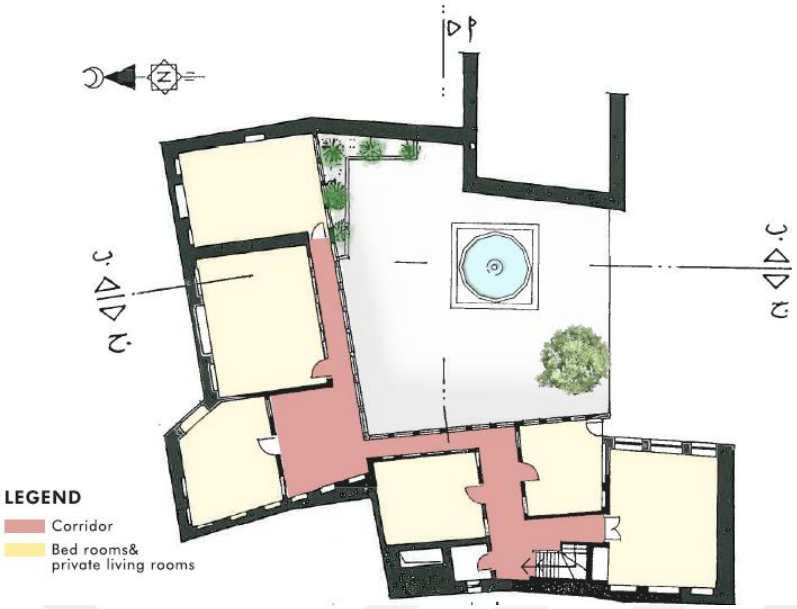


*Figure 24.*The first floor of Al-Tabaa house (Kabrit, 2000).

2.1.3.3. Envelope. Envelopes were built and designed following the cultural and traditional background of the inhabitants. The building envelope is a set of building components that act as a unit to protect the house from extreme climatic conditions (ASCE, 2014). Indeed, each component of this unit is expected to have a certain performance, construction materials and shape. ‘The building envelope consists of,

Foundations and floor, Damascene houses were built with direct contact with the ground to carry the weight of the thick walls and to absorb heat (Gut & Ackerknecht, 2011). Thus, the building’s foundations were built using stone (Ferwati, 1992). Since floorings should be made of high conducting materials, the houses were floored using coloured stone or marble; these materials have a high thermal capacity in which they act as thermal regulators between day and night. Furthermore, the coloured floor had an important role in reflecting sunrays or absorbing them *(Figure 25).* Hence, the houses were floored using dark and light colours of marble and stone to achieve thermal balance (Abidin, 1998). White, black, pink and red are the most common colours of floorings, these colours were used together to create geometrically shaped floorings (Kabrit, 2000).

Figure 25. Flooring type at Khaled Al-Azm house (Kabrit, 2000).

Walls are one of the most important envelope components since it is directly exposed to sun rays all day long (Khouli, 1982). Consequently, it is highly noticed that in most of the vernacular buildings' walls are thick and act as a thermal mass to protect houses from extreme temperatures (Oliver, Built to meet needs, 2006). In the case of the Damascene houses, walls were built using local materials and construction techniques. Here, some of the techniques are mentioned;

1. Adobe bricks: it was the most commonly used material for walls. The bricks were made of a dried mixture of mud and straws, with dimensions of 30*30*8 cm of each brick. This combination insured thermal insulation for the interiors (Waziri, 2004) *(Figure 26).*

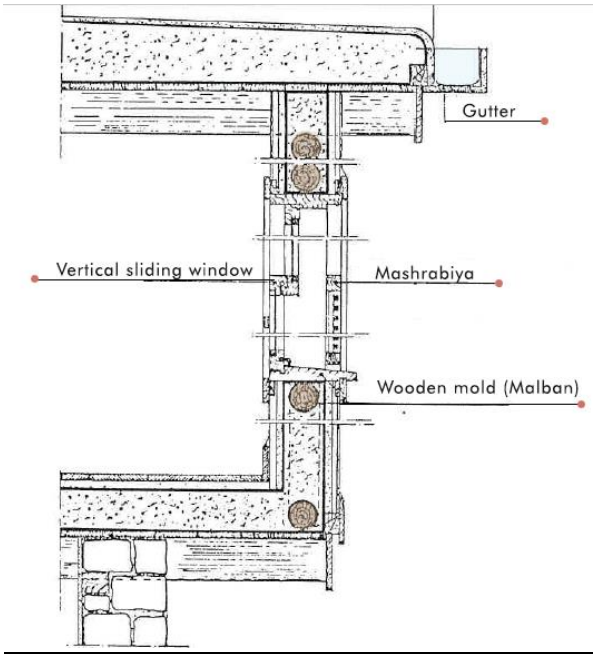


Figure 26. Adobe wall section (Kabrit, 2000).

2. The wooden structure technique, this technique was used in multi-stories houses, where the second floor was built using woods and mud to create smooth walls (Ferwati, 1992).
3. Stone walls, this technique was usually limited to palaces and public buildings because it was expensive. Nevertheless, stone-walled buildings are the most lasting ones. The thickness of stone walls is about 60-90 cm (Kabrit, 2000), where the most used type of stone in this method is limestone since Damascus is rich with this type of stone. Hence, it is locally imported (Garrett, 1936).

The walls of the house are divided into two types: exterior walls and inner walls. Each type has its characteristics. The exterior facades were modest lacked any kind of decoration or ornamentation which damascene houses are known for in the region. Besides, exterior walls included cantilevers to ensure shaded spaces for the alley. However, since the ground floor and first floor differ in their construction method and materials the outer wall finishing is also different.

Half of the exterior façade of the ground floor is usually covered by natural stone to add extra insulation for the house where outer windows are usually absent for climatic and privacy purposes. The upper part of the ground floor and the first floor are painted in white to reflect intense sun rays in summer. Additionally, the first-floor's outer façade included outer windows, but it is usually covered by Mashrabiya which acts as a shading device to maintain proper temperatures inside the house.

Unlike the exterior walls, interior elevations were very rich in their covering, decorations, and openings. Therefore, the interior walls of the courtyard were usually covered with a yellowish and black local stone called "Al Ablaq" *(Figure 27)*, which provided extra insulation for the walls. The walls of Al Qaah were covered with marble wood and lime for aesthetic and insulation purposes.

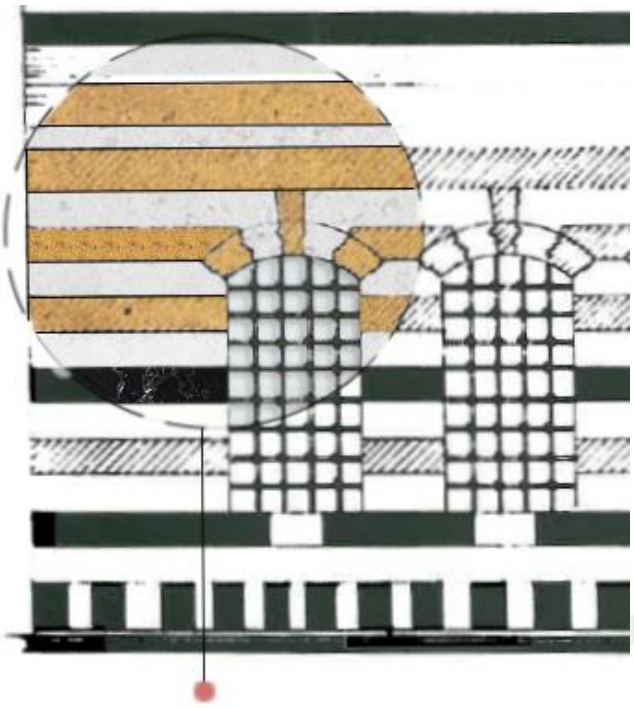


Figure 27. Interior elevation in Al-Azm Palace, Al-Ablaq stone is used for covering (Kabrit, 2000).

According to Hasan Fathy's book, windows were designed to serve three functions: 1. To ensure a view for people inside the house, 2. To allow sunlight, and 3. To let outside air in (Fathy, 1986). Consequently, the shape, material, size, and location of the windows vary according to the local climate. Indeed, the windows of damascene houses were built following these methods. Outer windows were very simple, small and far from ground level, which prevented the house from high-temperature transmission in the mornings and fast temperature droppings at night (Gut & Ackerknecht, 2011). Besides, there are several types of outer windows,

Outer windows with wooden shutters. This type usually has 3 layers, the first outer layer is wood latticed shutters with a decorated arch that block intense sun rays. The second layer is a metal screen that prevents insects, behind this screen a wooden framed glass window is found. Sometimes a fourth layer is found in this type which is an inner decorated wooden shutter following the decoration style of the surrounded wall

The second type is the outer window with Mashrabiya. Mashrabiyas have cultural and environmental benefits and it is widely known in Arab countries' vernacular houses. Mashrabiya is a cantilevered architectural element that is

made of lattice wood screens covering the wooden framed outer windows (Bagasi & Calautit, 2020).

Since damascene houses are inner oriented; thus, inner windows are the main used windows to provide air and natural light for the house. Inner windows vary in shape, size and distance from the ground. Hence, we can notice that in one wall an upper and lower window could be found. Inner windows are opened towards the courtyard with two glazed shutters. The lower windows of Qaahs have two frames: 1. a wooden one surrounding the thin glass that is about 2mm, 2. and a stone arched frame surrounding the wooden framed window. Besides, a crossed wooden or iron bars screen is also added in front of the lower windows of Qaahs.

The upper windows of Qaahs and first-floor inner windows are surrounded by a wooden frame with a 2mm glass thickness of each window. As a result of the lightness in glass weight and to ensure natural ventilation, the number of windows increased in Damascene houses, especially on the first floor. Moreover, some doors or windows have small openings over them particularly in the two Qaahs near the Iwan called Qamaria windows. These openings provide Qaahs with daylight and moisturized air, whereas Qamarias and some upper windows of Qaahs are usually covered with stained glass (Kabrit, 2000).

Roofs are the most critical part of the envelope as a result of the long exposure to direct sunlight during day time (Fathy, 1986). Thus, it is considered a major source of heat gain, but the percentage of heat transmission varies according to the used materials and their conductivity (Abuseif & Gou, 2018).In hot-arid areas the construction materials of the roof must have high thermal resistance to prevent heat radiation, besides, reflective outer surfaces are preferred in this type of climate. Therefore, Damascene vernacular dwellings' roofs were flat and they were built using poplar wood and mud (Kabrit, 2000). These materials have a low thermal conductivity property, which decreased heat gain in summers and heat loss in winters. According to "The Damascene house 1" book, the thickness of the roof is about 50-70 cm, where vernacular builders insured applying several layers while constructing the roof *(Figure 28)*,

Firstly, the beam is constructed using wood so it could allow poplar columns to lean on it. The width of these columns is about 20-30 cm and the height is about 6-8 meters. Wood shelves are placed on top of these columns

called “Al Tabaq”. After that, a combination layer of wet mud and gravel stones is being added and pressed, where its thickness is about 20-30 cm. When this layer dries, it is being covered with a sticky clay layer that prevents rain from seeping in. The roof’s final layer is ‘Al Zriqa’, which is a locally made thermal insulation material made of clay or lime combined with plant fibre.

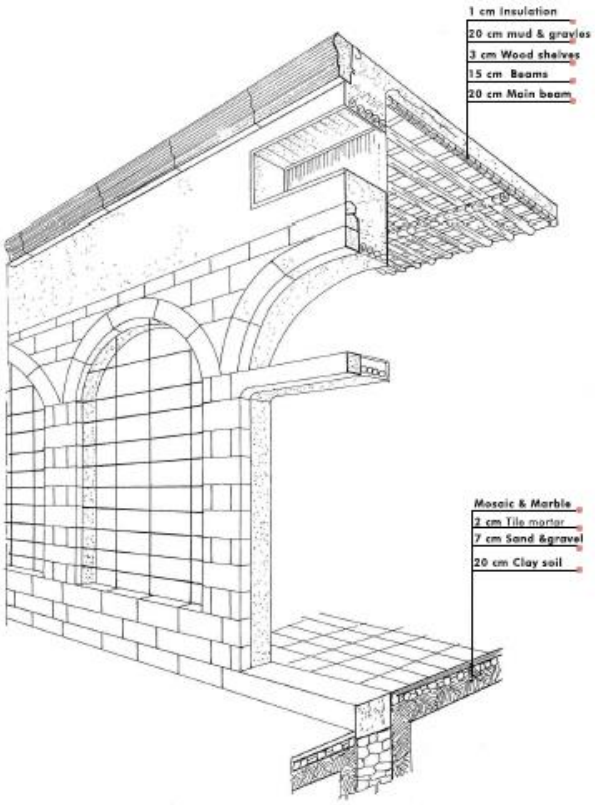


Figure 28. Pazar Bashi house, roof and ceiling structure (Kabrit, 2000).

2.2 Climatic Considerations

Recent studies mentioned that climate affects the urban and architectural form directly, for instance, the proportion of wall openings to the proportion of the walls change according to the Climatic zone (Fathy, 1986). Consequently, the climate is the average of the weather conditions in a specific location or region at a certain time (Karagoz, 2016). The climate of a certain region could be defined depending on several climatic factors (Koch-Nielsen, 2002) :

Air temperature, the unit of air temperature is in Celsius or Fahrenheit. Air temperature can be measured using a dry thermometer placed in a wooden box named Stevenson screen. However, to give clear information of air temperatures in a specific area these data should be analysed: 1. Monthly average temperature,

2. Monthly average of maximum and minimum temperatures,3. Absolute maximum and minimum temperatures. Indeed, other factors also impact the air temperature of an area directly such as latitude, seasons of the year, atmosphere, the location of the studied area near water bodies or not.

Solar Radiation the sun has a major role in human's life and their dwellings. Many factors determine the influence of the sun on the site. Hence, these factors should be analysed by architects before making design decisions. The factors can be concluded as follows: Duration, Intensity, The angle of incidence. Therefore, protecting from direct sun rays is the main goal that architects should achieve in their designs.

Wind is usually defined as moving air. Wind types are determined according to their direction, speed and intensity. Therefore, wind control techniques are preferred in windy areas. Building form and site has a significant impact on the building's natural ventilation and air movement. Thus, design decisions should be made in advance to determine the passive techniques.

Humidity is the invisible water vapour that exists in the surrounding air. Humid areas are usually the lands near water bodies (oceans, seas, lakes…etc.). Building materials, ventilation and other decisions should be made according to the humidity rate in the building site to reduce the rate or enhance it since humidity affect the thermal comfort of humans.

Precipitation this term is used to refer to the rain and snow rate in a specific area. Precipitation is influenced by the local weather conditions and geographic location where tropical areas and mountains have a high precipitation rate compared to other geographical areas. The used unit to measure precipitation rate is mm. Cities with high precipitation rates are usually classified as humid climates.

likewise, many features of the site could influence the microclimate directly, hence it could be enhanced. These features are,

- Topography
- The built-environment
- Water bodies
- Vegetation and ground cover.

These features were studied in the previous sections in the context of Damascus. Hence, the following section is mentioning the main climatic elements of the city and their relation with the thesis case study 'vernacular damascene houses'. Additionally, these elements are taken into consideration while proposing new energy-efficient housing in the region.

2.2.1 Hot-arid climate analysis. About 15% of the world's population are living in hot-arid zones (Gut & Ackerknecht, 2011). Hot-arid zones include desert and semi-desert lands (*Figure 29*). This climate is generally characterized by a low average of annual precipitation and high temperatures which in some countries could reach (40°-50°). Moreover, these temperatures may vary sharply between (day/night), (summer/winter). Accordingly, the crossing wind is usually dry with possibilities of sandstorms in winters. The intensity of solar radiation is high especially on summer's days; besides, sun rays could be reflected from the ground since most of these areas are located near sand grounds which has reflecting property (Wakil & Seraj, 1989).

The climate is usually being studied by architects since the previously mentioned climatic factors affect the design process directly. Thus, these factors are analysed to find good solutions that could cope with the surrounding environment and climate to provide thermal comfort, enhance the building's performance, and reduce its energy consumption.

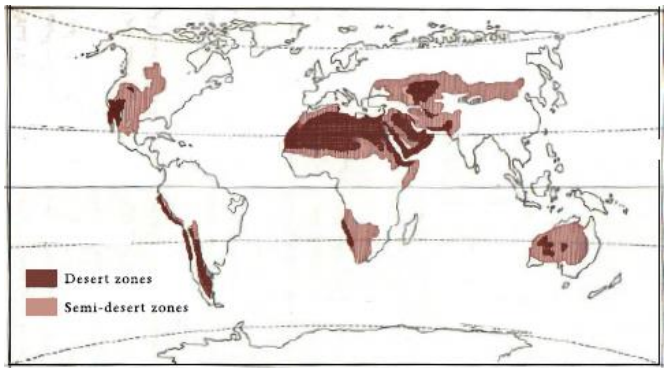


Figure 29. Hot-arid climatic zones (Wakil & Seraj, 1989).

2.2.2 Regional climatic standards. Damascus has a hot-arid climate, where temperatures may change significantly during the day and seasons. Indeed, many climatic factors and features affect the weather of the city. Consequently, the average temperatures of Damascus vary between (+35° and 0°), see *(Figure 30).* As a result of the geographical location and the local weather of Damascus, the intensity of solar is high on summer's days since the buildings could be affected by the three types of solar radiation (Direct solar radiation, diffuse solar radiation, and reflected solar radiation from the ground and the surroundings) (Koch-Nielsen, 2002).

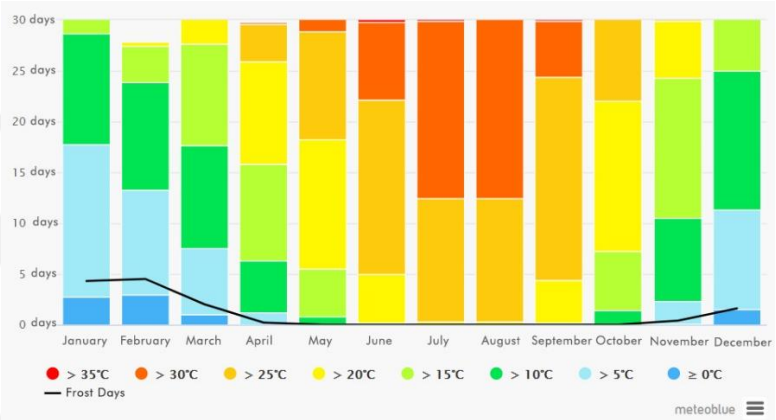


Figure 30. Average temperatures in Damascus during the year (https:// www.meteoblue.m /ar/weather/historyclimate/climatemodelled/)

Since Damascus is located in an arid zone humidity rate is very low but the presence of the Barada river in the city has helped to moisturize the air. Besides, the precipitation level is low as a result of the scarce rainfalls and snow *(Figure 31).* The wind is usually blowing from the southwest to the northeast, which allows the air to be purified by the trees of Al-Ghouta.

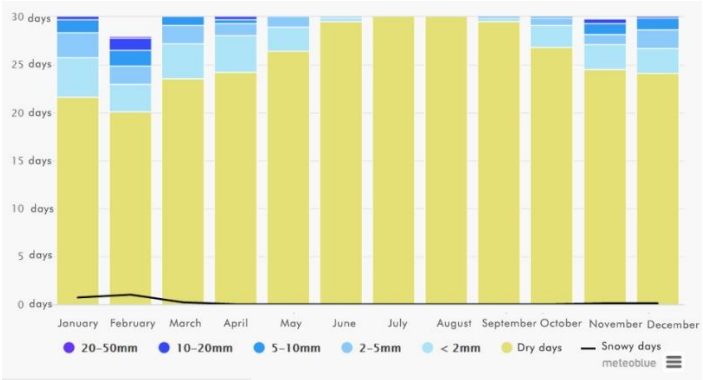


Figure 31. Precipitation Rate in Damascus (https://www. meteoblue. com /ar/ weather/historyclimate/climatemodelled/)

Climatic design Priorities:

1. Reduce extreme temperatures, dryness and uncomfortable conditions in summer.
2. Protect buildings from direct sun, glare and dust.
3. Design adaptable buildings to cope with the season's weather and to achieve a balanced climate in the interiors.

4. Improve natural ventilation and moisturized air by creating sufficient openings and water surfaces inside buildings.

Lower Priorities:

1. Let the sun in during winters.
2. Avoid winter winds.

2.3 Energy-Efficiency and Sustainability Aspects

Nowadays, a high concern with architectural practices regarding building performance and their energy efficiency has been noticed as a result of climate change. Governments are urging several disciplines including architecture to comply with protocols to enhance buildings performance and reduce consumption. Indeed, rethinking the design process and including passive design is very important to achieve energy efficiency. Therefore, many contemporary sustainable designs are referencing vernacular techniques where they provide proper indoor and urban conditions in a specific climatic region. Consequently, this thesis is studying the passive techniques of Damascene dwellings.

2.3.1 Urban passive design strategies. Recent studies have proved that urban planning and form affect the micro-climate directly. Accordingly, the urban components of the city such as streets, buildings, open spaces, etc. have a major role in enhancing thermal comfort. The studies have discussed climatic parameters, the influence of green areas and landscaping on the micro-climate (Yahia & Johansson, 2013). Indeed, they are aiming at reducing energy consumption and designing climate responsive cities and buildings. Consequently, 'climate-responsive design' refers to using passive and local strategies to integrate the aimed zone or building with the climate, hence, it helps with achieving appropriate conditions in a certain climatic zone, by result less demand of energy (Kaihoul, Sriti, Amraoui, Di Turi, & Ruggiero, 2021).

Paul Oliver has mentioned that vernacular architecture techniques are an indigenous way to respond and adapt to the climate (Oliver, 1997).

Accordingly, the vernacular urban design of Damascus achieved the ideal response to serve the natural and social environment. Thus, the urban passive design strategies of old Damascus could be summarized as follows:

1. The Urban form of the city has played a major role in reducing the exposure of walls and roofs to direct sun rays, hence, it helped to keep proper temperatures during summers.
2. The form of the narrow, zigzagging paths and their direction has helped provide shade spaces. Moreover, they helped with blocking dusty wind movement within the city. As a result of the paths form, the cool air was preserved at night to be released in the morning *(Figure 32).*
3. Wide-open spaces are rare in the old city of Damascus to prevent sun reflectivity and dusty winds; hence, they were replaced with recurring small open spaces. Each quarter had it small open space in between public facilities (mosques, baths, shops…) these spaces are a gathering space and a small node that links paths.
4. Houses' facades were designed to serve the aesthetical and environmental aspects. Hence, the cantilevered first floor's façade acted as sun breakers it helped with shading the outer walls of the houses and the alley (Khouli, 1982).
5. The cantilevered facades on both sides of the narrow alleys helped with activating the movement of hot air upwards to get rid of it.
6. Street directions towards N-S and E-W improved natural ventilation and cool air movement. Moreover, water surfaces in public spaces moisturized the air.
7. The spread of green spaces in residential and public facilities in the old city of Damascus played an important role in purifying the air. Besides, shading by green spaces ensures cool air since vegetation absorb and reflect radiant energy (Gunawardena, Wells, & Kershaw, 2017).
8. Sibat is another common architectural element that was used in Damascene paths to prevent pedestrians from being exposed to direct sun radiation. Moreover, it acts as a cooling tunnel that cools the passing breeze to preserve thermal comfort around the alleys.

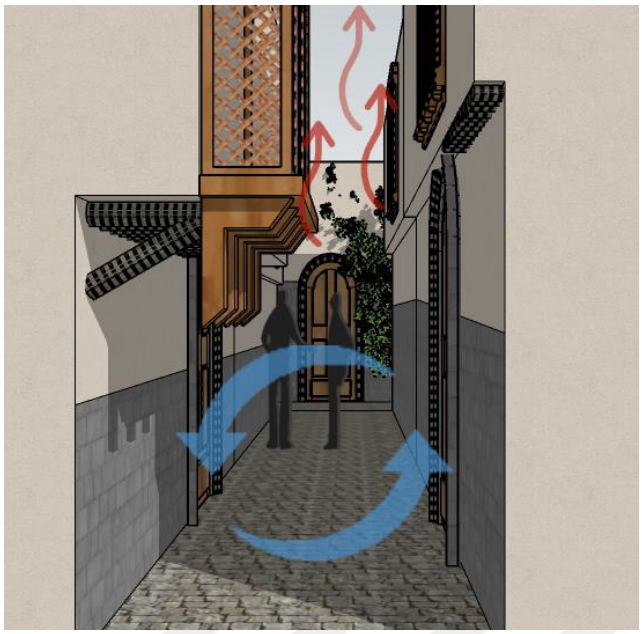


Figure 32. Air movement in old Damascus's alley (Author's own).

2.3.2 Vernacular dwellings' passive design strategies. Nowadays, many studies are arguing that sustainable 'energy-efficient' buildings could be achieved by combining "the best of the past with the best of the new". Indeed, considering advanced science technologies and vernacular architecture techniques that responded to the region's needs and climate would help design better contemporary buildings. Therefore, it is highly noticed that throughout history vernacular building decision-makers were aiming at integrating environmental controls with their designs to ensure comfortable conditions to the users. Moreover, Le Corbusier's famous principle of "the form follows the function" is a result of the urge to design a building that is effective in heating, cooling, and lighting by relying on its architectural elements (Lechner, 2014).

Accordingly, vernacular architecture has evolved with serving the needs of the users. Hence, the main aim of vernacular architecture is to create a comfortable environment by using proper local techniques and environmentally friendly architectural elements. Consequently, Damascene vernacular dwellings have responded to the extreme climatic conditions of the hot arid climate with local flexible design, that adapt to the surrounding and balance the amount of heating, cooling and lighting (Mousli & Semprini, 2015). The concept of Adaptation is considered as the essence of passive design where it refers to the combination of adaptation actions (physiological and behavioural) that people

could do in case of an uncomfortable change. Thus, people act in a way to restore their comfort.

However, the surrounding factors had a major role in influencing the process of passive heating, cooling and lighting in these vernacular houses including the socio-cultural aspect (Chandel, Sharma, & M.Marwah, 2016), which are highlighted in the coming sections.

2.3.2.1 Passive cooling. The geographical location of Damascus near the desert have affected the climate of the city to be considered a hot-arid zone. Summers are usually the longest in respect to the winter, hence, considering passive cooling while designing and building houses is essential (Kabrit, 2000). In the case of Damascene houses, passive cooling strategies were considered in the design process from the plan level to the construction and landscaping. Additionally, to achieve thermal comfort in vernacular houses during summers they used to create spaces that avoid heat gain using all the local strategies they have, besides, they considered designing architectural elements that could help with optimizing indoor environmental quality. As a result, buildings used to adapt to the local climate (Samuel, Dharmasastha, Nagendra, & Maiya, 2017).

Moreover, the performance quality of passive cooling techniques is depending on the interaction of the building and its architectural elements with the surrounding environment to achieve a balanced condition for the users (Freewan, 2019). Indeed, the surrounding features, building form, and internal layout are part of the passive cooling process (Koch-Nielsen, 2002). Thus, it is discussed in this section.

1. Building form: Damascene houses have an organic centralized compact form where all the units are oriented towards the central courtyard (Hatahet, 2016).In hot arid zones, temperatures vary significantly from day to night as a result of the heat radiation from the earth. Thus, temperatures may vary from (10-20 C^{o}) (Kabrit, 2000). In vernacular Damascene houses ‘Stack effect’ was considered to ensure inner cool breeze, this effect could occur since warm air is less dense than cool air, hence, warm air rises and it is replaced by cooler air *(Figure 33).* In the daytime, the air is warmed gradually since the courtyard is shaded by the mass walls of the surrounding rooms and vegetation. Therefore, the courtyard acts as an air modifier that keeps proper temperatures and cool

breeze around the house (Muhaisen, 2006). Indeed, the limited number of external openings and other characteristics of the courtyard played an important role in maintaining low temperatures *(Figure 34).*

Figure 33. Air movement in Damascene vernacular houses (Author's own).

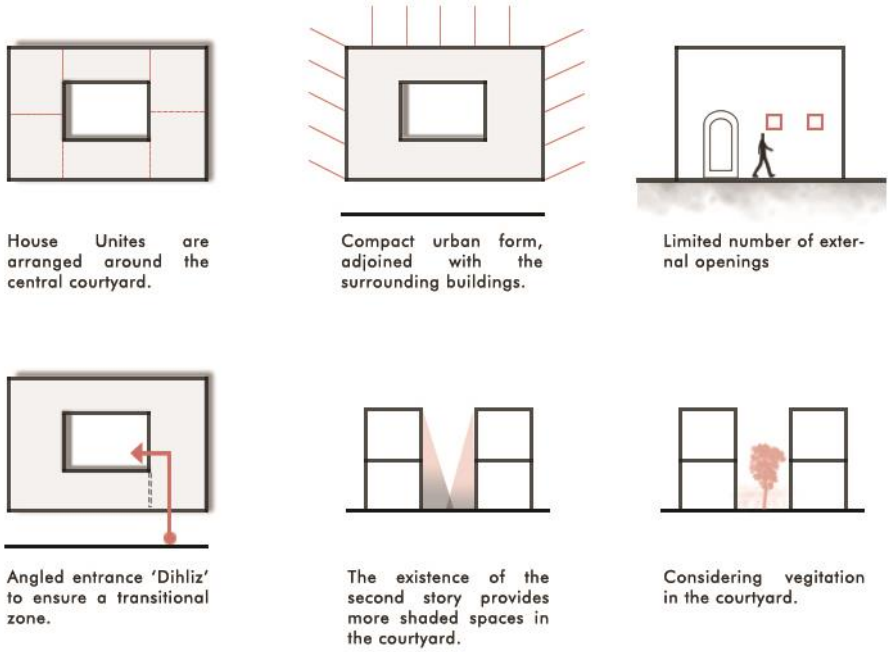


Figure 34. Form techniques for passive cooling in Damascene houses (Behsh, 1988).

2. Space organization: The concept of thermal zones was considered in Damascene vernacular houses to ensure proper temperatures all the year. Thus, the main houses' units were divided according to the seasons; houses may include summer Iwan and Qaah and winter ones. Summer Iwan and Qaahs are located on the southern façade of the courtyard opened towards the north to get the benefit of the summer breeze, whereas winter Iwan and Qaahs are usually located on the opposite side facing south warm sunrays or on the eastern and western part of the courtyard. The angled entrance of the house with the transitional zone 'Al-Dihliz' is a very important aspect regarding the concept of thermal zones since it prevents direct access of outer wind; hence it protects the house from dust, heat gain and loss. Kitchen and bathrooms are usually located in western hidden spots or dead corners, as a result, these units provide extra insulation. Moreover, some houses have whole sections for different seasons. Accordingly, the orientation of the house units and the concept of thermal zones achieved providing thermal comfort for the users *(Figure 35)* (Kabrit, 2000).

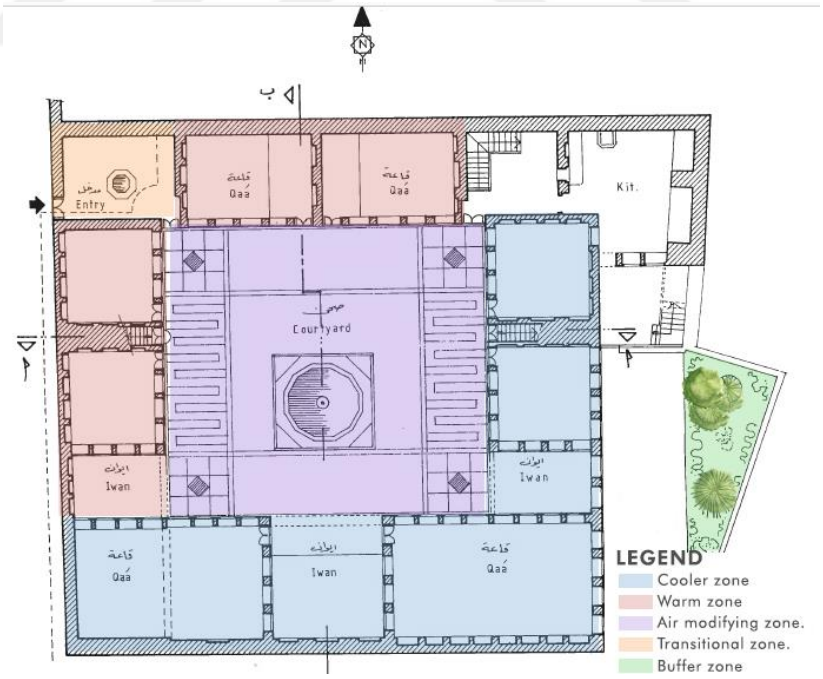


Figure 35. Thermal zones in a Damascene vernacular house 'Al-Dada House' (Kabrit, 2000).

2.3.2.1.1 Evaporative cooling. To achieve thermal comfort in hot-arid zones considering evaporation cooling is a must since it has pleasing refreshing and psychological effects (Fathy, 1986). The Evaporation of water is a process where the sensible heat is conserved into latent heat. Ancient architects and builders knew the physical states of water, hence they used it to optimize the climatic conditions in their houses (Bansal, 2014). The concept of evaporation cooling was considered in Damascene vernacular houses, and it is found in three methods:

Fountain (spray pond), it is usually placed in the middle of the courtyard where the cool air of the courtyard pass over the water's surface, as a result, heat will be absorbed and the air will be moisturized and cooled (Koch-Nielsen, 2002). gathering areas are usually opened towards the courtyard, such as Iwans and Qaahs to get the benefit of the cooled air. Some Qaahs have their own fountain, which would help cool the indoor area (Kabrit, 2000). Moreover, spray ponds help purify the air from dust particles hence they are more preferable in hot-arid zones and that was applied in Damascene vernacular houses *(Figure 36).*

Figure 36. Evaporative cooling, fountain method in Damascene vernacular houses (Author's own).

The second evaporative cooling method is incorporating evaporator porous clay jug in openings (Mashrabiya) this method is less effective and popular in Damascene houses than the fountain since it uses a smaller water surface and a still pond. These jugs were used to be placed in Mashrabiyas facing outdoor air to moisturize and cool it *(Figure 37).* Therefore, it provides comfort conditions and enhances houses' envelopes (Schiano-Phan, 2004). The third method is

green spaces, this method was applied widely in Damascene vernacular houses since vegetation enhance indoor air quality and moisturize it.

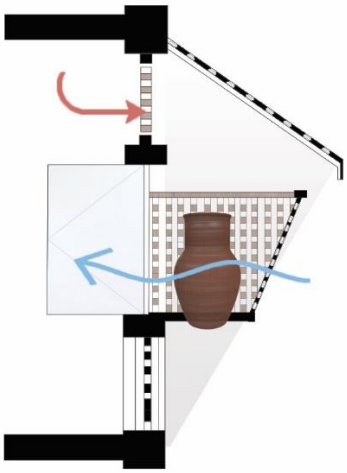


*Figure 37.*Evaporative cooling method (Cain et al., 1976).

2.3.2.1.2 Shading elements. Shading is among the most important characteristics that architects should pay attention to in hot arid-climate to prevent the house and outdoor spaces from direct sun and glare. Indeed, the optimal orientation of houses and the compact urban plan help achieve better-shaded space. Vernacular architecture is known for its multifunctional architectural elements. Thus, the surrounding walls courtyards in Damascene houses act as shading elements along with their main role. However, building elements are not enough in such an intense climate. Accordingly, it is noticed that Damascene houses included vernacular shading elements such as Mashrabiyas.

Mashrabiya is a lattice cantilevered screen that covers parts of the outer façade, it consists of decorated tangled wooden balusters (Samuels, 2011) *(Figure 38).* Throughout history, Mashrabiya was a cantilevered lattice space used to store water jugs in it, but its function evolved to be an important architectural element in Arab vernacular architecture. According to Zakariya Kabrit, Mashrabiyas have five main functions: 1. Controlling Daylight, 2. Controlling airflow, 3. Moisturizing the air, 4. Decrease air temperature, 5. Privacy *(Figure 39).* The design of Mashrabiya differs according to its location in the house and its function.

For instance, the characteristics of daylight on the southern elevation are

- Direct sunlight is intense on the southern elevation and its angle is wide on the floor.

- The reflected glare is less intense, but it affects the vision of the uses (Kabrit, 2000).

Consequently, the spaces between the tangled wooden balusters should be small to prevent direct sun and glare. Usually, the balusters near eye level are very close and tangled and the upper balusters are less tangled and more open to ensure lighting. Southern Mashrabiyas often have a wide surface since the space between the blusters is very small the wider surface of the Mashrabiya would ensure airflow compensation. Moreover, Mashrabiyas act as an air moisturizer since wooden blusters absorb the humidity of the temperate air at night, and it releases it when the blusters get heated by the sun (Kabrit, 2000). Therefore, bigger blusters absorb more night moisturized air than smaller ones as a result they work more efficiently in moisturizing dry air in the morning.

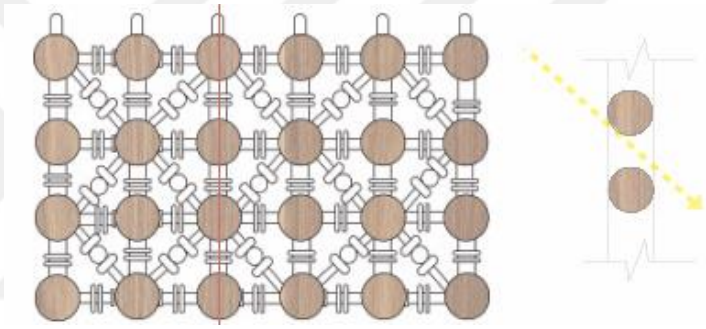


*Figure 38.*Mashrabiya's blusters (Samuels, 2011).

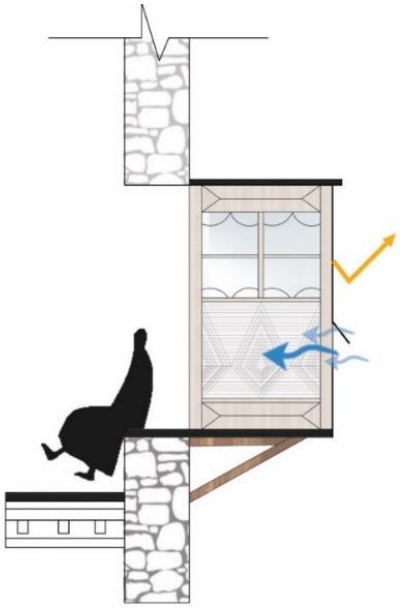


*Figure 39.*A Mashrabiya in a Damascene vernacular house (Autor's own).

2.3.2.1.3 Natural ventilation. Nowadays, thermal comfort, indoor air quality, and energy are some of the most important architectural research fields, where ventilation is an important aspect related to them. Natural ventilation represents effective support or alternative for air conditioning systems. Moreover, it improves indoor air quality and thermal comfort for the users since it regenerates the air constantly (Passe & Battaglia, 2015). Ventilation inside buildings has four main roles according to (Wakil & Seraj, 1989),

1. Replace polluted air with fresh air to prevent the increase of CO_2 inside the building.
2. Cooling human bodies by controlling air movement and speed hence thermal comfort could be achieved.
3. Cooling the air source since the new air mixes with the air inside the building hence the heat transfers. The thickness of the wall its colours and openings design effect directly this process since air temperature is affected by the temperature of the building's surfaces.
4. Moistening dry air inside by applying cooling evaporation methods with crossed ventilation.

Consequently, Damascene vernacular houses relied on these techniques to achieve thermal comfort. Indeed, the courtyard and wall openings are the main elements in the natural ventilation process. The courtyard ensures unpolluted ventilation by creating a constant airflow between inner and outer air, the green spaces in the courtyard help enhance indoor air quality by increasing oxygen levels. Since Damascene houses were built as rows where the houses' units are inner oriented and the outer windows are rare, the concept of crossed windows and crossed ventilation was not considered in these vernacular houses. Thus, it was replaced with "multi-level wall openings" to ensure air movement inside the rooms. In some Qaahs with high ceilings, three levels of windows were considered, the first one is the window that its height could reach the high of the door. The second level is a smaller window that could open to improve air movement and get rid of inner hot air. The third level is round coloured closed openings called 'Qamariat' and 'Shamsiat' which help get more sunlight in the room (Kabrit, 2000) *(Figure 40).* Malqafs (wind catchers) are absent in Damascene houses since outer winds are undesirable, as a result of the

multidirectional dusty summer winds. Therefore, courtyards were the main source of cool air inside the house.

Figure 40. Natural ventilation, multi-level windows (Autor's own).

2.3.2.2 Passive heating. According to figure 29, the temperature in Damascus during winter could reach below comfort level. As a result, vernacular builders considered passive heating while building their houses to ensure proper temperature. Passive heating is a process where heat is collected during the daytime to be released at night or when the inner temperature decreases (Wakil & Seraj, 1989) There are many types of passive heating, but mainly in Damascene houses direct gain and thermal mass are the most used ones. The orientation of the Damascene house and the courtyard allow the sun to get into the building where the heat is being stored by the stone floor or the thermal mass wall. As have mentioned earlier the south-facing façade on the ground floor usually include Qaahs that are the main units for the family to gather in winter. The windows of the Qaah allow the sun is where the heat is stored in the morning to be released at night when the family usually gather.

The walls of the ground floor and the first floor were constructed differently. Hence, different heat gaining methods were included. The ground floor was constructed using stone and adobe where the walls are thick that act as thermal mass to control temperature levels during winter. Moreover, the rare outer openings insured airtightness, thus the walls and the insulation layers in the roof could keep the warm air for a longer time *(Figure 41).* The first floor of Damascene houses was built using light materials 'adobe and wood'. Therefore,

the used method was direct sun gain since upper floor rooms had outer and inner windows consequently the sun could get in the room most of the daytime to heat it (Kabrit, 2000).

Figure 41. Passive heating in Damascene houses (Autor's own).

2.3.2.3 Daylight. Since the beginning of human beings' existence, people tried to cope with their surroundings and it is widely said that the history of architecture started with this coping process. Early civilizations made use of the sun and other environmental elements according to their geographical context (Boubekri, 2008). Daylighting is not a feature or element that could be added to the building unlike electric lighting; daylighting is planned and designed along with the building design. The building form, orientation, windows size, materials and location are critical decisions to design proper daylighting (Lechner, 2014) Accordingly, Damascene houses were planned to get the maximum use of daylighting, houses' units included different types of windows that differ according to seasonal and daily sun's path. The upper windows of the rooms are the main source to get sunlight in the rooms.

However, since Damascus is located in a hot arid zone direct sunlight was avoided to maintain proper temperatures accordingly trees and green spaces were planted in the courtyard to reduce the intensity of the sunrays and to prevent glare that could occur as a result of sun intensity and fountain's water. Indeed, the northern elevation of the house included more windows than the southern elevation since the northern elevation receives less amount of daylight. Thus, more windows would ensure a proper amount of daylighting (Wakil &

Seraj, 1989) Moreover, the light colour of the courtyard's and Qaahs stone flooring managed to reflect the light to deep parts of the room *(Figure 42).*

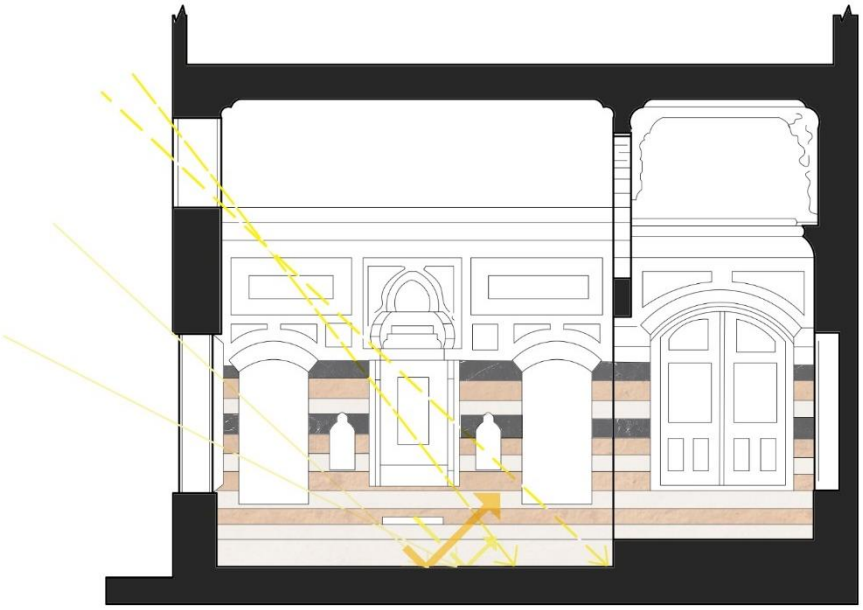


Figure 42. Daylighting in Damascene house's Qaah (Autor's own).

2.3.3 Indoor environmental quality. The indoor environment including (ventilation, lighting, temperature, etc.) affects the energy efficiency of buildings significantly. Moreover, it affects the users' work and activities efficiency. As a result, people tend to improve the indoor environment by actions that usually include energy implications; hence, poor indoor environments lead to more energy consumption (Swamy, 2021). There are several parameters for indoor environmental quality that are classified in many national and international standards. Thermal comfort and indoor air quality are the main aspects of the indoor environment that directly impacts the building and users' performance in terms of energy and daily activities.

Thermal comfort refers to the comfort zone which the building could achieve for the user(s). The standard 55-2010 of the American Society of heating, refrigerating and air-conditioning engineers (ASHRAE) defined thermal comfort as the people's state of mind which is pleased with the thermal environment (ASHRAE, 2010). There are several thermal comfort primary factors, which are temperature, humidity, radiant temperature, airspeed, clothing and activities (EU B. , 2007). Besides, other secondary factors affect thermal comfort such as human body shape and gender. Recent studies deduced that indoor air

temperature is slightly higher than outdoor temperature as a result of (Nasir, et al., 2011)

- Heat radiation from electrical lighting sources and other appliances.
- The convection of heat from the outside hot air.
- Heat transmission through the building's envelope and opening.

Additionally, there are two developed thermal comfort approaches that architects rely on to achieve thermal comfort and reduce energy consumption in their designs and buildings, which are Fanger's equation and the adaptive thermal comfort model. Fanger's equation on thermal comfort became a standard reference since his equation was conducted by using experiments and models. Fanger considered the evolution of thermal comfort as a milestone (Fanger, 1970). Hence, his equation explains the relation between human thermal comfort and the parameters that can affect it. The equation's experiments were done in a controlled room where the model argued that there is no difference in thermal comfort created by gender, body shape, colour…etc. Fanger categorized six parameters that can affect human thermal comfort, two of the parameters are related to the occupant(s) and four are related to the surrounding environment, these parameters are (Karyono, Abdullah, Cotgrave, & Bras, 2020):

- Clothing insulation.
- User(s) activities (metabolic rate).
- Temperature.
- Radiant temperature.
- Airspeed.
- Humidity.

Fanger's equation has become the basis of ISO7730–2005 and acknowledged by ASHARE as the Predicted Mean Vote (PMV)/Predicted Percentage of Dissatisfied (PPD) models in ASHARE 55 standard. Nevertheless, in reality, human's gender, age, different cultural habits, and people with disabilities have different thermal comfort responses. Thus, the adaptive approach is clarifying people's psychological and physiological adaptation regarding different thermal parameters.

The adaptive approach was firstly introduced by Nicol and Humphreys where they formulated their approach on the human nature of adaptability. The adaptive model is also acknowledged by ASHARE 55 standard (ASHRAE, 2010). Unlike Fanger's equation, this model is defining thermal comfort with regarding the occupant(s) thermal experiences in changing states such as clothing, activities, and in cases of disabilities and ages (elderly and children). These aspects influence the human's response to the previously mentioned thermal parameters. Consequently, the adaptive model argued thermal adaptation types which are (S.Brager & de Dear, 1998),

- Psychological adaptation is the state of mind that responds to the thermal zone according to previous experiences and known behaviours.
- Physiological adaptation, the human's body responds to adapt to a certain temperature.

The adaptive model is very effective while designing a human comfort system for multi-users to achieve proper conditions in reliance on their behaviours and responses, which could enhance building performance and create more energy-efficient buildings.

However, contemporary buildings worked on ensuring thermal comfort of the users by relying on an active system (HVAC) that consumes a considerable amount of energy daily and affects indoor air quality. Indeed, passive techniques can replace or support active heating or cooling systems to achieve the thermal comfort state for the users and reduce energy consumption. Thus, passive heating and cooling techniques should be analysed by architects while making design decisions since passive strategies should be included in advance.

On the other hand, vernacular dwellings have long achieved thermal comfort by relying on the building structure and passive techniques where they do not consume energy but rely on natural sources. Moreover, the houses were the mirrors of people behaviours and adaptation experiences, thus, they achieved crating effective human comfort zones. A recent study was conducted by (Mousli & Semprini, 2015) analysed the performance of the internal courtyard of the vernacular Damascene houses, their materials, and structures. Accordingly, they concluded that the internal courtyard of Damascene vernacular houses has a major role in achieving thermal comfort. Moreover, they proved that the

materials, vernacular structures, green spaces and the fountain are the main effective elements of the courtyard that managed to reduce temperature. Besides, the high thermal mass managed to maintain proper microclimate. Indeed, the achieved private spaces have a significant influence on thermal comfort levels for women since women were able to reduce clothes during summertime.

Indoor air quality 'IAQ' has been widely considered a major concern in recent studies since people spend 90% of their time in indoor environments (Giuli, Da Pos , & De Carli, 2012). Moreover, indoor air pollution is ranked as one of the top five environmental dangers by the US environmental protection agency. Poor indoor air quality causes several health problems (Kandar & Nimlyat, 2015). Ensuring proper air quality includes improving ventilation, air sources and indoor air purification. Additionally, the main role of ventilation is maintaining low levels of pollution, where ventilation in a building could be provided either in a passive or active method (Nasir, et al., 2011). Indeed, natural ventilation is considered an important factor in determining indoor air quality.

Generally, the comfort level of ventilation per minute is 20 square feet per person, but this level may change according to the indoor activities that are related to air pollution such as smoking, cooking and cleaning (Kandar & Nimlyat, 2015) . Likewise, many studies mentioned that many sources could affect the IAQ such as building materials, furniture, space heaters and other chemical products used by the users (Abdel-Salam, 2022). Therefore, many methods are suggested by 'EPA' to enhance indoor quality these methods include (EPA, Improving Indoor Air Quality, 2021),

Source control: this method can be achieved by reducing the emissions from individual sources including controlling indoor activities of the users such as smoking, painting and other activities that should be done outdoor, and modifying other sources like gas stoves. Indeed, this method is more cost-efficient than other methods such as mechanical ventilation since increasing the active ventilation systems consume more energy.

Ventilation: most of the HVAC systems do not bring fresh air mechanically, hence, to enhance the inner air users should consider opening windows and doors daily to refresh the air and reduce the emissions.

Air filtration: these systems should be considered to decrease harmful gas emissions that could affect users' health such as Co2 and other harmful gases especially when some activities that pollute the air are done indoors.

Damascene vernacular houses achieved indoor air quality by relying on natural sources to purify the air and sterilize houses. The Open space within the house has a significant impact on IAQ. The courtyard and its green spaces managed to purify the air from dust and it reduced the amount of Co2. Moreover, they achieved spaces where people can do certain activities outdoor, which eliminate emissions from individual sources since harmful emissions are being reduced with the help of natural ventilation. Accordingly, the quality of indoor air should be considered in each building with the assistance of natural sources since polluted indoor air may cause respiratory diseases in the long term especially for children and the elderly.

Chapter 3

Regional Architecture: A Critical Discussion on Today's Damascene Dwellings

Regionalism as a word is defined in the Cambridge dictionary as 'a phrase, characteristic, form…of a particular place' (Dictionary, 1995). Regionalism in architecture is defined in terms, concepts, and architectural types such as 'genius loci', 'sense of place' 'vernacular architecture'… (Heath, 2009). Lewis Mumford wrote in his book, regionalism is not about using local architectural style or materials, but regional architecture is about meeting users' needs in their current living conditions to make them feel at home in their surrounding environment, hence, it achieves reflecting the current cultural conditions of the region (Mumford, 1941). Other studies argued that regionalism simply is "a local life aware of itself" (Canizaro, 2007).

Accordingly, the concept of 'critical regionalism' was firstly introduced by Alexander Tzonis, Liane Lefaivre in the early 1980s as a form of 'resistance architecture', they described a type of architecture that is related to its particular cultural, nature, and geographical conditions (Eggener, 2002). Regionalism is about adapting to the current surroundings and culture; therefore, it is necessary to distinguish critical regionalism from reviving some vernacular features that can't adapt to today's needs (Frampton, 1993). Nevertheless, the concept is urging evoking vernacular techniques by evolving them to cope with today's needs and the collective identity by using today's instruments.

The emergence of the modernization movement in Damascus has affected the city and its dwellings negatively. 'Buildings were produced, but yet no architecture' since 'modern' buildings could adapt neither to their environment nor to the dwellers' needs and dynamics (Porphyrios, 1989). Therefore, this chapter is discussing the essence of Damascene homes, the vernacular abandoned strategies, and wrong 'modern' practices to have guidelines for the proposed new regional design with consideration to the global priorities and today's life needs.

3.1 The Concept of Identity: "The Spirit of a Place"

According to the identity discussion in the literature review, "place" is not just a location, but it is an essential part of existence. In other words, a place and

its elements are products of the users' habits, activities, and beliefs (Arefi, 2014). Consequently, places build their own identity following the reflected identities of the users. However, humans' activities and functions are not similar according to Norberg-Schulz (Norberg-Schulz, 1976). Even the most basic human habits such as gathering, sleeping, eating, etc. differ according to the cultural, environmental, traditional, and climatic conditions, hence, the demands and properties of places differ accordingly. Therefore, a space becomes a *'place'* when it creates its character, which is capable to transmit meanings, serving the users, and communicating with the surrounding. But a place loses its identity if its relationship with the surroundings and the user is corrupted (Erdem, 2005). Thus, placemaking demands working in different contexts and achieving different aims (Silberberg, Lorah, Disbrow, & Muessig, 2013).

Going back to the phenomenon of place by Christian Norberg Schulz, he suggests that the "everyday life-world" should be the main concern by architects. Besides, he considers that the language and literature are the keys to understanding the identity of the place and our life-world of what he named 'the phenomenology of the daily environment'. Additionally, recent studies mentioned that literature and poetry are the main sources of information to expand the understanding of self, surroundings, and society (Simecek & Rumbold, 2016). In this respect, to understand the main elements that form the identity of Damascene houses and their spirits, in which it shaped 'the regional, self-efficient home'; this section is analysing a poem written by a local Damascene poet 'Nizar Qabani' describing his house:

> …. A small wooden gate opens. and a journey starts towards the green, red and lilac, and a symphony of light, shadow and marble also starts.
> Bitter orange tree holds its fruits where the jasmine tree gave birth to a thousand white moons and hung them on the bars of the windows….
> The marble around the fountain is black, the fountain fills its mouth with water and blows it, the water game continues day and night, neither the fountains get tired nor the water of Damascus ends….
> In this green belt, I was born, crawled, and pronounced my first words…
> This house 'shelter' left its marks on my poems, just as Granada, Cordoba and Seville left their mark on Andalusian poetry….
>
> (Our Damascene house, Nizar Qabani)

The poet Nizar Qabani has described Damascus, its alleys and houses in many of his poems. It is clear that there were interactions between the identity of the poet, 'his daily environment', and the identity of the house in which he 'dwelled'. According to the poem, the green 'belt' and the fountain are the spirits of the house. Moreover, he described the 'light' and 'shadow' created by the form of the house, the hung jasmines on the bars of the windows, the fountain that blows water from its mouth as the main elements that form the character of the house. Aren't these mentioned descriptions represent some aspects of the house's identity and main elements of passive techniques at the same time? In this regard, it can be deduced that vernacular Damascene houses had a 'strong' relationship to the tangible and intangible sense.

This strong relationship enhanced the performance of the houses and served the users on many levels including the spiritual and the physical, where the houses improved their environmental quality in accordance. On the other hand, the identity of the Damascene house has evolved following the identity of the users, besides, it succeeds in arousing 'belonging' and 'comforting' feelings and left marks on the inhabitants' daily life-world in the same way that it left marks of Nizar's poems "This house 'shelter' left its marks on my poems" *(Figure 43).*

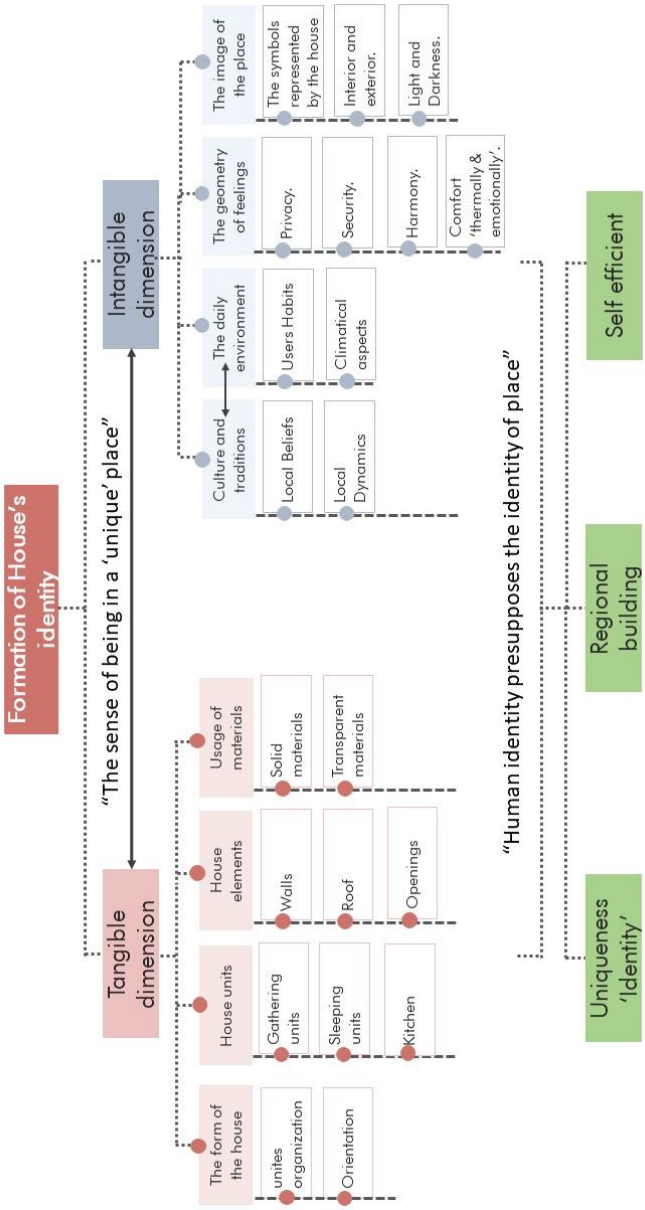


Figure 43. Formation of house's identity (Autor's own).

As have mentioned, architecture is 'inhabited by the spirits' and it gives life to the people and their places. Hence, architecture and building performance are affected by the users' daily life habits, identity, and psychological fluctuations. The 'daily life-world that was mentioned by Christian Norberg Schulz affects the energy consumption in the building directly. Moreover, recent studies have proved that the energy consumption of the users is directly related to their expectations from the surrounding indoor environment and their perception of 'comfort'. Therefore, nowadays it is essential to study the daily habits of the users such as spending hours in each unit, the nature of done

activities, when simulating the energy performance of a building. Besides, age, gender, and other details related to the psychological state of the users and their behaviours are taken into consideration (Laaroussi, Bahrar, El Mankibi, Draoui, & Si-Larbi, 2020). Accordingly, we can conduct that the spirit of the place or the genius loci which is defined as "what a thing wants to be" has a significant impact on energy consumption.

However, the users may evolve coping mechanisms that are related to their behaviours and social norms since people tend to develop and modify their dwellings to cope with the surrounding environment and achieve the state of personal 'comfort' and belonging' (Tuniki, Jurelionis, & Fokaides, 2021). This process of adaptation has created the vernacular houses and their passive techniques that were evolved 'locally' following the traditions and the dynamics of the region's inhabitants by using traditional housing forms, local materials, and construction techniques *(Figure 44).* These aspects are discussed in the following section.

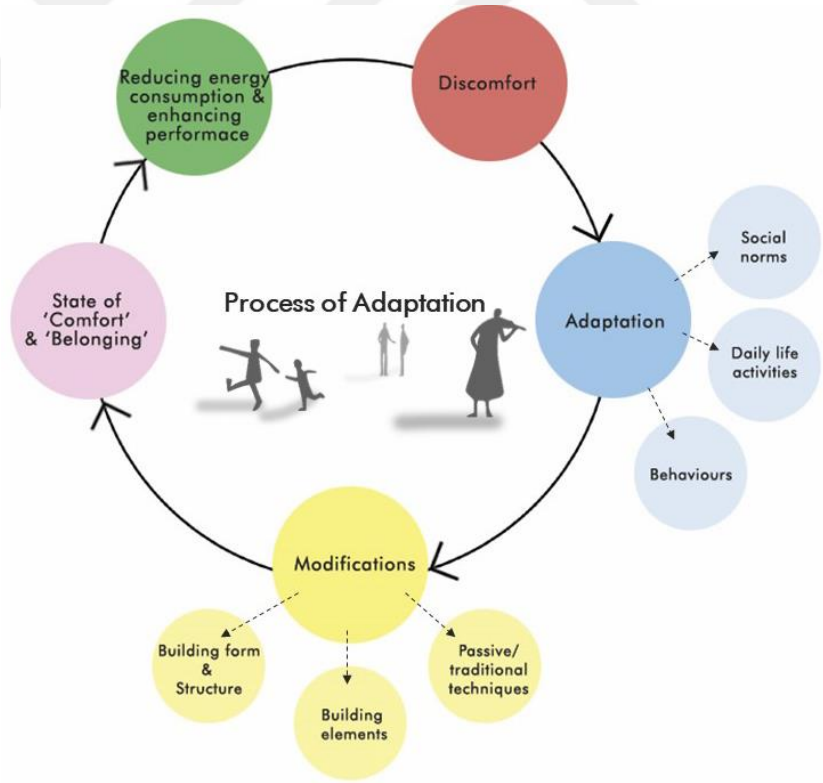


Figure 44. Process of adaptation (Autor's own).

3.2 Regionalism in Architecture, Vernacular Dwellings Background

Vernacular architecture is the oldest and purest form of regionalism. Vernacular architecture can be defined as a creative adaptation process that translates experiences, traditions and skills into buildings that are influenced by the climatic conditions, region's landscape, local traditions, cultural structure and the dynamics of the people and their local identity (Tipnis, 2012). Good architecture was defined in many books and studies as a 'building' that is sensitive to its location and climate as well as the cultural structure of the region, and it is also cost-effective. Clearly, these aspects of good architecture define vernacular architecture aspects. Vernacular buildings relied on the existent local sources and the inherited techniques to adapt to the region's environment, thus, it represents a sign of identity where buildings are the mirrors that reflect the region's nature, traditions and environmental conditions (Sayigh, 2019).

Fascinatingly, the elements of the vernacular dwellings are multi-functional and serve the buildings and the users in several ways on the physiological, psychological and cultural levels. Mashrabiya for instance is very popular among vernacular Arab dwellings, this cantilevered architectural element acts as a sun breaker to block direct sunlight, and it is a traditional element that ensures privacy for the users, hence, women used to enjoy the outdoor view without being seen by strangers (Fathy, 1986). Moreover, it has an aesthetic aspect since Mashrabiya is a piece of art that reflects the values of the region and the identity of the place, besides, it achieved providing the users with thermal comfort. In this regard, it can be concluded that vernacular architecture, the identity of the place, and users' habits are all influenced by each other and they represent the keys to achieving regional energy-efficient buildings.

Since vernacular architecture is a process of adaptation, hence, it continuously evolves to cope with the changing users and socio-cultural environment of the region. 'Vernacular architecture and regional design' book suggest that we should understand the 'tradition' and the 'identity' in light of a changing world to get the benefit of the past techniques and improve it with today's instruments (Heath, 2009). Accordingly, recent 'sustainable' buildings are referencing the techniques of the region's vernacular dwellings to enhance building performance in its local context, reduce energy consumption and serve users dynamics (Salgin, Bayram, Akgün, & Agyekum, 2017).

The emergence of globalization policies has created a gap between the users and their buildings. Moreover, the produced ‘modern’ ‘universal’ buildings didn’t resemble the vernacular dwellings or the region that they were built in. Modern buildings failed to serve the users and their daily habits (Porphyrios, 1989). Therefore, they consume more energy than the vernacular dwellings since the buildings were built without considering the local climate or environment. Consequently, many architects worked on developing a form of ‘resistance architecture to re-connect with the users, nature, and to evoke the collective identity of the region’s architectural style.

Regionalism as a concept in architecture is not recent, it is as early as the Roman empire. Roman writers, philosophers, and architects discussed regionalism in their books and defined it. The concept has evolved through the years to cope with the region and inhabitants’ needs. Vitruvius who was an engineer architect and writer believed and wrote in his book that natural causes determine the architectural form of buildings. In other words, he mentioned that “if a thing cannot happen in nature, it cannot be forced by humans in an artifact”. Consequently, he classified the architectural styles and forms according to the regions (Roman and Greek) and described them in detail, besides, he mentioned that the diversity in the architectural forms of these buildings is a result of their different characteristics (the physical environment) which is ordained by the nature (Tzonis & Lefaivre, Architecture of Regionalism in the Age of Globalization : Peaks and Valleys in the Flat World, 2012).

Later, after the emergence of the international style, regionalism has evolved and was redefined by many architects, where the concept became popular and it arose as a form of resistance. Architects like Frank Lloyd Wright, Alvar Alto, and some others in that time translated the concept and definitions of regionalism into real design implementation where Alvar Alto for instance was more concerned with the selection of regional materials to adapt to the site and the surrounding landscape. Moreover, Elizabeth Mock called to mind and argued that architecture must adapt to the region’s climate, besides, she was concerned with ‘*contextual sensitivity to the site’*. On the other hand, Mumford argued that regionalism should resist the universal style, hence, it has to help people to enhance their relationship with the ‘place’ in terms of *‘the actual life conditions’* to make them feel at ‘home’ (Mumford, 1941).

Likewise, other regionalist architects argued that they have to learn and be aware of the traditional architecture and preserve their characteristics "the shaded, transitional, enclosed, paved, quiet…spaces" that were results of people's habits in the region (Rudolph, 1949). Additionally, they disapproved of some popular concepts in that time like Louis Sullivan's "Form follows function", where later William Mc Donough commented, "Form does not follow function, it follows evolution". The term evolution means evolution from the region's vernacular forms, passive techniques, and materials.

The concept of critical regionalism that emerged in the 1980s also represents the "Architecture of resistance" against globalization and universalization policies. Kenneth Frampton wrote six main points to achieve critical regionalism in which he suggested that architectonics features of the region should be preserved against universalization, where regional architecture should evolve the techniques of the region to cope with today's needs. Moreover, he referred that critical regionalism should maintain a high level of self-consciousness where the architect can be inspired by local spirits and the site, and enhance the relationship between the architect and the user. Consequently, critical regionalism emphasized the relationship with the surrounding nature, where changing the characteristics of the topography and the landscape of the building site is named *"the condition of absolute placeness"*.

Critical regionalism argued that buildings should be capable of arousing feelings and communicating with the user and the observer even tectonics should rise as construction of art. Therefore, buildings should not be forced to a site, but they have to merge with it and reflect today's "spirit" and "Identity". Moreover, it has to be in a delicate and permanent process of evolution to be able to serve the needs of the "daily-world life".

3.3 Reading the Place: The Tangible and Intangible Dimension of Damascene Homes

Since ancient times, human beings have been in constant search of shelter, a place to keep them safe, comfortable, and protected from natural physical threats. Moreover, people seek heaven for their spirits, minds, and souls. A home that represents them, their beliefs and habits in which they refuge not just of a house, but a piece from their own heaven. When people dwell in a house, they make certain changes in response to their surrounding natural environment as a

form of ritual acts of sheltering, in which these acts reflect the dwellers and their location in the world. The evolution of these dwellings can range from spiritual 'identity' to the materials, tangible to the intangible, person to the community. Hence, according to Ralph Knowles's book, reconnecting our lives and dwellings to the rhythms of the surrounding nature can promote the ritual use of spaces as a type of energy conservation, besides; it enhances the occupants' lives and buildings quality (Knowles, 2006).

Indeed, the correlations between the tangible and intangible elements of architecture have a significant impact on its development process. The tangible dimension includes the physical elements of a building that a human can touch and feel "artifacts", besides, tangible elements are made and consciously influenced by human beings.[1] On the other hand, the intangible dimension is usually more complicated than the tangible since it represents traditions, knowledge, skills and religion (Malec, 2018). In this sense, knowledge can be defined as the reflected structured reality of the personal perception of the world, hence, it allows designing new solutions; where the collective knowledge represents the distributed information between people which guide problem-solving techniques (Hecker, 2012). Traditions are passed knowledge and beliefs from one generation to another; thus, traditions are part of the architectural development process since the transmitted knowledge is making use of the successful theories to be employed in the designing and construction techniques. Therefore, the architectural traditions can be connected to certain used construction materials, techniques and designs.

Additionally, it is highly noticed that many religious habits are translated and transformed into traditions in which they merge to create spiritual spaces within buildings, hence, the intangible is being transformed consciously into tangible elements (Malec, 2018). The relationship between the tangible and intangible dimensions in architecture is changeable through time, but it is an important element in the evolution of architectural practices and techniques. Consequently, the intangible dimension influences the formation of the tangible dimension in various ways *(Figure 45).*

[1]English Oxford Living Dictionaries, s.v. "tangible," https://www.oxfordlearnersdictionaries.com/definition/american_english/tangible (accessed 21 November 2021).

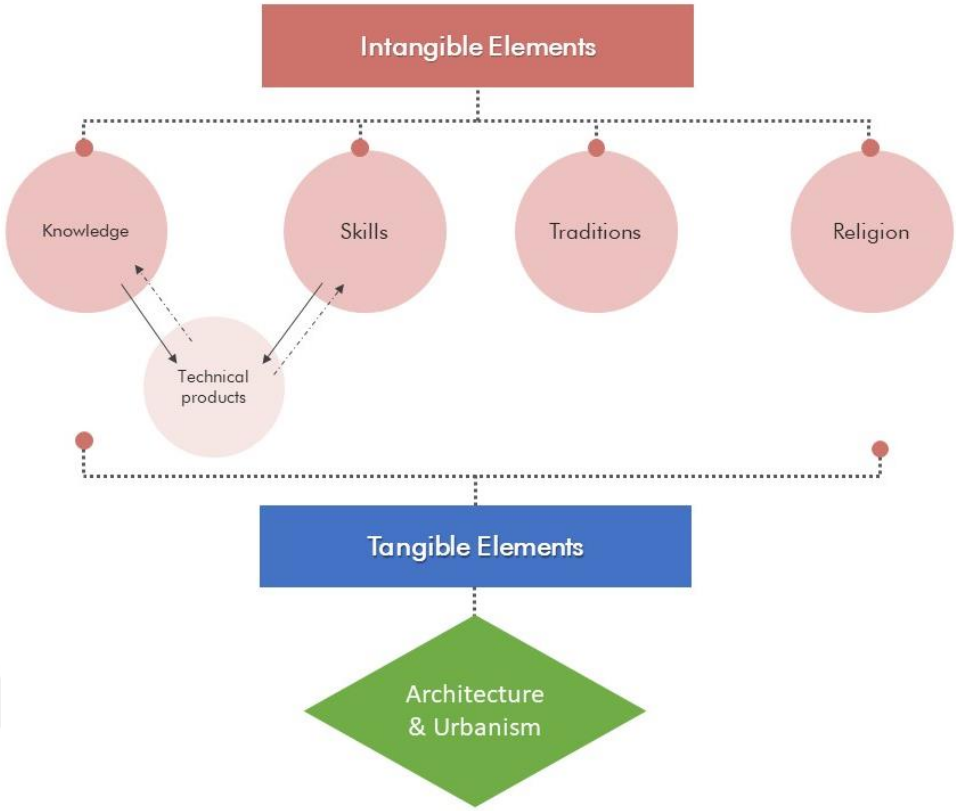


Figure 45. The relationship between the tangible and intangible elements (Malec, 2018).

3.3.1 Early home-making. When people refuge in a house, they are in a constant state of the home-making process where they recognize and emphasize the dynamic relationship of the body, emotions and their response to different conditions and parts of the house. Hence, they tend to modify its elements, structures etc. to fulfil comfort levels. In the process of home-making, people create spaces to express boundaries, cultural dynamics, beliefs, power…these tangible goals affect the home-making process in many ways (Knowles, 2006). However, people seek socializing and connection, thus, they live in communities and they develop their houses according to the shared dynamics, knowledge and traditions.

Consequently, to understand the early home-making of Damascene vernacular dwellings it is important to understand the socio-cultural structures of the community that designed and built these dwellings. The principles of the building process were the results of the collective knowledge and traditions that were passed from generation to generation. Besides, the early place-making principles of the dwellings on the individual level and 'neighbourhoods' on the communal level were derived from the spirit of the surrounding natural

environment and the Islamic religion (Alwaz, 1995). Accordingly, the houses and the city were shaped following the cultural and religious beliefs of the inhabitants, which can be summarized as follows (Ferwati, 1992):

- The daily life habits of Damascene people were coordinated according to the five prayers; hence, mosques were built in each neighbourhood close to the residential and commercial areas.
- The preferred limited interaction between women and men formed clear segregation aspects in the homemaking process, consequently, Damascene vernacular houses have separated sections for women "Haramlek" and for men "Salamlek", besides, they have developed elements for women to enjoy the outer view and socialize with the neighbours without being seen such as Mashrabiya and Mandalon.
- Privacy and safety aspects are very important for Arabs; hence, the house is inner oriented, even the entrance "Dihliz" is angled to ensure a high level of privacy and it included a transitional space (corridor).
- Pursuing "the image of paradise" is a very important aspect which the Damascene vernacular house was built and developed following this image which is discussed in detail in the following sections.
- The vernacular organic form of the dwellings was planned following the Islamic principle "Neither darar nor dirar" which means neither harming others and the surroundings nor acting to harm them, this principle influenced home-making decisions such as; locating the house, orientation, etc. Additionally, the principle affected the formation of the main elements of the house and its structure to ensure privacy for the occupants and to build with nature preserve "the image of Aiden".

Indeed, these aspects and principles have shaped the spatial and sensory Damascene homes; moreover, they assist with creating their dreamed paradise.

3.3.1.1 Spatial damascene home. The built environment (neighbourhoods, houses, streets, etc.) are the tangible 'physical' products of the community's thoughts, customs, and beliefs. These aspects shape our cities and affect every part of them including our interactions with the built environment and building performance, besides, energy consumption is directly related and influenced by the psychological state and comfort level of the occupant. The vernacular building techniques are the products of the social and cultural heritage. As have mentioned in chapter 2, the courtyard house was first built in Damascus in the Roman era, but Damascus and the Damascene vernacular house flourished and evolved during the Islamic era. Thus, the following mentioned principles of the special Damascene home are focusing on the vernacular house in the Islamic era. The traditions and the cultural background of the inhabitants developed building codes and shaped the spatial Damascene home on the urban planning regulations and house levels.

On the urban planning level, as have mentioned the main principle that influenced the evolution of architecture in the Islamic era is "neither harming others and the surroundings nor acting to harm them", accordingly maintaining comfort levels for the inhabitants is the main aim.

- The city was planned and separated into zones (residential, commercial, and industrial); this process manages to reduce disturbance levels. Furthermore, even bakeries and baths were forbidden in residential areas, except for small ones to eliminate the huge amount of smoke and voiced that could disturb and harm people. Recent studies mentioned that smoke and high voices affect human's psychology and health, besides, they might disturb olfactory and auditory comfort for the inhabitants (Boduch & Fincher, 2009) Additionally, tanneries and other industries were located on the edge of the city to reduce pollution levels (Alwaz, 1995).
- People seek privacy regardless of traditions, backgrounds, and religion. Consequently, the evolution of street networks was relying on three functional purposes, these three functioned served the privacy aspect. Moreover, they ensured thermal comfort and acted as an effective climate-responsive element since they blocked dusty winds and created shaded spaces (Ferwati, 1992).

1. The street network was developed organically, streets are narrow and curved to ensure privacy for the quarter inhabitants and to prevent passers from overlooking the houses in the alley.
2. The streets were designed in a way that does not reveal the destination of the passer; hence, it developed a kind of defence system that protects the inhabitants.
3. Main huge squares were absent, the courtyards of the mosques acted as gathering spaces for socializing. Nevertheless, each quarter has a semi-public space that manages the inhabitants of the quarter to interact and socialize.

- The inhabitants were not allowed to locate their main house door in front of the neighbour's door to ensure privacy and not violate it (Bakeer, 2021) *(Figure 46).*

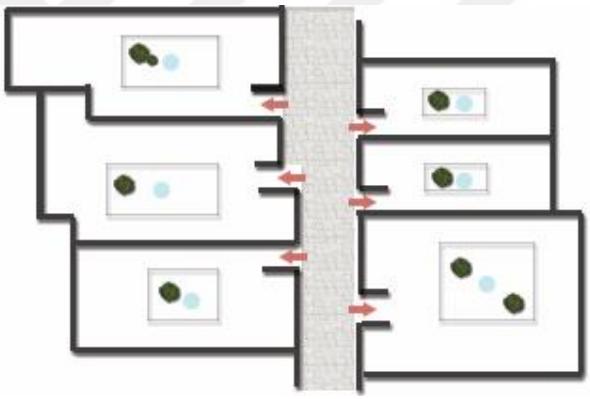


Figure 46. Houses' entrance's location to ensure privacy (Ferwati, 1992).

On the house level, unity, and humbleness are socially inherited values and they are reflected in the architectural structure of the city. The following mentioned aspects are the main principles that formed Damascene vernacular houses

- The noticed humble facades and settlements are the result of the communal traditions which urge unity and avoid ostentation from the outside. This aspect was influenced by the saying "God does not look at your appearance or wealth, but look at your heart and deeds" (Akbar, 1988). Accordingly, houses were developed following this principle where houses are rich on the inside. Indeed, this principle directed the residents to pay more attention to the internal elevations and spaces than the external ones, which is desirable in the hot dry climate to improve indoor environmental quality.

- The segregation between women and men was clear even in the vernacular house's units, thus, the house was separated into distinct zones to ensure privacy. These "traditional" zones acted as thermal zones in which they ensured proper temperature and privacy at the same time.
    1. Guests' zone (Al-Barrani): this zone follows the main entrance which includes Qaah for the guests and family gatherings. In some palaces, this section might include a separate Iwan and courtyard for the visitors and it is called "Salamlek" (Kabrit, 2000).
    2. Family zone (Haramlek): this zone is considered private and limited to family members and it has to functionally separate areas, "living area" on the ground floor and "sleeping area" on the first floor.
    3. Service area: it includes storage, bathroom, and kitchen which is usually located in the corners of the house where family members could work freely without being seen by the visitors.
- In the traditional beliefs of the inhabitants' windows were considered more harmful and privacy-violating than doors for they could overlook the neighbours. Therefore, outer windows were rare and if found they have to be high enough so they don't violate the neighbours' privacy. In this sense, Mashrabiya was found and developed to preserve privacy and societal norms (Alwaz, 1995).

In this regard, building traditions and knowledge were developed to fulfil not just the customs and religious beliefs of the inhabitants of Damascus, but also to achieve psychological and physiological comfort levels. These principles have urged building with nature and eliminating disturbance and harming levels. Building rituals, codes, and principles were not limited just to the spatial aspect of houses to achieve building efficiency and sustainability, but also the imaginary and sensory aspects were considered.

3.3.1.2 Sensory damascene home. "…. When the peaks of our sky come together my house will have a roof" (Eluard, 1947, p. 115) . The relationship between architecture and space is not limited to the physical dimension, but also the metaphysical. A home is a series of images that represents identifies and defines situations and relationships. Many studies argued that the most powerful tool that a place (architectural product) could have is the capability of transmitting images, telling stories, and experiences (Pallasmaa, 1986) (Bachelard, 1957). Successful building forms and components are not the ones with high artistic and spatial quality, but the ones with simple forms that reflect the cultural structure of the region and its inhabitants in which it manages to arouse feelings and images to the observer.

A complete experience of home could be achieved through human senses that allow one to experience his/her surrounding world. Although the eye "vision" is considered as the main sense that allows human beings to explore their surroundings, but also other senses are very important to have the 'complete experience' (Pallasma, 1996). Vernacular builders or decision-makers knew the importance of involving human senses, and their beliefs in the home-making process to create sufficient dwellings and represent the occupants' outlooks, experiences and tell their own stories. According to Gaston Bachelard, 'the more memories and beliefs are fixed in an architectural space the sounder they are', besides, he states that a house should allow the user to dream in peace (Bachelard, 1957).

Therefore, the religious beliefs of Damascenes and their longing for the image of Aiden (paradise) had a major role in shaping the vernacular dwellings and giving the users the full experience that they are longing for. The courtyard represents the open space that connects the inhabitants with the sky (God) where they derive the natural energy for themselves and their houses. Moreover, the inhabitants evolved their houses mimicking the described image of Aiden that was mentioned in the Holy Qur'an *"Believers will eternally dwell in Aiden gardens where rivers flow underneath it"* The Qur'an 20:76. Hence, the courtyard included the mentioned gardens (trees, plants and flowers), and water elements 'fountains' were also included. The full experience was achieved when the house evoked the visual, auditory, and olfactory senses by using different colours, textures, voices and smells, which are familiar to the users' knowledge.

This full experience of the architectural space 'the courtyard' is transmitted through the spiritual presence and embodied materials. Additionally, the collaboration between the physical and mental structures "poetics" have managed to create meaningful spaces and the spirit of the place (Spence, 2020). In this sense, the indoor environmental quality was optimally achieved.

Moreover, the architectural elements of the house were designed to satisfy the multisensory nature of the humans' mind. The phenomenology of multisensory and architectural tectonics was defined and mentioned by many architects, where it was argued that the carefully transmitted images through the visual elements, humidity, temperature, materials selection, odours, the layout of spaces, and the integration of the building to the site…etc are all the keys to evoke all human senses in an architectural space (Tabucbuc, 2016). Thus, the multisensory experience was achieved in vernacular Damascene houses by following these aspects. Many architectural elements within the house were multi-functional and stimulated several human senses. For instance, the fountain in the courtyard has aesthetical psychological and thermal benefits in which it evokes the visual, tactile, and even auditory senses. In this regard, we can conclude that the houses were enabled to tell stories and communicate with the observer through good architectural practices, which form the identity of the place (Spence, 2020). For instance, we can detect that Damascene vernacular houses encourage regional architecture practices, hospitality "guest zones were considered", humbleness, respecting the neighbours and eliminating disturbance and harm. Furthermore, Damascenes were fascinated by the power of nature and the image of paradise; this explains the dependence on passive and natural techniques to enhance building performance.

3.4 Rethinking Vernacular Abandoned Strategies

The emergence of modernization policies in the 20th century has affected Damascus radically on many levels (Lababedi, 2008). Traditional techniques of sheltering were abandoned to be replaced by modern "high-class" ones. Nowadays, our sheltering habits and rituals are unable to reflect the inhabitants' and nature's rhythms (Knowles, 2006). Modern neighbourhoods and buildings do not resemble the historical city and the inhabitants of Damascus. Moreover, the 'modern' houses are not a developed model of the vernacular Damascene houses, but rather they represent imported copies of 'modern' Western houses

that were firstly built in Syria during the French Mandate period and have continued spreading in the city to this day (Ferwati, 1992).

The imported modern houses failed to serve the users and the surrounding environment. Additionally, the main principle of modernism 'transparency' was celebrated and applied by designing glass facades (curtain walls), and orienting the house outwardly which failed to achieve thermal comfort, besides, it created an uncomfortable indoor environment in the conservative region with a hot arid climate. As a result, modern buildings tend to consume more energy than vernacular ones since these types of buildings maintain proper temperature by using HVAC systems, consequently, the house and its elements were unable to work efficiently in such climate. The principle that describes this architectural type is "build cheap" and "maintain expensive" (Knowles, 2006). Unfortunately, the imported building principles and codes have changed the face of the historical city spiritually and physically (Mansour, 2015). Therefore, the following sections are describing these changes and how they affect the identity of Damascene houses, their performance and energy consumption by shedding the light on the abandoned vernacular strategies and the situation of today's dwellings.

3.4.1 Orientation. Architectural styles, design, principles, etc evolve to cope with the current era and to serve the needs of the current generation. Indeed, an effective design should tackle the region's problems and be the mirror of society and domestic habits (Yilmaz & Maz, 2006). Unfortunately, many vernacular strategies were abandoned and neglected by the modern houses' design in Damascus (Alwaz, 1995), where the orientation of the house is one of the main principles that was abandoned as follows.

- Old Damascus has narrow alleys that lead to vernacular houses in which it reduced dust and heat. Modern neighbourhoods were developed to include wide streets for cars in which the inhabitants can have direct access from the main street to the building entrance. This type of building orientation is affecting indoor air quality and increasing the temperature.
- The vernacular houses were inner oriented, besides, the exterior windows were very rare, to ensure privacy and maintain a proper indoor environment. On the other hand, modern houses neglected the climatic solutions of the vernacular

dwellings and the socio-religious aspect that they reflect. And they chose to celebrate exterior windows as a replacement solution for the inner windows of the courtyard. Moreover, the view was replaced from the image of “Aiden” to the physical human-made built environment.

- The arrangement of the house units in the vernacular houses was relying on the socio-religious factor, the importance of the rooms, and sun direction. Hence, as have mentioned earlier the house was separated into functional zones where they were arranged according to the short-cut principle in which the occupants can take a straight line to move from one unit to another to maintain privacy and ensure simplicity. Conversely, the modern house units were arranged according to the surrounding neighbours, as a result, the users might be deprived of their privacy, sunlight and many other privileges because of the adjacent buildings. Indeed, this type of zoning ‘modern’ is continually challenging the energy performance of the buildings and the harmony between human beings, buildings, and nature (Ferwati, 1992).
- Salim Ferwati categorized “western modern houses” of Damascus into three types: Attached building apt, Detached building apt, Elevator building apt. Moreover, he compared the layout of these three types with the vernacular house *(Figure 47).*

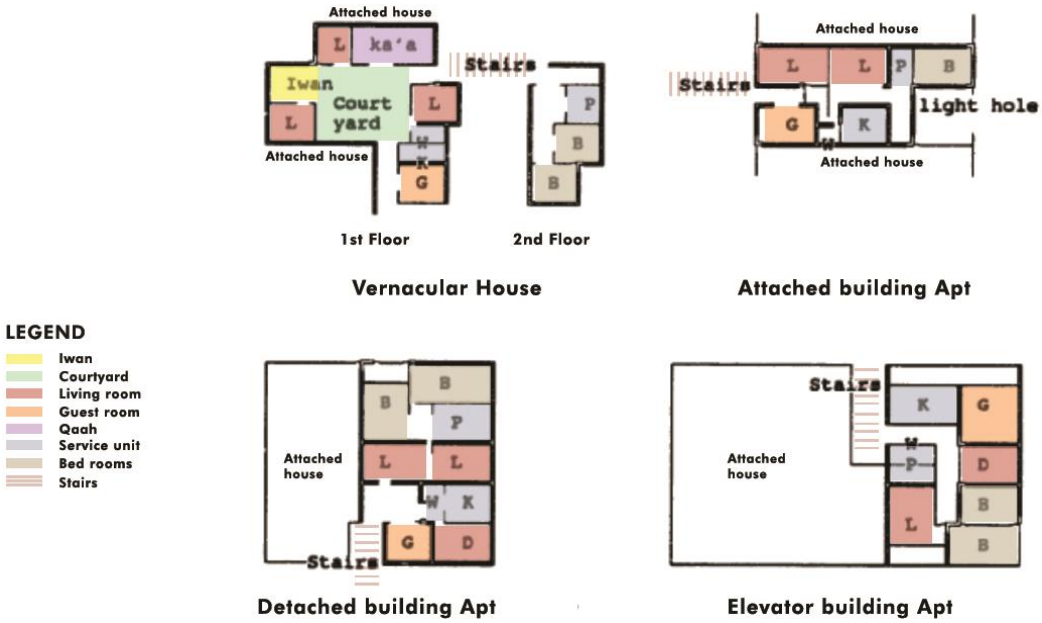


*Figure 47.*Damascene houses types and room arrangements, vernacular and modern (Ferwati, 1992).

3.4.2 Local materials. Materials and surfaces have their own language to communicate with the observer, thus, they should reflect the geographical structure, origins, and refer to the era (Pallasmaa, 2000). Building materials are used to reveal the climatic and geographic conditions of the region. For instance, the dwellings that were made of mud and adobe are directly related to the hot region as it works as a natural thermal insulation that improves indoor temperature. However, nowadays modern buildings around the world are speaking the same language, besides, they neglect the region in which they were built, its climate, and natural resources. Nevertheless, modern architects pride themselves on the universal light materials and structures. As a result, modern apartment high rise buildings look alien to the region with their huge inconsistent scale.

As have mentioned in the previous chapter, vernacular houses used natural local materials to build the house. Adobe, stone, and wood were used as the main building materials in the region. These natural vernacular materials and techniques act as a thermal regulator which enhances thermal comfort in summers and winters. On the contrary, modern houses used foreign building materials that couldn't adapt to the local climate of the city. The main used materials in modern houses are, concrete, reinforced concrete, stone, glass, and steel. Stone was used for aesthetic purposes, similarly to some used vernacular elements (Muqarnas, Arches, and domes) also served aesthetical purposes in modern houses (Ferwati, 1992).

'Cement boxes' with glass facades were spreading widely in the city and affecting its image radically. Moreover, applying the transparency method in the hot arid climate of the city has affected thermal comfort as these facades were acting as heat absorbents (Mansour, 2015) Cement has negative effects that are not limited to the appearance of buildings only, but also the environment and building performance. In recent decades, cement is considered one of the main contributors to greenhouse gases (Poudyal & Adhikari, 2021). Moreover, it affects indoor environmental quality as it emits gases that affect human health in the long term (Tsakas, Siskos , & Siskos, 2011). Hence, these materials should be reconsidered and replaced with more green ones that serve the climate of the region and reduce greenhouse gases emission rates.

3.4.3 Courtyards. With the free choices that modern architects took to build 'modern' buildings from building form, arrangements, heights to building materials, modern buildings in Damascus ended up with conflicting problems. One of the radical changes from the vernacular houses to the modern is the courtyard. The courtyard was considered a cornerstone of the house and a symbol of Damascene architecture, where people's daily habits in the house and public buildings were attached to it. Since modern houses choose to be outwardly oriented, hence, the courtyard was absent even in 'villas' detached houses they didn't consider a courtyard, but a small outwardly oriented garden (Ferwati, 1992).

Modern buildings replaced the open space of the courtyard with balconies where some of them were integrated with the adjacent room to increase the internal space of the house and others were closed with curtains and glass to reduce dust coming from the main street, direct sunlight, and glare (Alhawasli & Farhat, 2017) Furthermore, Iwan which was considered as the main space inside the house for family gatherings was replaced with a closed area (room) called 'sofa or salon'. Modern houses in Damascus lacked privacy and comfortability, which are the main aspects to be considered while designing houses. Additionally, green spaces in old Damascus were usually found in private spaces (houses) or the courtyard of public buildings (mosques, baths, government buildings…). Nowadays, trees and green spaces are found in public spaces (streets, parks, squares). Unfortunately, the percentage of green spaces is decreasing as a result of rapid urbanization, the emergence of slums around the city (near Qasiun mount and Al Ghouta) (Mansour, 2015).

3.4.4 Passive design strategies. Modern houses in Damascus are consuming a considerable amount of energy to maintain proper lighting and temperature inside the house. Consequently, pollution rates and carbon footprint are increasing in the city day by day as a result of poor urban planning, and architectural practices. Nevertheless, the government did not consider any building regulations, codes, or sustainable plans to enhance the environmental and architectural situation (Atieh, 2012). Even climatic design codes of building materials, layout ratio, etc were not considered by the government and the concerned authorities, which arose a real crisis affecting nature and the inhabitants of Damascus directly.

Moving back to the vernacular houses of the old city, as have mentioned earlier, vernacular dwellings applied passive techniques to enhance the performance of the house. These techniques were part of the Damascene architectural heritage that also were neglected by modern houses. Mashrabiya which was an important architectural element in Damascene houses to protect the house from intense sunlight and to achieve privacy was absent in the modern buildings. Moreover, it is replaced by sliding shutters called 'Abajour' made of aluminium, these shutters are usually used at night to prevent being seen by the neighbours when the lights are turned on. Thus, they were designed not to serve the climatic aspect (protecting from the sun and glare), but for privacy. Ironically, some people are using these sliding shutters in the daytime to reduce the amount of direct sunlight and heat where they have to turn artificial lights on to have clear vision in the 'morning' which leads to consuming more energy *(Figure 48).*

Water elements are not considered in modern houses, except for some luxury villas, where fountains and swimming pools were added for aesthetical purposes. Sadly, inserting HVAC systems and mimicking some foreign architectural practices were referred to as a sign of civilizing and advancement. Indeed, this distorted image of 'advancement' had a deep impact on architectural practices which lead to abandoning the climate-responsive techniques of the vernacular houses (Mansour, 2015). Furthermore, some houses did not consider the thermal insulation layer while building the house as a result of some economic reasons, which takes us back to the principle of "build cheap" and "maintain expensive".

Figure 48. The replacement of Mashrabiya with sliding shutters (Edited by the Author).

3.4.5 Identity and local dynamics. "Despite her happiness in the new house in Abu Rummaneh, Zain was longing for that small alley that wraps itself like a womb, the windows that are close to each other, and for the mud skin of the houses that almost seem alive. She realized that the house is big with its people, dynamics, perfumes and spices." (Alsamman, 1999).

The local identity and the socio-religious background of the inhabitants of Damascus have formed its architectural structure. However, these inherited principles were neglected in the modern part of the city, besides, they were considered backward and uncivilized (Lababedi, 2008). Indeed, many aspects affected the city and the local dynamics of people which influenced the architectural identity and the image of the city. The changes in people's lifestyle and beliefs had a major impact on houses organization as houses follow the dynamics of the inhabitants "social or psychological forces shape space" (Hillier & Hanson, 1984).

Nowadays, modern buildings in Damascus are being built without knowing the daily habits of the inhabitant and their needs. Moreover, 'copy paste' buildings are very popular in the city where buildings with 6 stories and more are being built in groups and sold without considering the dynamics and the climate of the city. Which cause serious issues and affect the performance of the buildings. These practices are leading to distorting the identity of the place since buildings are incapable to mirror the users and the region. Additionally, the inhabitants in the modern houses may experience a state of loss since their house does not function as expected. Therefore, people tend to use products that can consume energy and harm the environment and their health in order to maintain a comfortable atmosphere.

Kevin Lynch mentioned that “uniqueness” is the sign of identity, this sign is absent in the modern part of the city. Moreover, it is affecting the old part “vernacular” since investors are buying the vernacular houses to use them as “bars, hotels, restaurants, etc.” The city of history became a commodity and a place with a high rate of pollution. Sadly, today Slums make up 60% of the city's area, as a result, of poor ‘modern’ urban planning. Besides, 46% of the city’s inhabitants are living in bad situations in slums, which also influence pollution rates (Mansour, 2015).

3.5 “Modern” Urban Plan of Damascus

“I miss my old house while I’m in my exile, in Abu Rumaneh Street, and my biggest fear is it might get demolished…. I feel embarrassed in front of the neighbours of my clothes, my words, and my mind... this lonely house... Amidst the strange orchards that buildings bite day after day, and I am like someone who lives in a construction site...here, there are many aggressive people that I could never live with.” (Alsamman, 1999)

After World War II many countries were to the concept of “modern city”, this concept was mainly imported to the Levant region by French colonization where they suggest masterplans for the Levant’s cities including Damascus (Al-Sabouni, 2017). The “western” suggested urban plan of the city strikes every traditional root of the city and its inhabitants (Taiiarah, 1982). Moreover, it divides the city into ‘territories’ and ‘functional’ zones in which these aspects have led to real issues that affect the urban fabric of the city and its architectural identity negatively.

The noticed neglect in urban planning and the lack of architectural practices regulations have led to depriving the residents of Damascus of their right to adequate housing. Consequently, inadequate houses and slums were popular among the city and they distorted the identity of the historical city in which it became “*unreadable”.* As a result, the percentage of energy consumption increased since the basic environmental architecture practices were neglected (Atieh, 2012) These aspects are being discussed in the coming sections.

3.5.1 Ecochard-Banjoyas' urban plan

In the 1930s Syria was still under the French mandate’s control where they were leading architectural and urban planning works in the capital of the country (Damascus). In 1935 a French firm undertook the planning process of Damascus, led by two French architects/urban planners ‘Michael Ecochard’ and ‘Rene Danger’ (Fries, 1994). Michael Ecochard the young architect worked in Damascus as an archaeologist during the French mandate before working on the master plan of the city. Hence, he was familiar with the history of the city, its organic formation and vernacular fabric. Nevertheless, he was fascinated with the imported concept of ‘modernity’, Ecochard and Danger prepared the first modern masterplan of the city where they suggested these main ideas to modernize the city,

1. The two French architects suggested modernizing the city by making it more ‘functional’, ‘accessible’ by vehicles where they can move freely by implementing modern street networks (Fries, 1994).
2. Demolishing some ‘old’ buildings to have enough area to implement street network and to enhance the sewage systems of the old city where it was referred to as unhygienic.
3. Separate the city into zones ‘territories’ the modern part is for the elites and the old part of the city is for the poor. They claimed that this type of city dividing would manage to keep the socio-economy stable (Lababedi, 2008).

Indeed, this suggested masterplan upset both the indigenous residents and architects especially when the old city of Damascus was considered a “backward” place, besides, the French architects were aiming to replace the organic vernacular plan that respect the traditions of the inhabitants with “universal concept of modernity” (Lababedi, 2008). Faedah M. Totah mentioned in her book ‘Preserving the old city of Damascus’ that, the master plan of Ecochard aimed to distort the identity of the city and the inhabitants (Totah, 2014). However, the urban plan had many serious issues and it was stopped after the independence of Syria by UNESCO in 1953 until the 1960s, Al-Baath party re-hired the French architect Ecochard to modernize the city and the Japanese architect Banjoya (Matsubara, 2015), they completed the unfinished masterplan and re-suggested ‘modern’ ideas including,

1. Replacing the inwardly ‘close’ plan in the walled part of the city, with a transparent ‘outwardly’ plan in the modern part (Al-Kodmany, 1995).
2. Implementing large public open spaces (parks, squares plazas, etc)
3. Recommending demolishing and gentrification works in the old city of Damascus instead of restoring the old houses.
4. Considering some squares as the commercial heart of the city and increasing high-rise office buildings around it.

These radical changes in the urban fabric of Damascus have led to an extreme change in the inhabitants' behaviours and their relationship with the place. Moreover, the masterplan affected architectural practices since architecture both influences and can be influenced by urban planning. The

reversed orientation affected the thermal comfort and the privacy of the user(s). Additionally, high-rise buildings were introduced to the city as a response to the rapid population where they are oriented randomly, which affect the surrounding buildings and prevent them from their right to natural ventilation and cool breeze.

The government didn't complete applying Ecochrd-Banjoyas' master plan and there weren't any formally presented master plans to cope with the rapid population of the city. Accordingly, the city was expanding randomly beyond the master plan of Ecochrd-Banjoyas' which have led to the emergence of slums (Figure 49). People were forced to develop their own plans, and create their own zones and houses to fulfil the need for shelter, thus, modern houses in the city are unlike the vernacular they have no feature of living (Al-Sabouni, 2017). Although these recently built houses were built according to the residents' knowledge without the help of architects, we cannot consider them vernacular houses since they do not resemble the city and the region. Moreover, sustainable techniques were absent in the buildings.

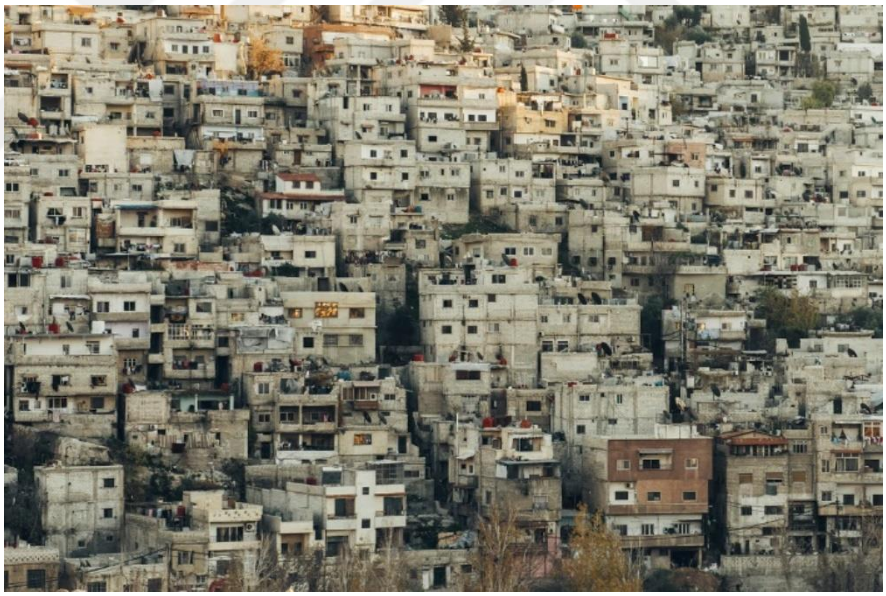


Figure 49. Slums in Damascus (https:// www.flickr.com/ photos/ 75554425 @N03/33476577068)

Chapter 4

Methodology: Energy -Efficient, Regional Building Design proposal

As have mentioned in the literature review, relying on fossil fuels to generate energy for buildings is affecting both nature and human health negatively. Moreover, the large emitted amount of greenhouse due to energy consumption is causing global warming. As a result, architects are responding to solve this crucial issue by enhancing building performance and reducing energy consumption where governments are preparing plans and protocols for architects to follow including considering NZEB's.

According to IEA, the household sector is responsible for 50% of total energy consumption in Syria (IEA, Country Nuclear Power Profiles, 2017). The country is relying on national fossil fuels (natural gas and oil) to generate energy, which is considered a very crucial issue that impacts the environment. Nowadays, the energy sector is in chaos due to the political conflict in the country (Khaddour, 2021). Therefore, architects should seek alternatives that manage reducing energy consumption and respond to climatic and cultural conditions. Indeed, poor architectural practices, which were following the international trends and neglecting the vernacular heritage have affected the capital Damascus its urban fabric, architectural identity and building performance. Accordingly, this chapter of the thesis is aiming to propose design strategies for 'villas' and 'residential buildings' to reflect the region, cope with today's needs and consider the global priorities.

4.1 Design Guide

Good architecture can be achieved by relying on "the best of the past and the best of the new", thus, contemporary sustainable design should consider this principle. Design strategies for contemporary buildings must include advanced building technologies along with regional techniques and local traditional ideas to comply with the user(s) needs. Building design strategies should tackle many issues, but most importantly occupants' comfort and energy consumption as these aspects are affecting people's behaviours in a place, which leads to wrong behaviours that impact the environment and cause climate change.

Architectural practices that involve relying on fossil fuel sources should be replaced with cleaner and more sustainable ones. Indeed, the right process 'platonic' to design a building could be concluded as follows,

1. Interview the user(s) to collect information related to their dreamed home, daily habits, cultural background, etc.
2. Analyse the site and the climatic conditions.
3. Decide the design strategies that could meet the desires of the interviewed user(s) with the climatic conditions and the regional sources.
4. Propose design alternatives to improve the building performance.
5. Make simulation related to energy efficiency.
6. Include the best results in the design.

However, these steps are ignored in many designs, which cause many serious issues. Accordingly, the following sections are proposing new design strategies for the region by relying on the previously mentioned steps.

4.1.1 Urban planning strategies. Urban planning regulations have a great impact on urban form and the microclimate which affect buildings and their energy consumption. Nevertheless, outdoor thermal comfort and the microclimate were mostly not considered in the urban planning process. Recent studies are arguing design strategies that could improve the microclimate in hot arid areas. These strategies include increasing vegetation, water bodies, shading element, etc. Indeed, streets are the most crucial component of the city's physical structure, besides, the street form affects the outdoor and indoor environment since it is responsible for sun reflection, solar gain, air quality, wind speed and many other aspects.

A study was conducted by (Yahia & Johansson, 2013) they analysed and simulated three zones in Damascus, the old city zone, the modern residential zone, and the rural inhabited zone in terms of microclimate, the impact of street trees on thermal comfort and the effect of H/W ratio and orientation on surface temperature. The study deduced that the modern part of Damascus and the planning regulation are highly inefficient. Street orientation is not decisive in the modern part of Damascus that includes detached houses; however, the E-W and N-S street orientation in old Damascus is lower than the other two zones, as a result of the proper H/W ratio in old Damascus.

Moreover, in both zones of the modern part of the city, streets are mostly exposed to solar radiation whereas in the old city vice versa. Additionally, they found out that increasing vegetation (planting row of trees on the pavement) has a significant impact on the microclimate. In another study, the authors deduced that landscape elements and green spaces achieved maintaining thermal comfort even in the warmest hours of the day and in the most problematic season in the city 'summer', nevertheless; in winters the thermal comfort values are lower than the comfort temperature 'neutral' (Yahia & Johansson, 2014).

In terms of the cultural structure of the city's urban planning, as have mentioned in the previous chapter the privacy aspect was maintained in the old city by creating narrow angular alleys that do not reveal the directions, hence, the sense of safety was achieved in the old part by creating ideal H/W ratios. On the other hand, in the modern part of the city urban planners argued that to maintain a sense of safety and privacy they have to enlarge public spaces so people can accommodate their private space "bubble spaces" (Al-Kodmany, 1995). Consequently, this principle has created very problematic public spaces to tackle in a hot arid climate since wide-open spaces are more exposed to solar radiation which affect the outdoor and indoor temperature.

Accordingly, to enhance the microclimate and thermal comfort in the modern part of Damascus these design strategies should be considered and implemented,

- Shaded spaces should be increased to reduce exposure to direct sun, especially in summer. Hence, flexible landscaping elements are preferred to maintain thermal comfort in summers and winters such as movable street shading devices, arcades, and trees.
- Green spaces should be considered since vegetation has a dramatic impact on the microclimate; besides, it improves air quality by tying down dust and purifying the air from toxic gas emissions. Oasis-like spaces are desirable with rows of deciduous trees, evergreen trees and ground covers. The trees should be selected according to the region; thus, they can cope with the climatic conditions and consume less water. Small parks and lanes should be also considered to facilitate natural ventilation in the city.
- External open spaces should be treated carefully since they are the key to reducing solar gain, reflection and glare. Thus, huge open spaces such as

plazas, parks, and squares should replace hardscapes with softscapes (green spaces). Moreover, water bodies should be integrated to moisture the air.

- Most importantly H/W ratio should be analysed while planning new zones where buildings should create shaded spaces most of the day. Hence, narrower streets should be considered and building elements that create shaded spaces for the streets should be implemented such as cantilevered upper floors facades, horizontal shading devices, etc. *(Figure 50).*
- Attached buildings 'grouped' should be considered where east and west walls should be close to each other to create mutual shade.

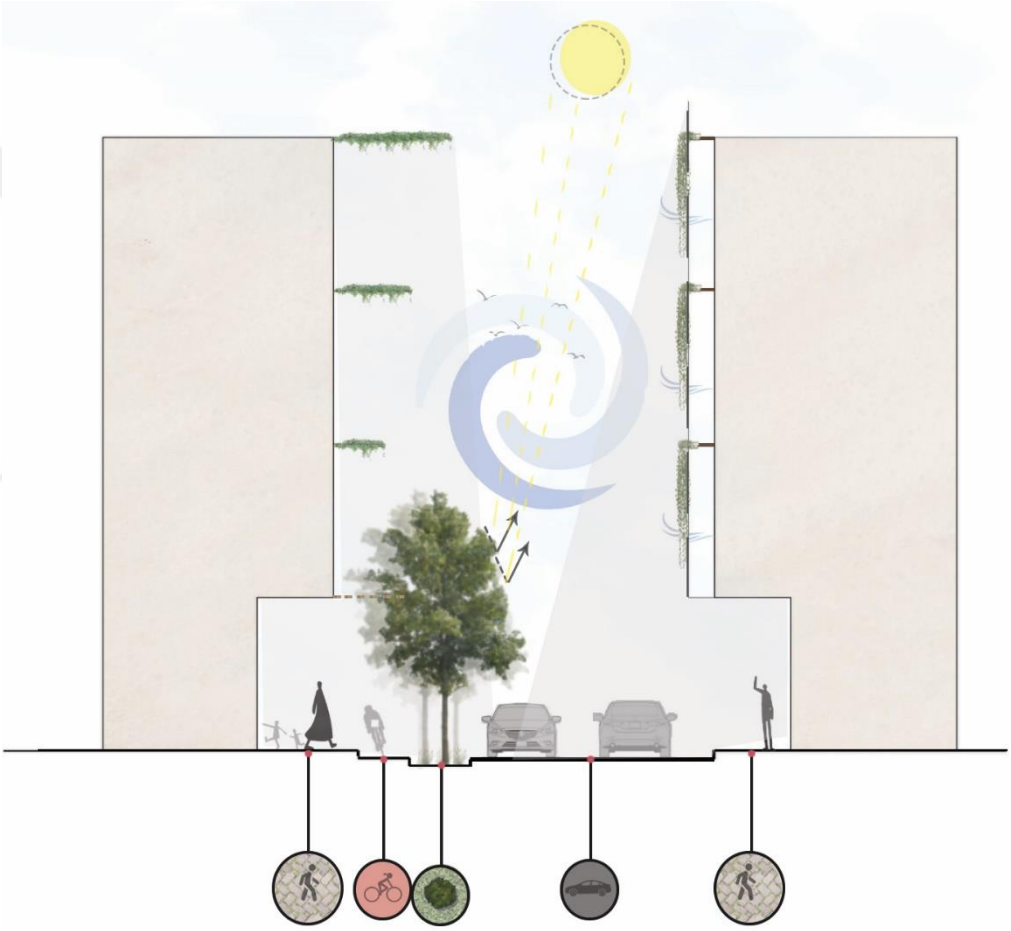


Figure 50. Shaded spaces created by considering H/W ratio and vegetation (Author's own)

4.1.2 Architectural design strategies. Recent architectural studies are focusing on energy efficiency and creating NZEB, they have argued many aspects to reduce energy consumption in contemporary designs. Charles Eley stated in his book that, the most important design decisions related to energy efficiency should be done in an early stage. The orientation of the building, number of floors, materials, etc. are all important decisions that impact building performance and the future opportunities related to daylighting, heat gain, heat loss, ventilation, etc (Eley, 2016). Accordingly, the following sections are suggesting design strategies that would facilitate reducing energy consumption in contemporary designs.

4.1.2.1 Identity and privacy: the geometry of home. Architecture has to deal with changing society, advances in technologies, it should be open to new experiences and other phenomena that impact the physical and spiritual structures (Yilmaz & Maz, 2006). In 'place identity participation and planning' book the authors argued that, since identity is a dynamic concept, hence the identity of a place might evolve and change according to the changing world where new functions may arise, users may differ, the goals might change (Hague & Jenkins, 2005). However, most importantly, the spatial qualities, characteristics of the inhabitants, social relations and cultural background, are the signs of identity that distinguish a place from other places should be celebrated by architecture by creating regional designs.

Consequently, to create a unique place it should evoke the sense of placeness which can be presented as follows *(Figure 51)*,

- the place should merge with the surrounding nature and touch the earth lightly this could be achieved by creating a sustainable building that respects the environment and the society.
- It should arouse a sense of individuality, which can be achieved by analysing the daily life habits of the users and their desires in the place-making process.
- It should ensure the sense of being at home and safety by respecting the traditions of the inhabitants and considering the physical structures to achieve them, such as ensuring the image of Aiden by designing inner courtyards and protecting privacy by adding Mashrabiya.

- The place should communicate with the past and be open to the future, by doing so buildings can create their own identity and achieve energy efficiency by considering past experiences and including today's advanced technologies.

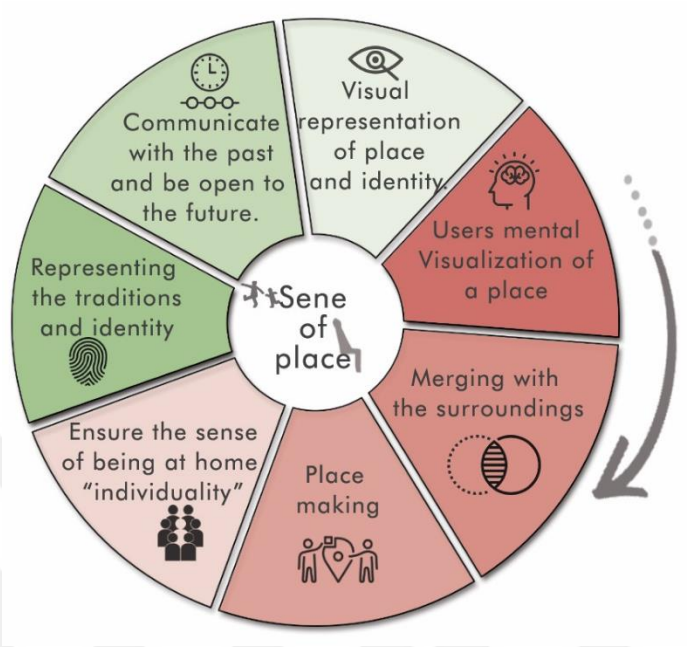


*Figure 51.*The sense of place (Author's own).

According to (Al-Kodmany, 1995) the main aspect that formed the vernacular architecture of Damascus and affected today's buildings is the sense of privacy. It is highly noticed that many spaces inside modern houses are being neglected by the user(s) since they can't cope with their needs, besides, they provoke unpleasant feelings. These spaces and feelings are the results of alien architectural designs and practices. Most people today in Damascus are ignoring the balconies that are facing the neighbours' houses or the easily viewed balconies by street passers. Moreover, the function of the balcony in these houses has changed from a place to please the user(s) to storage or a place to dry their clothes. Even windows are mostly being closed by sliding shutters or covered by curtains *(Figure 52).*

*Figure 52.*Closed windows and balconies in the 'modern' part of Damascus (Alhawasli & Farhat, 2017).

Therefore, to solve these issues the following strategies should be considered and implemented in the new designs to achieve privacy,

- Residential buildings should be built in rows; hence, the opened windows and balconies could be acceptably far from being seen by the neighbours.
- Singular family Detached houses "villas" should consider courtyards instead of front and backyards. If front or backyards are found, the walls "the fences" of the house should be high enough to prevent being seen from the passers and to create a shaded space. Moreover, screen blocks could be considered in the walls of the yard to enhance the view, airflow and aesthetical quality (*Figure 53).*
- Plants should be considered to prevent being seen by the neighbours and create pleasant spaces (shaded and generate fresh air) by planting them on balconies or house's yards.
- Wide windows could be considered in living and family gathering spaces where smaller windows are preferable in bedrooms. However, to ensure privacy and to reduce direct sun in the hot arid climate of the city, screens (Mashrabiya or block screen) and vertical louvres should be considered for windows and balconies.
- The spacing between the louvres, plantings or screen openings should be designed depending on the distance between the house and the neighbours, and sun intensity.
- For the interior spaces, a buffer transitional zone between the interior and the exterior should be added. Hence, it reduces heat gain and ensures privacy. Guest room "if found" should be designed near the main door.

Figure 53. Screen block fence can be considered in the front or backyard (Author's own).

4.1.2.2 Landscaping and orientation. The orientation of the building is considered one of the fundamental elements in passive solar design, besides, it is the most easily addressed aspect. Proper building orientation is a highly effective method to reduce energy. Wakil and Seraj argued in their book that, the long elevation of the building should be the northern elevation in the hot arid climate (Wakil & Seraj, 1989). In this way, one long elevation in the house could absorb heat in winter the "southern", and the other the "northern" elevation would be less exposed to the sun in summers *(Figure 52)*. A study was conducted by (Atieh, 2012) where the author simulated the performance of a base case modern building in Damascus in twelve orientations, he stated that the worst orientation of the building is facing a 300 degree where the annual additional energy requirement is increased to reach 1265Kwh. Moreover, the study presents that the best orientations of the building are 30,150,210 where energy savings can reach annually 7500Kwh.

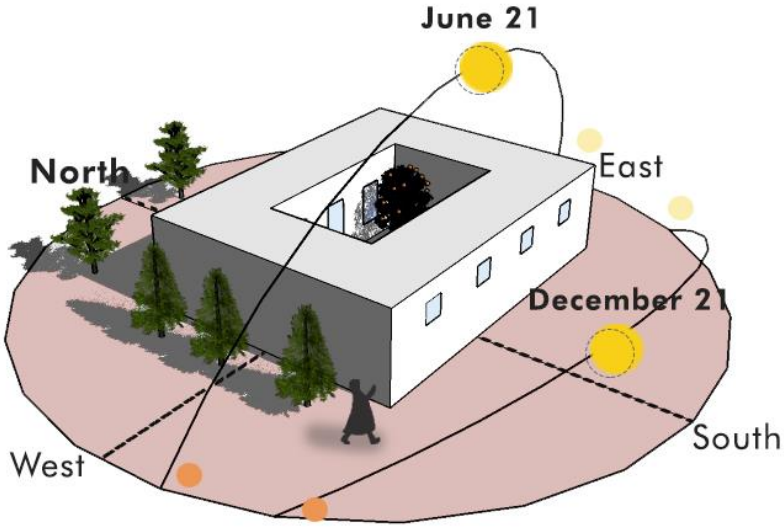


*Figure 54.*Sun path and buildings' suggested orientation (Author's own).

Additionally, Vegetation is considered in many studies as an effective tool to reduce the amount of solar radiation falling on the building surfaces. Moreover, trees manage to reduce about 5 C^{o} of the ambient air temperature (Kurn, Bretz, Huang, & Akbari, 1994), thus; green spaces enhance thermal comfort and reduce the intensity of the sun by reducing glare and creating shaded spaces.

Therefore, the proposed strategies for the hot-arid climate in general, and Damascene houses in particular in terms of vegetation and orientation are *(Figure 55)*,

- Buildings are best to be arranged in rows where the exposure to the east and west should be prevented. The longest building elevations should face north and west where the eastern elevation is considered the worst. Thus, it should be protected from direct sun by reducing the number of openings and implementing shading devices.
- North-south orientation with 25° south-eastern direction is considered the best in such climate (Atieh, 2012).
- High-rise buildings 'if found' should be built on the western side of lower singular houses (villas) or apartments residential buildings to provide shaded spaces for the neighbouring building.
- Including courtyards in the design would increase the number of northern surfaces and shaded spaces, therefore, implementing courtyards in such climate is preferred.

- Planting evergreen trees and climbing vines near the eastern and western facades would reduce the amount of heat gain due to intense solar radiation. Moreover, shrubs should be placed near the western or northern façade.
- Deciduous trees should be planted at a distance from southern facades to allow daylight and passive heating during winters. Vines can be planted on pergolas near the southern façade to form a shading device in summer.
- Increasing green spaces in the balconies, front yards, backyards and courtyards, helps cool the air and decrease temperatures dramatically.

Figure 55. Landscaping and orientation strategies for the Hot-arid climate (Author's own).

4.1.2.3 Form and space organization. Building form and mass have a significant role in gaining or losing heat, as a result of the created shaded spaces on building surfaces by the form, hence, more shades are created in multi floors courtyard houses (Figure 56). Furthermore, it is noticed that the more complex the shape of the building becomes, the more shaded areas are being created (Wakil & Seraj, 1989). Recent studies are running simulations to prove that building morphology has a fundamental role in increasing/decreasing energy consumption (Catalina, Virgone, & Iordache, 2011) Hence, the building form and mass are considered very important design decisions in terms of energy consumption.

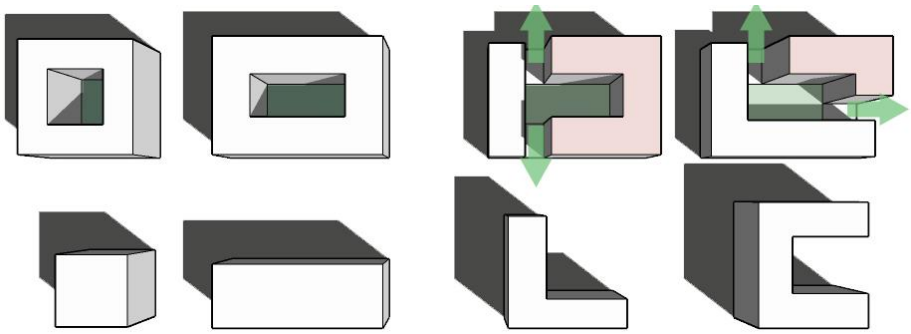


Figure 56. Shades created by building form (Author's own).

Besides the shape of the building, inner space organization is considered very important to facilitate people's daily life and reduce energy consumption. The inner layout of the building should be designed according to the daily life habits of the inhabitants. Moreover, the architect should be familiar with the using hours of each unit to ensure proper daylighting, heating and cooling requirements for each room.

To achieve thermal comfort and reduce energy consumption in terms of building form and space organization these strategies should be considered in a hot arid climate *(Figure 57)*,

- Buildings should be compact and massive to create shades on building surfaces, besides; solar orientation should be considered more than wind orientation in such climate. The optimum building ratio is 1:1.3 since it can gain maximum heat in winters and minimum heat in summers (Wakil & Seraj, 1989).
- Courtyard houses are the optimum solution they can resist the surrounding environment and bring the focus on the inner realm. Moreover, they can ensure proper daylighting without gaining heat in summers.
- In the case of high residential buildings, the building should be also compact where apartments should ensure cross ventilation to reduce heat. Hence, larger windows could be considered in the northern and southern elevations, but they should be protected by shading devices or screens. Ventilation shafts or patios could also be considered, but in this case, green spaces should be planted facing the wind to purify it from dust and water ponds should be added.
- The concept of thermal zones and thermal barriers should be considered in these houses. The western elevation that receives more heat should act as a thermal barrier, thus, less used units should be considered in this zone such as

(baths, toilets, storage). Moreover, heat-producing areas (kitchen) should be separated and far from other units to prevent overheating in summers. Bedrooms should be located on the east side of the house in this way they can cool until sleeping time since eastern elevations receive heat in the morning. The living room which is usually the most used room by the user(s) should be located on the northern side to receive less amount of heat during the day.

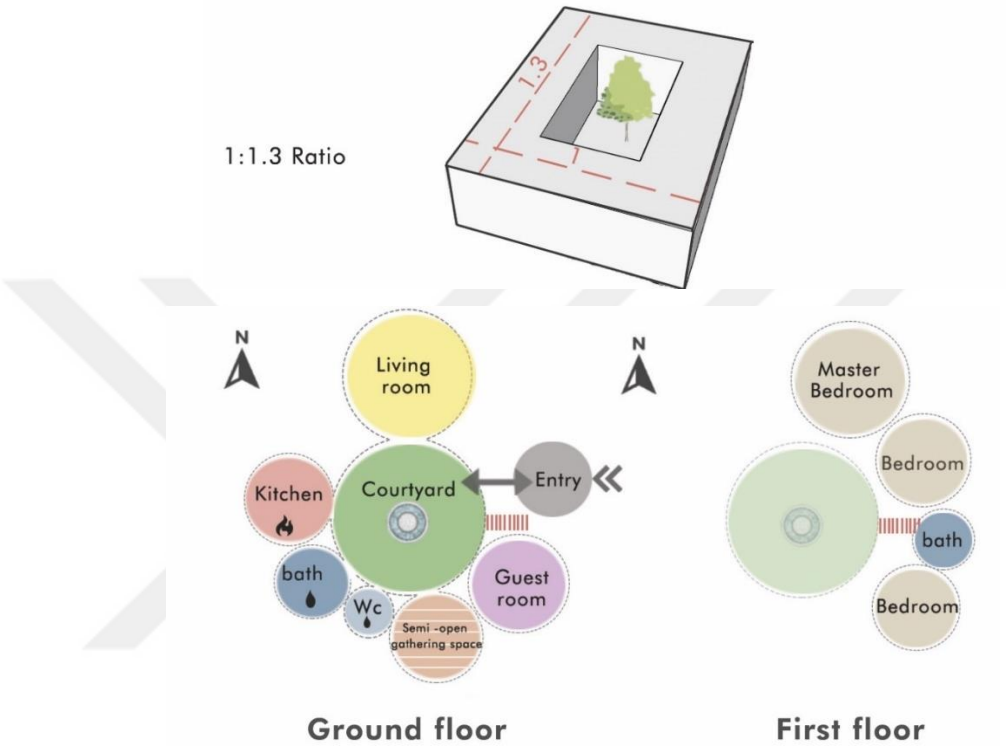


Figure 57. Proposed courtyard house ratio and bubble diagram (Author's own).

4.1.2.4 Envelope. The building envelope forms the limits between the interior and the exterior environment. Therefore, the selection of building envelope determines the amount of energy consumption since its main role in the hot arid climate is decreasing heating gain and dealing with the significant variation in temperature during day and night. Hence, this type of climate requires thermal mass to absorb heat and release it when needed. According to (Koch-Nielsen, 2002)There are three methods in which buildings transfer heat,

1. Solar radiation is absorbed by the building's external surfaces then transferred to the internal, this method includes heat exchange.
2. Solar radiation (direct gain) entered the house through the openings, which results direct heat gain.

3. Heat exchange (heat transmittance) is due to the difference in the ambient air temperature between the interior and the exterior environment (the exterior is cooler).

The following strategies are elaborating the building envelope performance under roof, wall, floor and window titles to reduce heating and cooling requirements.

1. Roof design strategies. The roof is the most important element of a building's envelope since it is exposed to solar radiation all day. Thus, design decisions regarding roofs are very critical. Non-flat roofs such as domed roofs absorb less heat as a result of the created shaded spaces derived from their form. However, chapter 2 explained how Damascene vernacular houses tackled this issue regarding their flat roof. Cross air and roof ventilation reduce heat transfer which mange reduce cooling requirements and energy consumption. Consequently, roofs should have a smaller U-value (thermal transmittance) and bigger R-value (thermal resistance), besides, reflective coating materials and high protection against solar radiation exposure should be provided (Barrios, Huelsz, Rojas, Ochoa, & Marincic, 2012).

- The roof should be constructed with high thermal resistance materials; hence, today's light concrete roofs have a fundamental role in raising the inner temperatures.
- The roof should be covered with robust thermal insulation material as a finishing material to reflect the sun and reduce heat gain.
- Vaulted roofs can be considered in some parts of the house.
- Ventilated double roofs can be considered as a solution to reduce heat gain, thus, the roof of the house would act as a reflecting umbrella to protect the main roof under the ventilation gap that acts as thermal insulation. The roof should be constructed using light-reflecting materials where the ceiling should be massive *(Figure 58).*
- In the case of the courtyard houses, slopping roofs towards the courtyards can be implemented to allow cool air to flow downwards.
- Green roofs could be considered, local plants with low water consumption and shade creating groundcovers can be planted (Ma'bdeh, Ali, & Rabab'ah, 2022).

Soil with the lowest U value should be considered and the thickness of the soil should be chosen according to the plants' requirements.

- Wooden pergolas and climbing vines can be considered in some parts of the flat roof to create functional spaces (gathering spaces, sleeping spaces, etc.).

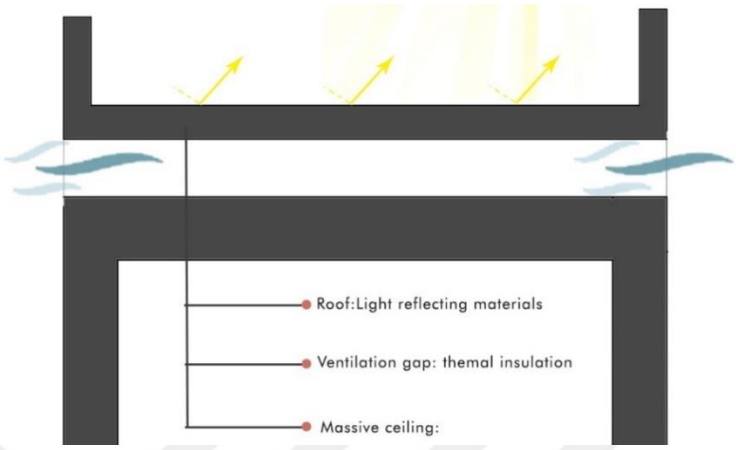


*Figure 58.*Ventilated double roof strategy (Author's own).

2. Walls design strategies. Additionally, walls are very important to protect the house from external climatic conditions. The heat amount that a wall receive depends mostly on its orientation. Similarly, to roofs' considerations, walls should have a bigger R-value and lower U-value where they should be covered with light coloured reflective finishing material. However, thicker walls (thermal mass walls with high heat storage) should be considered on the ground floor to protect the house from extreme temperatures during the daytime, to maintain proper temperatures at night and to increase time lag. Accordingly,

- Walls with high thermal mass are preferable in living zones, but low heat capacity materials are more preferable for bedrooms.
- High transparent materials such as curtain walls should be prevented in such a climate to eliminate sun reflection and glare, but if found ventilated double-skin façade is the optimal solution *(Figure 59)*.
- Light colours, thermal insulation, and high reflective insulation finishing materials should be provided especially for eastern and western elevations.
- Courtyard buildings with inner oriented walls and wall openings are more preferable.
- Walls and wall's openings should ensure airtightness to prevent heat transmittance.

- Vegetation on pergolas, evergreen trees, or climbing vines could be considered for eastern and western walls. Moreover, walls shading devices may be considered in the eastern and western elevations.

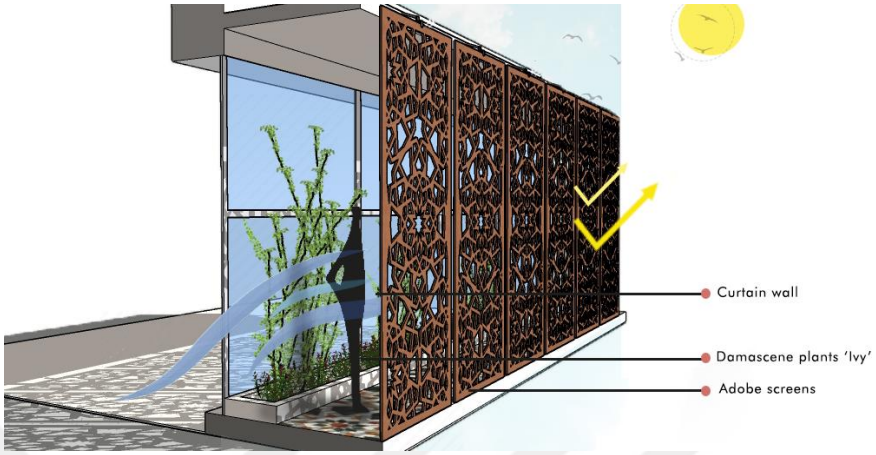


Figure 59. Suggested double skin façade for curtain walls (Author's own)

3. Windows design strategies. Wall openings are very critical since they affect energy savings directly due to several factors. Heat flow through windows and daylight are part of these factors, where heat flow contains two parts, the first one is solar heat gain due to the transparency in the window's glass and the second one is caused by the different temperatures between indoors and outdoors. Moreover, proper daylight should be ensured through wall openings to enhance the vision in the interiors and the sense of the surroundings; besides, outwardly open windows should be prevented to reduce glare, dust and heat gain. Consequently, the optical and thermal performance of windows can be presented in terms of the following parameters: visible (light) transmittance, U-value, and solar heat gain coefficient (SHGC) where the thermal performance (U-value and SHGC) are the most crucial parameters that influence energy saving in hot arid climate in terms of thermal comfort. However, visible transmittance can also affect energy saving since lighting energy can occupy a large portion of energy consumption according to building typology such as office buildings.
    - Visible/light transmittance: refers to the optical property including the visible portion of the light that passes through the window's glass. Light transmittance ranges from 90-10%, where the less percentage is caused by the high reflective coating material. Besides, the high light transmittance leads to a reduction of electrical lighting and heating load requirements.

Accordingly, the optimum percentage of visible transmittance should be considered in a hot climate, for instance, the standard double-glazing openings shows about 78% of light transmittance (Aguilar-Santana, Jarimi, Velasco-Carrasco, & Riffat, 2020). Nevertheless, this percentage could be reduced by adding reflective coatings to reduce heat gain.

- U-value: refers to the total thermal transmittance, thus, the window's U-value measures its effectiveness as an insulator (Park, Kim, Jeong, Lok Do, & Kim, 2021). The evaluation of the U-value is based on the heat transfer through the window's components. Accordingly, windows with low U-value should be considered in hot climates to enhance thermal comfort.
- SHGC or G-value refers to thermal transmittance through windows due to solar radiation, thus, it is the amount of absorbed solar energy through the window's components and its emission in the inner space. This parameter is used to determine shading devices capabilities. Consequently, the lower this value is the more solar radiation resistance.

Additionally, optimum windows to wall ratio should be considered. Glazing with a low U-value should be provided to reduce heat gain, windows should prevent air infiltration to maintain lower indoor temperatures. (Monna & Masera, 2010) analysed windows to wall ratio in three middle-eastern cities with hot arid climate (Riyadh, Doha, Dubai), they simulated different walls orientation and glazing percentages the following table (Table 2) is presenting the best-recommended results where (+) refers to high performance, (-) low performance, and (0) is medium performance.

Table 2

Performance of Glazing Percentage in Different Walls Orientation. (Monna & Masera, 2010).

Wall orientation	Glazing percentage	Energy efficiency	Thermal comfort	Daylight	In-out view
South	30%	+	+	0	-
South	50%	0	0	+	+
North	50%	+	+	+	+
North	70%	+	+	+	+
East	30%	+	+	0	0
West	30%	+	+	0	0

- Accordingly, the optimum percentage of glazing in southern oriented walls should be between (30-50%) since the windows receive sunlight at a steep angle, thus, solar radiation is less intense than it is on western and eastern facades since they receive sunlight at a shallow angle. Hence, the glazing percentage in western and eastern facades should not exceed 30%. Larger windows should be considered for the northern façades (50-70%) with a limited solar gain capacity to enhance daylight (visual comfort).
- To prevent penetration of dust and hot air, windows profiles and closing joints should be tight.
- Double glazing, double argon-filled glazing, reflective glazing, and active glazing are the best options for this climate in terms of energy efficiency, thermal comfort, daylight and view (Monna & Masera, 2010).
- Mashrabiyas and windows screens manage to reduce heat gain and glare; hence, they should be implemented in the problematic building facades.
- Exterior shading devices are essential to protect the building from direct solar radiation and glare, moreover; they are more effective than indoor shadings since they trap hot air. However, shading types differ according to the façade orientation and heating demands in each building unit which is explained in the passive cooling strategies section.

4. Floor design strategies. Floors have a fundamental role in transmitting or resisting heat since they are in direct contact with the ground. Hence, heating requirements should be identified to improve building performance. In the hot arid climate, thermal storage capacity and thermal conductivity on the ground floor are required.

- Buildings' floors should be built with maximum contact with the ground or into it. High thermal-conductance materials should be included to create a thermal mass that transfers heat to the ground.
- Building surrounded ground should be shaded during the daytime to ensure the radiant heat process.
- Heavyweight construction materials should be considered because they have higher thermal capacity.

4.1.2.5. Materials. The proper choice of materials and construction techniques is directly related to the effectiveness of the building envelope in terms of thermal comfort. The choice of materials should be done in light of their properties and how they respond to the climatic conditions, hence, it should be made according to how a material: reflects heat, absorbs heat, stores it, emits it, and its ability to reduce heat flow. These aspects should be taken into consideration according to the climatic zone and existing materials. Furthermore, the thermal effects on materials should be analysed since materials could experience these thermal forces, conduction, convection, and radiation (Gezer, 2003).

According to (Koch-Nielsen, 2002), to control heat radiation through the envelope the reflectivity property of the material should be analysed since it represents 'the first line of defence' against heat radiation, materials with high reflectivity properties can stop the heat from being absorbed by the envelope and reflects it. Moreover, materials have different thermal capacities to absorb heat (gain heat) and emit it (lose heat) (Figure 60). Therefore, in the case of Damascus,

- The building envelope should be painted with glossy white paint since it can reflect about (70-90%) of heat. Off white paint or light yellow can also be considered, they reflect about (65-70%) of heat.

- In terms of open spaces, hardscapes such as Asphalt reflect 10% of heat, whereas softscapes can reflect about (15-40%). Thus, increasing green spaces and vegetation in wide-open spaces is preferred in this climate. Asphalt can be replaced by cool pavement such as cement concrete, which would manage to enhance solar reflectivity and reduce heat islands (EPA, 2021).
- Surfaces' materials should absorb less heat (gain less heat) and emit heat more (lose heat). Whitewashed brick or plaster also can absorb (20-40%) and emit (85-95%) (Koch-Nielsen, 2002). Solid walls such as stone, brick, and earth are good for hot arid climate in terms of night heat emission and time lag. Burnt clay bricks are also useful for thermal resistance (Gut & Ackerknecht, 2011).
- Additionally, phase changing materials (PCM) are a very effective example in the sense, they are highly recommended in hot-dry zones where the differences in temperature between day and night may vary significantly. The commonly used substance for these materials is usually made from organic sources such as paraffin waxes, salt hydrates, eutectics and organic fats (Jiang, et al., 2021). PCM's bio composite usually melts in temperatures between (34-35) C^o, where they absorb heat from the ambient air during the melting process. Conversely, it releases heat during the solidification process where PCM becomes solid in temperatures between (22-23) C^o (Boussaba, Lefebvre, Royon, Grados, & Makhlouf, 2021). This material is an effective solution to delay the heat waves between the interior and the exterior in a hot dry climate. Hence, it helps to enhance thermal comfort and reduce energy demands for heating and cooling. Nevertheless, undesirable heat can be prevented when passive strategies and regulated ventilation are used along with these materials.

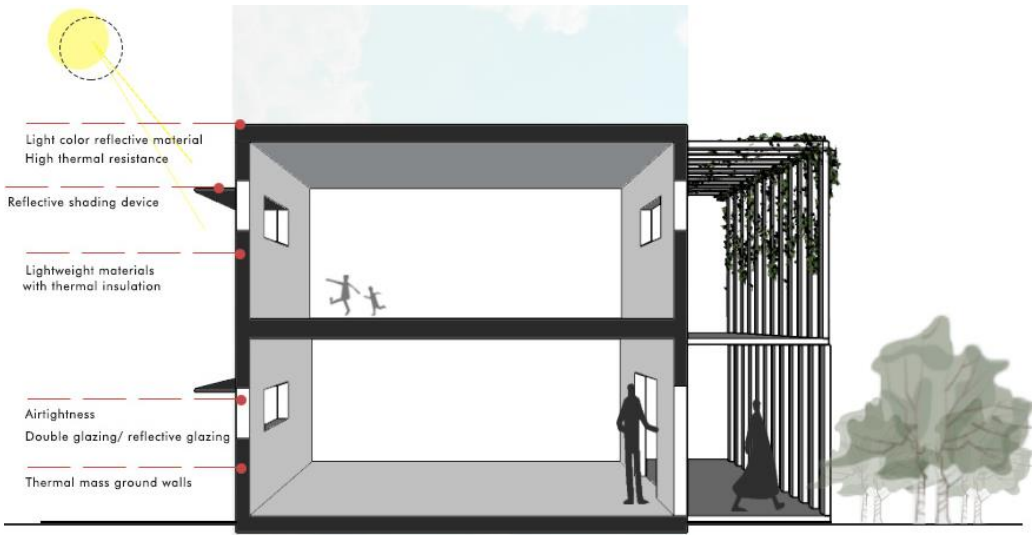


Figure 60. Envelope's materials characteristics in hot-arid climate (Author's own)

Heat resistance is also a very important property in materials, the heat resistance capacity of the envelope components could be increased by creating a gap between construction layers, the radiation in the layer gap can be reduced if the surface of the gap has a low capacity to absorb and emit heat such as aluminium shiny sheets (building elements with high thermal storing properties should be placed in the inner side of the gap) where building elements with lightweight should be placed in the outer surface of the gap. This strategy reduces heat transfer through the envelope.

Consequently, the following bullet points are suggesting some aspects for choosing proper building materials in the hot-arid climate,

- **External materials** should have high reflectivity properties to reflect heat and reduce solar gain. Moreover, they should have thermal capacity to absorb heat during the daytime and release it at night. Accordingly, walls should have a good reflective finishing to reflect direct heat from the sun and reflected heat from the surrounding buildings and adjacent walls. Thus, they should be painted with light colours.
- The selection of materials with high thermal capacity for the building envelope (roof, floor, walls) can regulate temperature variations between day and night since the heat storage capacity of materials increase the time lag, for instance; rammed or compressed earth (250 mm) can increase time lag to 10 h and stone (400 mm) increase time lag to 10.5 h (Koch-Nielsen, 2002). Additionally,

materials with lightweight and thermal insulation properties can be used along with materials with thermal storage capacity to create a composite building envelope. This strategy is similar to the construction technique of Damascene vernacular houses, where they used thermal mass walls on the ground floor and lightweight materials on the first floor to fulfil the thermal demands of the region. Accordingly, living rooms which are used usually all day requires about (9-12 hours) time lags, whereas, bedrooms don't require a long-time lag.

4.1.3 Integration of passive design strategies. The passive design has very old roots since ancient Roman times. It refers to the way people use natural sources and building components to maintain proper inner conditions in terms of thermal comfort, daylighting, etc (Lechner, 2014). According to (Rodriguez-Ubinas, et al., 2014), to optimize building performance and lower its energy requirements, a deep analysis of the climate and the site natural sources should be made. Moreover, architects should understand the interior necessities, if a building needs to gain more heat or lose more heat. Adding or reducing humidity also affects the thermal comfort of the occupants. Hence, the passive design strategies in terms of thermal performance consist of passive heating and passive cooling. In the hot arid climate of the region, passive cooling strategies should be highly considered and implemented to enhance thermal performance and reduce heat consumption. Although, in such an extreme climate ACs can be considered. Hence, the building envelope should ensure airtightness. Passive heating strategies are highlighted briefly since the climate does not require high heat gain.

4.1.3.1 Passive cooling strategies. Ensuring proper inner temperature and humidity rate during summertime is the most important aspect that architects should consider in hot-arid climates. Passive cooling strategies and evaporative cooling strategies can reduce energy consumption significantly if they are considered in the design properly. Accordingly, during summertime, hot-arid regions should avoid heat and humidify the ambient air. The following strategies would help achieve these goals,

- Natural ventilation must be regulated in such a climate to provide fresh air and avoid dust. Thus, the location of air intake openings should be analysed to prevent dust. Indeed, rooms with high ceilings improve air circulation so they

maintain cooler temperatures than low-ceiling rooms. Internal heat sources (kitchens) should be ventilated separately.

- Water bodies should be placed near wall openings in the direction of the summer breeze.
- Courtyard houses with water ponds have a significant impact on thermal comfort during summer since they allow fresh air in the house after being purified and moisturized by vegetation and the fountain. Including courtyards reduce energy consumption dramatically.
- Multi-story buildings should consider stack ventilation by designing an atrium in the middle of the building open at the top and to each floor. Accordingly, hot air rises out of the building and it is replaced by cooler air. It is preferred to have green spaces within the atrium to purify the air. Moreover, the Bernoulli effect can be considered in the atrium design to improve air movement by using wind speed differences, where the height and the width of the tower (atrium) should be decided according to the surrounded air stream to enhance its efficiency and the air volume this strategy can be combined with earth-air heat exchanger to have cooler air from the ground *(Figure 61)*.

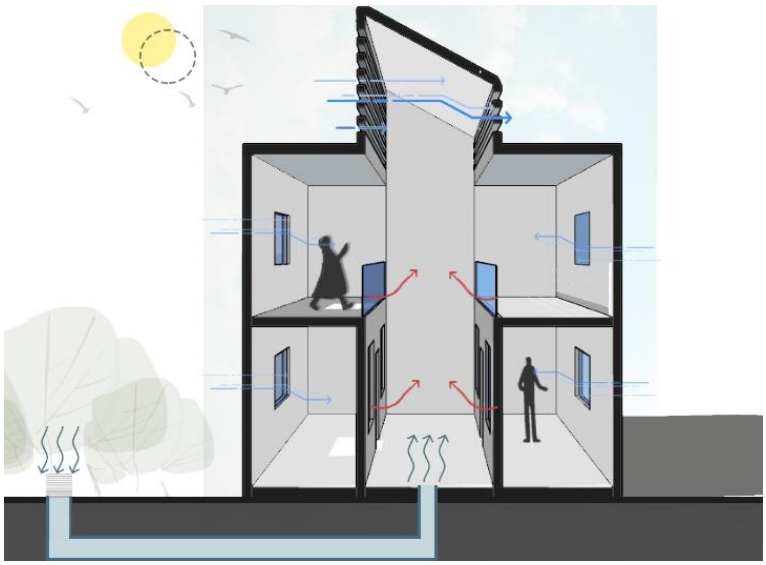


Figure 61. Bernoulli effect with earth-air heat exchanger (Author's own).

- Shading devices must be inserted, and the selection of the shading depends on the sun path and angle *(Figure 62)*. Most importantly, shading devices should

be made of reflective materials since they can add heat load on the attached building element if they are made of heat-absorbing materials (Lechner, 2014).

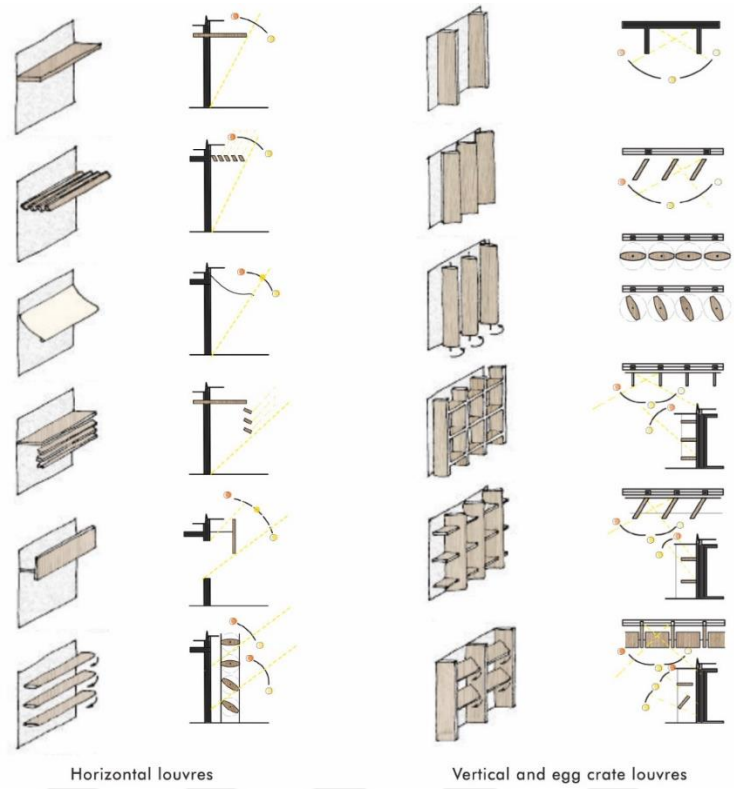


Figure 62. Shading devices types (Wakil & Seraj, 1989).

- Roof ponds may also be considered. Nevertheless, this type of passive cooling strategy demands expensive technical solutions.
- E-cooler screens evaporation system is a good strategy in the sense. These screens are made of hollow ceramic tiles that can hold and transfer water with the valves that connect the tiles. Therefore, they can be placed in front of the northern and southern openings to humidify the air and prevent direct sun; hence, it acts as a Mashrabiya with a porous jug. It can be added as a partition wall inside the house to enhance inner temperature *(Figure 63)* (Emdadi, et al., 2016).

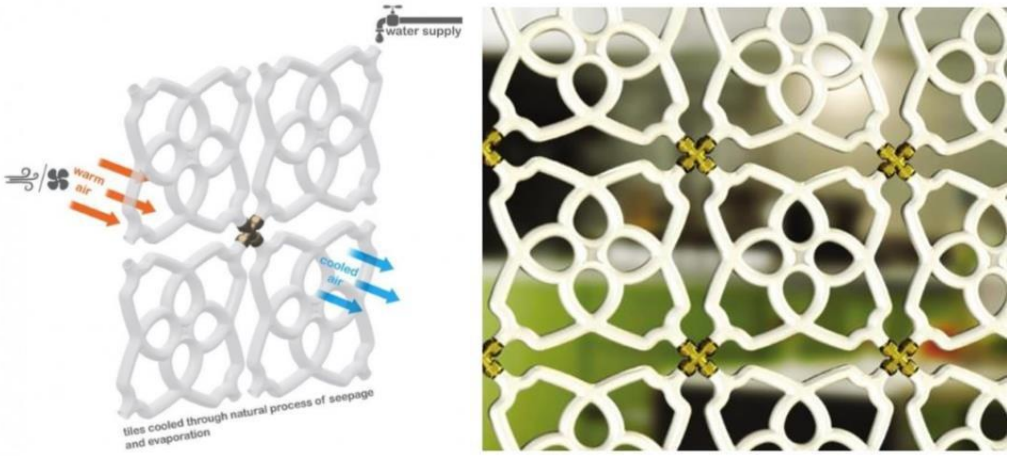


*Figure 63.*Ecooler screens (Emdadi, et al., 2016).

4.1.3.2 Passive heating strategies. Passive heating refers to the process that collects and stores solar energy. The climate in Damascus 'hot-arid' climate might vary dramatically between summers and winters. Hence, to enhance building performance and reduce the need for active heating, passive solar strategies should be considered. However, they have to be analysed and regulated to prevent overheating during summers. The following strategies could be implemented in hot arid zones,

- Direct gain should be considered as the main active heating strategy since this strategy can be regulated during summers by using shading devices since it is depending on the building envelope and walls' openings.
- Accordingly, south-facing glazing could act as solar collectors in winter, hence, considering optimum windows size (discussed in envelope strategy) with moveable louvres help to collect heat directly. Additionally, thermal mass walls or floors should be also provided in this strategy, thus, they can store heat during the daytime to release it at night. A right mix of the thermal mass and south-facing glazing should be calculated during the design process to prevent overheating *(Figure 64).*

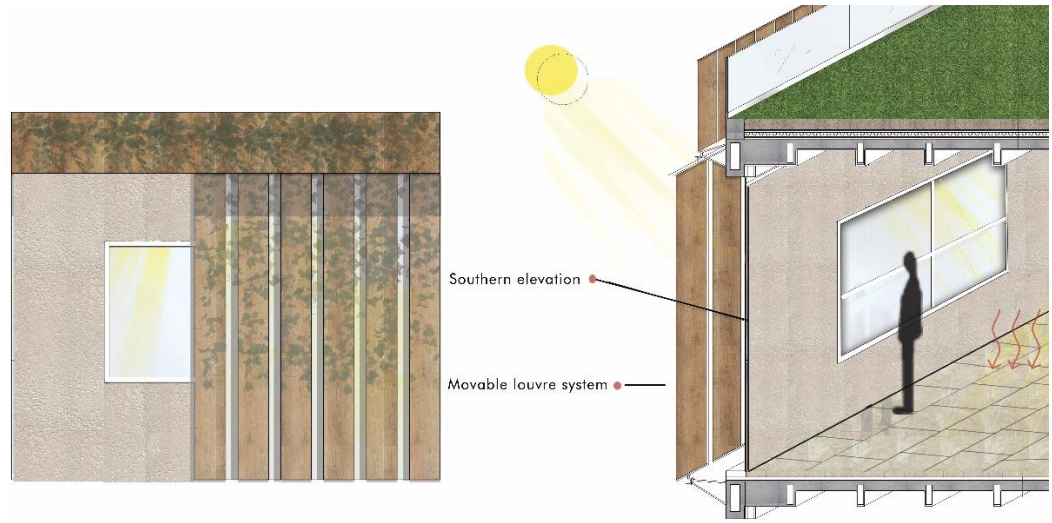


Figure 64. Southern elevation, direct heat gain' with consideration of vertical movable louvre system (Author's own)

- If the thermal mass is included in the flooring, dark colour tones of flooring should be considered, but if the thermal mass is included in the walls, hence, lighter colour tones of flooring should be provided to reflect the sun to the walls. Thermal insulation should be included to prevent heat loss *(Figure 65).*

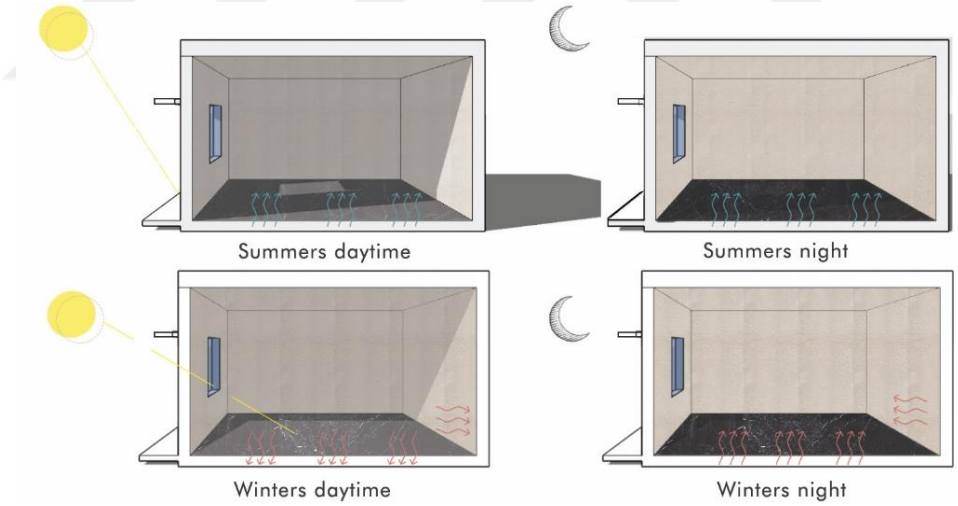


Figure 65. Thermal mass technique (Author's own).

- Indirect gain should be less considered than direct gain since these passive strategies are harder to be regulated during summer. Nevertheless, this section is highlighting some indirect gain strategies that might be beneficial in some hot-arid zones with low temperatures during winters and summer nights.
- Half-height Trombe walls could be considered. A Trombe wall is a thermal mass wall made of heavy materials such as stone, adobe, etc painted with dark

colours placed behind a south-glazed façade, accordingly, it can absorb heat to release it. Half-height (parapet) Trombe walls are more preferable in a hot arid climate to prevent overheating (Dabaieh & Elbably, Ventilated Trombe wall as a passive solar heating and cooling retrofitting approach; a low-tech design for off-grid settlements in semi-arid climates) *(Figure 66).*

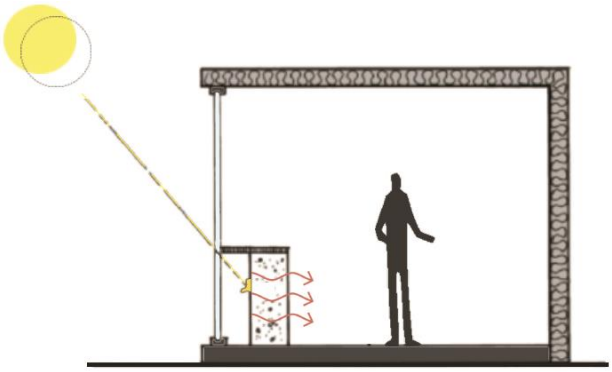


Figure 66. Half-height trombe wall to control heat gain (Lechner, 2014).

- Ventilated trombe walls could be implemented to reduce heat during summers and gain heat in winters. This type of trombe wall has a shutter placed in front of the glazed layer, besides, an upper vent, lower vent and top vent are included, and these vents allow heat transfer in summers and winters *(Figure 67).*

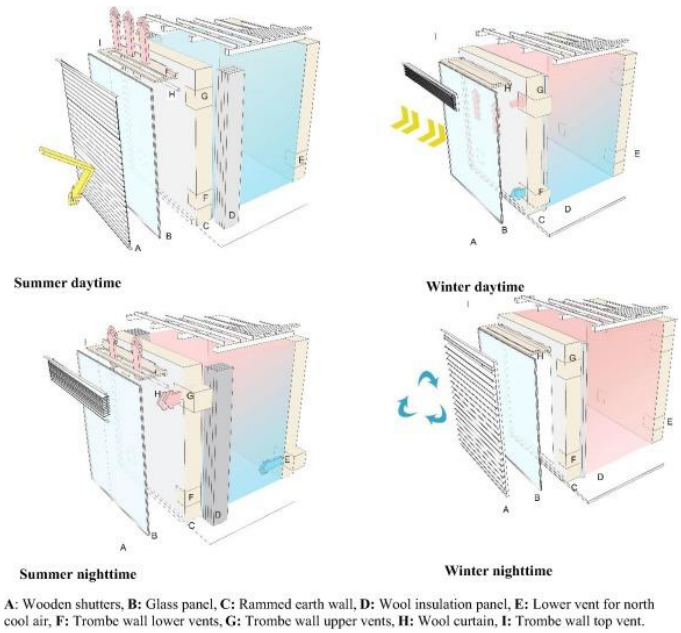


Figure 67. Ventilated trombe wall with shading (Dabaieh & Elbably, 2015).

- To prevent overheating during summertime shading devices must be included with all the above-mentioned passive solar strategies.

4.1.4 Active systems design strategies. The climate of the city 'hot-arid' can sometimes exceed the comfort level, hence, a proper design that combines passive strategies with mechanical heating and cooling systems can lower heating and cooling requirements, and reduce energy consumption.

- Geothermal Heat pumps this heating/cooling strategy is considered one of the fastest-growing renewable energy in the world since its main technique depends on the underground's undisturbed temperature that is between (5-30) C^{o}. Geothermal heat pumps system (GHP) provide cooling, heating and domestic hot water for the household, where it has two basic configurations: open-loop, and closed-loop systems, which can be installed horizontally or vertically according to the soil type, rocks, location and many other factors (Curtis, Lund, Sanner, Rybach, & Hellström, 2005). An open-loop heat pumps system can be installed in two wells or water ponds (lake); therefore, a closed-loop system is recommended in the case of Damascus. The pipes are usually made of polymer plastic filled with water and glycol and placed (1-2) m deep if they are horizontally installed or (50-70) m deep if vertically (Chaldezos & Karytsasa, 2017).

  During winters the pipes absorb heat from the adjacent ground and send it to the heat exchanger, in some cases heat exchangers are not added, hence, the pipes can pump the refrigerant (that is used to move heat from one spot to another), to the compressor directly. The compressor needs a small amount of energy (electricity) to flow the heat "uphill" from a lower temperature to a higher temperature. In summers, it extracts heated air from the house returns it to the evaporator and to be replaced with cooler air from the adjacent ground. Accordingly, the ground is used as a battery for "heat".

- Earth-air heat exchanger systems (EAHE), this strategy is considered very promising in terms of ensuring thermal comfort and reducing the energy demand, the system can be effectively used to pre-heat/cool the air in winters and summers. Moreover, this system is also relying on the constant temperature of the earth. The undistributed temperature of the earth is higher than the ambient air in winters and lower than in summers. Consequently, it functions as follows, fresh air is drawn through pipes underneath the building buried in a calculated depth, hence, the pipes heat the air as a result of the higher temperature of the adjacent ground (during winters) and vice versa in summers (Bisoniya, 2015).

  In Damascus, we can use a hybrid system, in the case of high residential buildings, the stack effect could be considered along with EAHE. A courtyard or courtyard-like atrium can be considered in the middle of the building to provide the building with natural lighting and ventilation; hence, it can enhance the work of the EAHE. However, the openings at the top of the atrium should be closed in winters to ensure air tightness where they should be opened in summers (Moxon, 2010). Additionally, in this strategy air purifier can be considered to purify the air from dust and improve air quality, besides, a water pond "fountain" can be considered in the middle of the atrium to humidify the air.
- Hybrid system EAHE with water spray channel, this strategy is a combined application of the previously mentioned earth air heat exchanger systems with water spray channel. After the air passes through the ground buried duct which results in pre-cooling airflow, the pre-cooled air is directed to enter through the bottom of the water spray channel where water is sprayed from the top of the channel. Consequently, the airflow increases and the exchange in heat between water droplets and air mange decrease the air temperature and humidify the air, after cooling and humidifying the air, it enters the house to cool it. Furthermore, a water circulating pump is used in this strategy to send back the collected water from the bottom of the channel to the water tank to reuse it again. The channel should be well insulated to prevent heat transfer *(Figure 68).* According to (Ahmadi, Shahrestani, Sayadian, Maerefat , & Poshtiri , 2021), this hybrid cooling strategy can enhance thermal comfort and meet people's cooling requirements in summers.

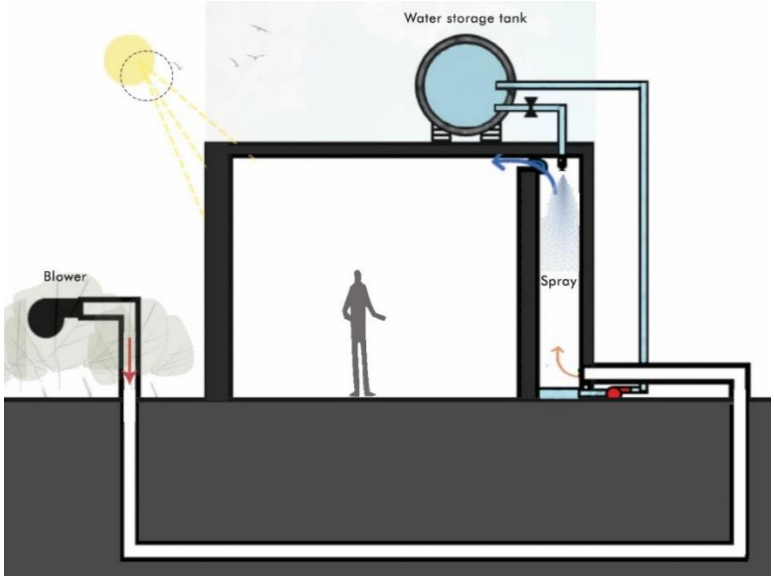


Figure 68. Hybrid system earth-air heat exchanger with water spray channel (Ahmadi, Shahrestani, Sayadian, Maerefat , & Poshtiri , 2021)

- Misting fans are an energy-efficient and cost-effective example, these fans are good to use in small spaces for limited users. These fans have water supplies where the fan pulls water to release it through small vents in it. The rotation of fans' blades breaks water droplets to create mist that evaporates to cool down the air and humidify it. Misting fans can approximately reduce the dry-bulb temperature by about (1.38-1.57) C^o (Wong & Chong, 2010).

4.1.4.1 Photovoltaic systems. Photovoltaic (PV) cells are made of materials that can convert solar radiation into electricity. Hence, it is considered a green energy system that manages to supply buildings with electricity without harming the environment. There are two known types of PV systems used for buildings stand-alone and grid-connected systems, where the stand-alone system is the most popular one. The grid-connected system does not need a battery to store power, during daytime the generated power is sold to the utility to get it back at night. On the other hand, a stand-alone system needs a battery to store electricity during shiny daytime to use it during the night or cloudy days. To ensure safety and longer life for batteries they should be preserved in a cool, dry and ventilated place, accordingly; PV cells can be integrated with passive strategies to ensure enhance their performance and thermal comfort (Figure 69).

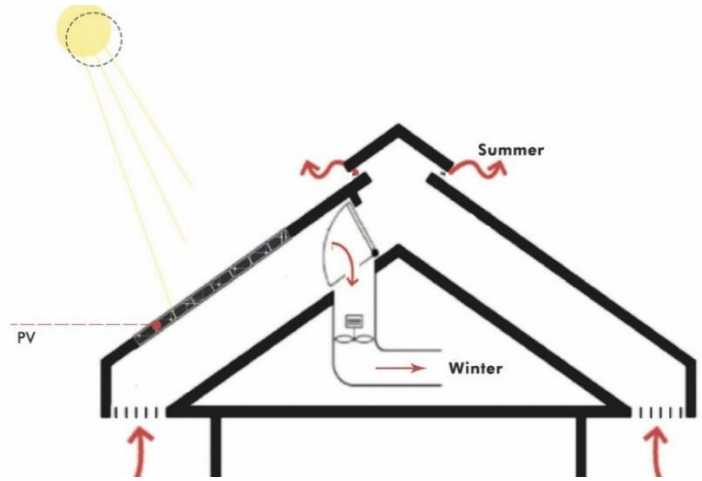


Figure 69. Application of PV system on the roof (Lechner, 2014).

Photovoltaics can be integrated with the building in various ways and according to many factors including orientation. They can be inserted in the building envelopes (roof, walls, glazing, sun shading devices, etc.) and the adjacent land or yard. The maximum collection of solar radiation should be considered; therefore, PV cells should be perpendicular to the direct radiation beam. Usually, the southern facing orientation is the most optimum. Covering the roof and south-facing surfaces (facades) manage to generate about 70% as much as the roof (Lechner, 2014) However, all of the building's facades could be clad with PV cells except for the northern façade since it doesn't receive sunlight *(Figure 70).* Additionally, PV cells help to generate the required energy for the hot arid climate especially during summers where more energy is consumed, save money and enhance aesthetics in public buildings with transparent facades.

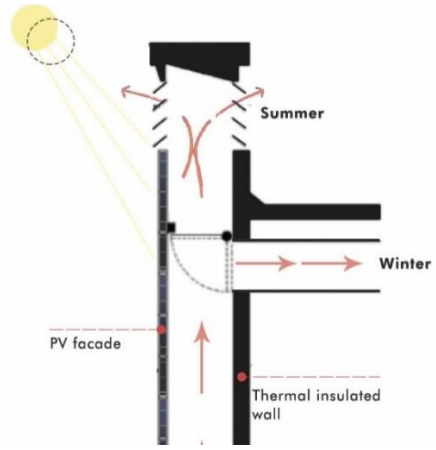


Figure 70. Application of PV systems on the building's façade (Lechner, 2014).

4.2 Application of Passive Design Strategies on Existing Detached Villa House in Damascus

This section presents a modern villa (a representative case of modern villas in Damascus) located in a modern suburban neighbourhood in Damascus. Moreover, it is based on a questionnaire that was prepared for the users of the modern villa in 'Al-Saboura' to analyse their daily life behaviours related to energy consumption and house performance in terms of,

- Thermal comfort.
- Daylight.
- The usage of the house's units and garden (front yard, backyard).
- Privacy and safety.
- The reflectivity of the design in terms of the identity and the users' daily life.

Accordingly, the integration of the passive strategies and the replacement of some of the house's features in this section is relying on the users' experience (the gathered data from the interviews) and the climatic condition of the region.

4.2.1 Case study analysis. The villa is the 'home' for five users who were interviewed to collect data about their daily life behaviours related to energy efficiency and design reflectivity.

4.2.1.1 Location and site characteristics. the case study is in a suburban area located west of Damascus; the neighbourhood of the case study is for the "elite" where it comprises modern detached villa houses for singular family use. Some of the villas are built in rows to have the maximum number of houses. The site has green spaces, which help to improve the climate and air quality, but the houses were built following foreign imported designs that influence thermal comfort and building performance in such climate *(Figure 71)*.

Figure 71. The neighbourhood of the case study (https:// mapio. net/ pic/p-409765/).

Form and space organization of the case study, the selected modern villa was built in the 1990s following foreign modern villas designs. The land of the house is rectangular (13*26) m^2, the villa consists of two stories a ground floor (living area) and the first floor (sleeping area) where it is surrounded by an adjacent neighbouring house on the west, southern front yard, northern backyard, and garage space on the eastern side of the house *(Figure 72).*

Figure 72. Selected villa (Author's own).

The ground floor of the house (the living area) was designed following the open plan concept; accordingly, the kitchen is connected with the living room, stairs area, and dining room. After analysing the ground floor plan, it was concluded that these factors affect the thermal comfort on the ground floor *(Figure 73)*,

- The long elevations in the building are the eastern and western elevations instead of the northern and the southern. Although the western elevation is connected with the adjacent house, the eastern elevation (the long elevation in the house) is exposed to direct sun.
- The open plan design and the connection between the kitchen and the living room is adding extra heating loads, which increase the house's temperature and affect thermal comfort, especially during summers.
- The courtyard is replaced by a front yard and backyard with low fences, the southern fence is (90cm), and the northern fence is (200cm) which expose the building facades to direct sun. Besides, the outward orientation of the garden makes the occupants feel like they are in a "public space".

- Tall trees are planted in the backyard (north part of the house) facing the northern façade, which has the most openings in the building, consequently, it influences the quantity of diffused light in the living room. Furthermore, trees are absent in the eastern parts of the yard where a semi-open garage is considered instead, hence, the eastern facade is more prone to glare in summers.
- W.C and stairs are located in the western part, which is considered the optimum location for these units.

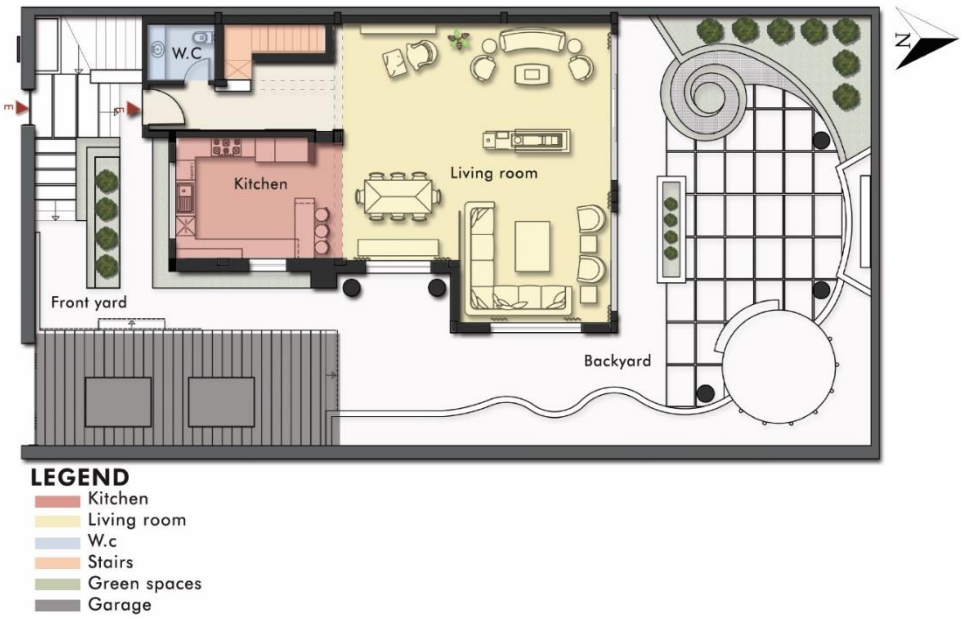


Figure 73. Ground floor of the selected modern villa (Author's own).

The first floor (sleeping area) has a compact plan where these points were concluded after analysing the first floor *(Figure 74)*,

- Atriums and inner yards are absent where a small balcony connected with the bedroom is found.
- Bedrooms are located in the eastern part of the house, which is the optimum location for sleeping units. Furthermore, the dressing room and the bathroom are located in the western part of the room, which manages to reduce heat gain since they are acting as a buffer zone between the western and eastern spaces.
- The corridors of the first floor are dark as a result of the surrounded closed rooms and the absence of wall openings. Hence, lights are usually turned on in this part of the house.

Figure 74. First floor of the selected modern villa (Author's own).

4.2.1.2 Envelope analysis. The walls of the house were built following the standard wall layers of modern houses in Syria. However, since the villa is located in an elite neighbourhood the facades were covered with local yellow travertine stone and Rihaybani stone. Besides, some parts of the facades are covered with white plaster. The roof of the villa is a gable roof covered with red bricks; accordingly, the users cannot use the roof.

The windows of the house, which are the most critical part of the envelope were analysed deeply in terms of glazing percentage performance and privacy. Table 3 is presenting glazing performance in different units of the house. The presented results represent the approximate performance; the following table is relying on (Monna & Masera, 2010) simulation of glazing performance in different walls orientation of buildings in hot arid climates.

Table 3

Approximate Performance of Glazing Percentage in Different Walls Orientation of the House Units (Author's own).

House units	Wall orientation	Glazing percentage	Thermal comfort	Daylight	In-out view
Living room	North	90%	0	+	+
	East	70%	-	0	0
Kitchen	East	30%	+	0	0
	South	90%	-	+	+
Master bedroom	North	70%	+	+	+
	East	70%	-	0	0
Bedroom1	East	70%	-	0	0
Bedroom2	South	50%	0	+	+

The windows are covered with louvred wooden shutters which are usually used at night since they affect daylight if they were used during the daytime. Accordingly, the shutters can't be used to reduce glare and direct solar radiation. Other outer shading devices are not considered *(Figure 75).* Internal shadings are used (curtains), although curtains manage to reduce direct sun, they trap heat in and affect the quality of daylight negatively.

Figure 75. Exterior wooden louvred shutters of the house (Author's own).

4.2.1.3 Daily life habits of the users. As have mentioned earlier the house is occupied by a singular family consisting of five members. The occupants were asked about their age, profession, daily life habits, units' performance and usage. Accordingly, after analysing the users' answers it can be deduced that,

- Some of the house's units are used for multiple functions, such as bedrooms, one and two are used as a bedroom and office/study room, the living room is also used as a guests' room.
- The number of occupied hours in a day of the house's units differ between daytime and night, summers and winters since some of the users spend more time at home during summers. Thus, more time is being spent in the living room and the garden than in winters. Conversely, the bedrooms are used more in winters since they are also used as a study room/office see *(Figure 76).*

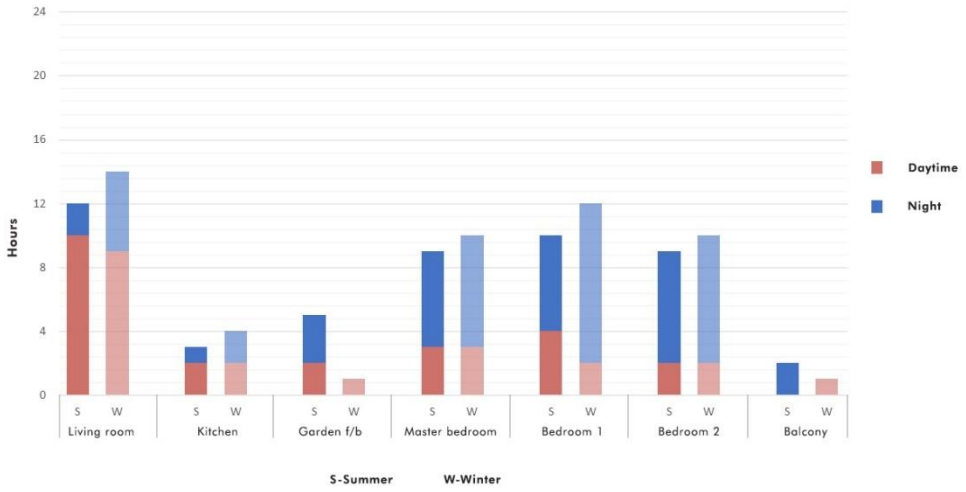


Figure 76. Occupied hours during summers and winters (Author's own).

- As shown in the previous figure, the users cannot use the garden and the balcony most of the time due to their low thermal performance, the absence of passive strategies and the users' "uncomfortable feelings of being seen by the neighbours and street passers".
- Additionally, the users are not satisfied with the fenestration system and space organization. Although the outer louvred shutters are ensuring privacy at night, they deprive in-out view, besides; they can't be used in the daytime. Moreover, the open plan of the ground floor affects their privacy especially when they host guests.

4.2.1.4 Thermal comfort and active heating/cooling systems. The house was built without considering the passive techniques that Damascene houses are known for. As a result, the users were not satisfied with the house's thermal performance, especially during extreme climatic conditions. According to the users, the house is performing badly during winters and summers between (15th of November – 1st of March) and (15th of June – 15th of September). Consequently, active heating and cooling systems operate mostly during these dates (Figure 77).

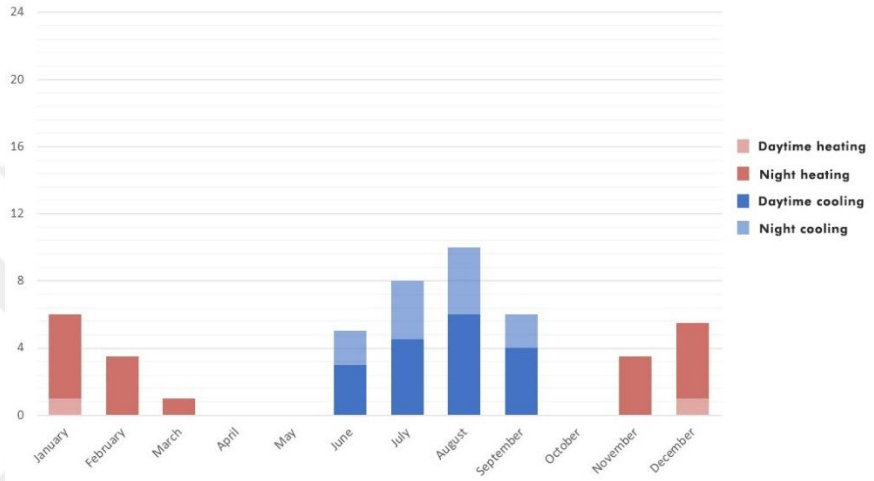


Figure 77. Approximate operating hours of active heating and cooling systems throughout the year (Author's own).

Split air conditioners are used in the house for cooling where during July and August the users might leave the ACs turned on during the whole night to ensure thermal comfort while sleeping. Furthermore, central heating systems (gas boilers) are used for heating. According to the users, "the open plan of the ground floor makes it more difficult to cool and heat the whole space". Additionally, the existed fireplace on the ground floor is a gas-operating fireplace that is used for the view since it can't heat the whole space. Hence, they usually operate it when they host guests.

4.2.2 Reviving abandoned vernacular strategies. The users were asked about the house's units that they prefer to change or modify. Moreover, they were asked if they prefer to integrate some of the vernacular elements in their modern house. Accordingly, the following suggested modifications in the house are based on the users' answers (preferences) that cope with the identity of the place and the climate.

4.2.2.1 New design proposal. The following recommendations and suggested modifications are being proposed after analysing the urban, architectural, and social characteristics of the region on different scales including the city, neighbourhood, the representative house and the users' behaviours and desires. Furthermore, the modifications are limited to the existing dimensions, spaces, and building height in the representative case to prove that researchers can rely on the found inputs to establish more climatic responsive and regional architectural products. Additionally, the facade materials are suggested after investigating the existing local materials.

4.2.2.1.1 proposed new settlement. The proposed villa is attached to the neighbour's house in the west and the street in the south; moreover, it is near to the neighbour's house in the east where the northern façade overlooks green open space. Accordingly,

1. to improve thermal comfort, visual comfort and privacy on the settlement scale an eastern alley between the RV and the neighbour's house is suggested by taking two meters from the house's site. Hence, the house is "semi-attached". Moreover, the narrow alley allows the house to have openings toward the eastern side (*Figure 78*).
2. The alley is shaded throughout the day as a result of the H/W ratio which is 600/200. According to (Golany, 1983), narrow alleys ensure cool air during the day and warm it during the night. Hence, linking compact houses and streets with narrow alleys manage to reduce the temperature and improve air movement which helps to create a mild climate for the entire urban fabric (Alabsi, Song, & Garfield , 2016).
3. The following envelope section is proposing a cantilevered eastern façade with green ivy, which also creates more shaded spaces and improve air movement; moreover, vegetation element would help to humidify the air.

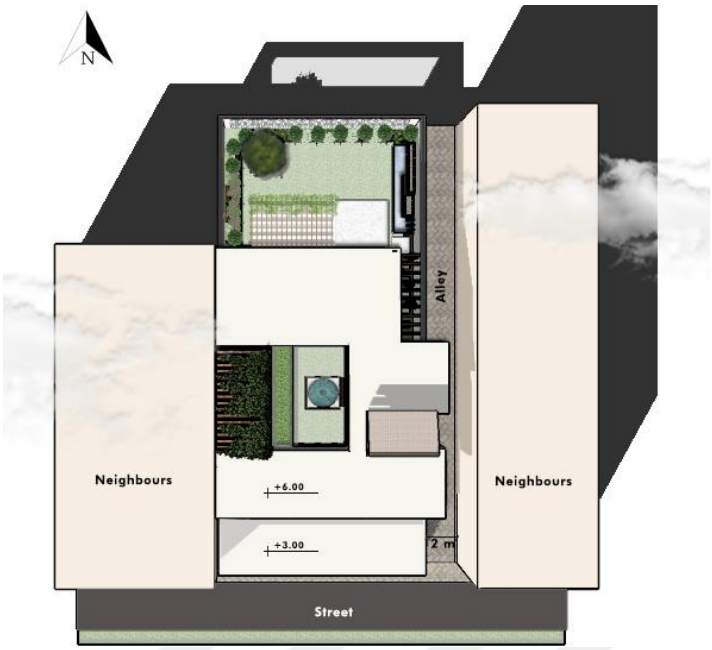


Figure 78. Proposed site plan (Author's own).

4.2.2.1.2 Proposed form and space organization. The first aspect that the users were complaining about in the house is the building form and space organization. Hence, modifications to the existing representative base case are made according to the current dimensions of the building site and the house's units. However, the houses units are reorganized following the concept of thermal zones and users' preferences related to privacy and daily life aspects; besides, some of the vernacular elements are integrated with the new proposal *(Figure 79)*.

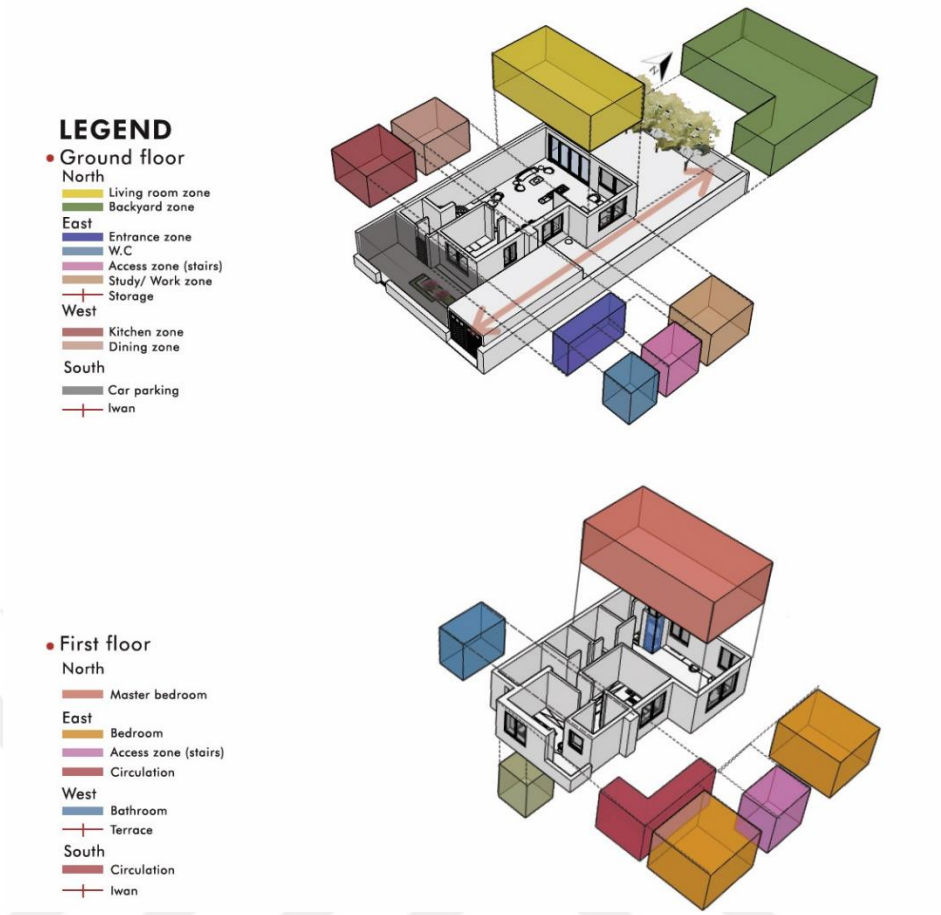


Figure 79. Existing and proposed spatial and thermal zoning (Author's own).

The following points are introducing the modifications on the representative case *(Figure 80)*, the actual dimensions and spaces of each unit are considered and ensured in the proposal *(Figure 81) (Figure 82)*,

1. A closed floor plan is considered (separated units) to maintain privacy and to ensure thermal comfort.
2. The office/study room is separated from the living room since nowadays the users are spending more time at home working/studying due to the pandemic situation.
3. Multi open spaces in different locations are integrated to provide daylight for the inner oriented house units, natural ventilation and open gathering spaces for summers and winters. Hence, a courtyard with an Iwan (semi-opened gathering space) and a fountain in the middle of the house, a southern backyard and a western terrace are proposed to provide privacy, prevent overlooking by the neighbours while sitting in an open space and ensure proper thermal and visual conditions (*Figure 83).*

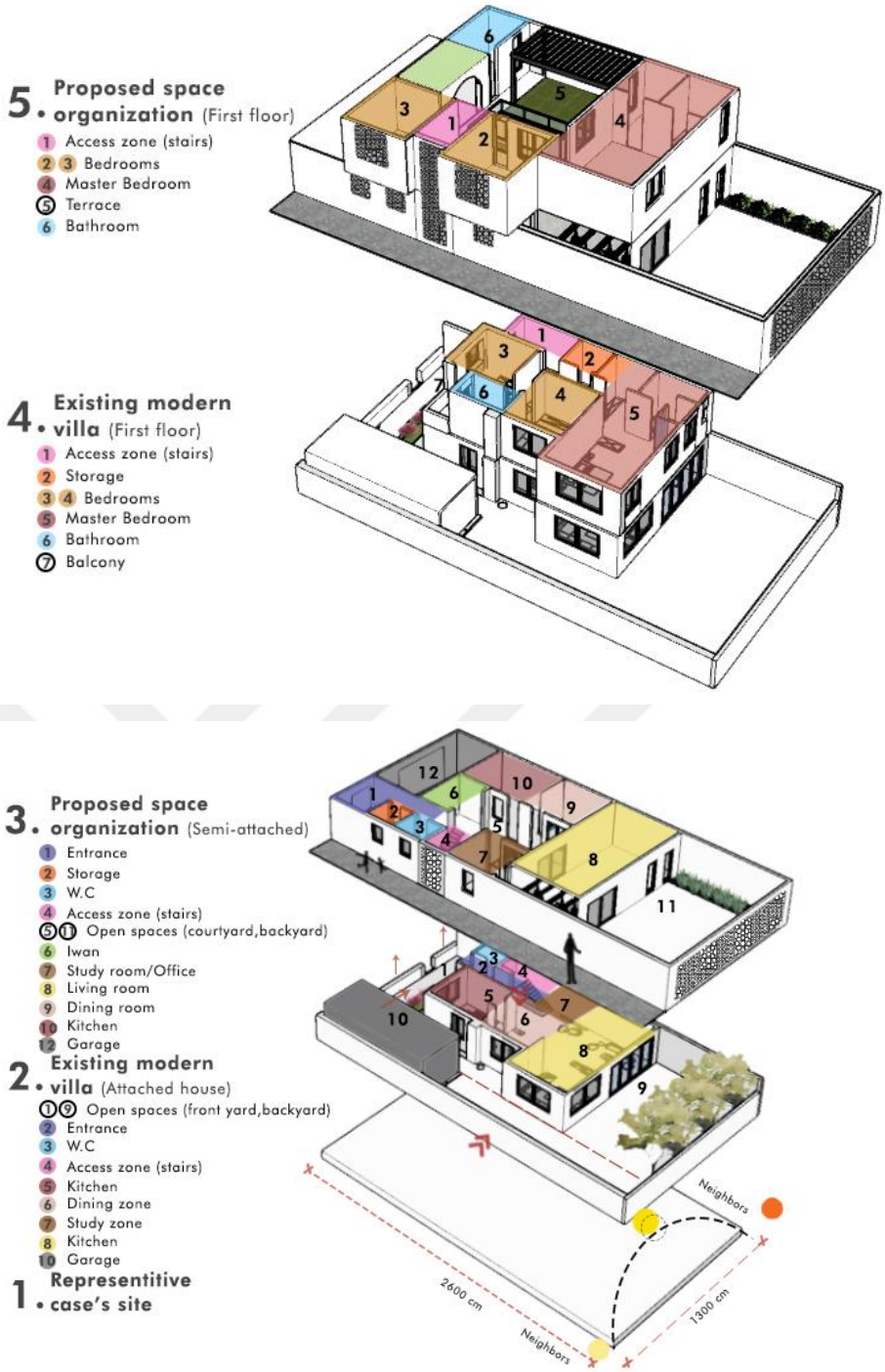


Figure 80. Proposed modification and space Organization to the representative base case (Author's own).

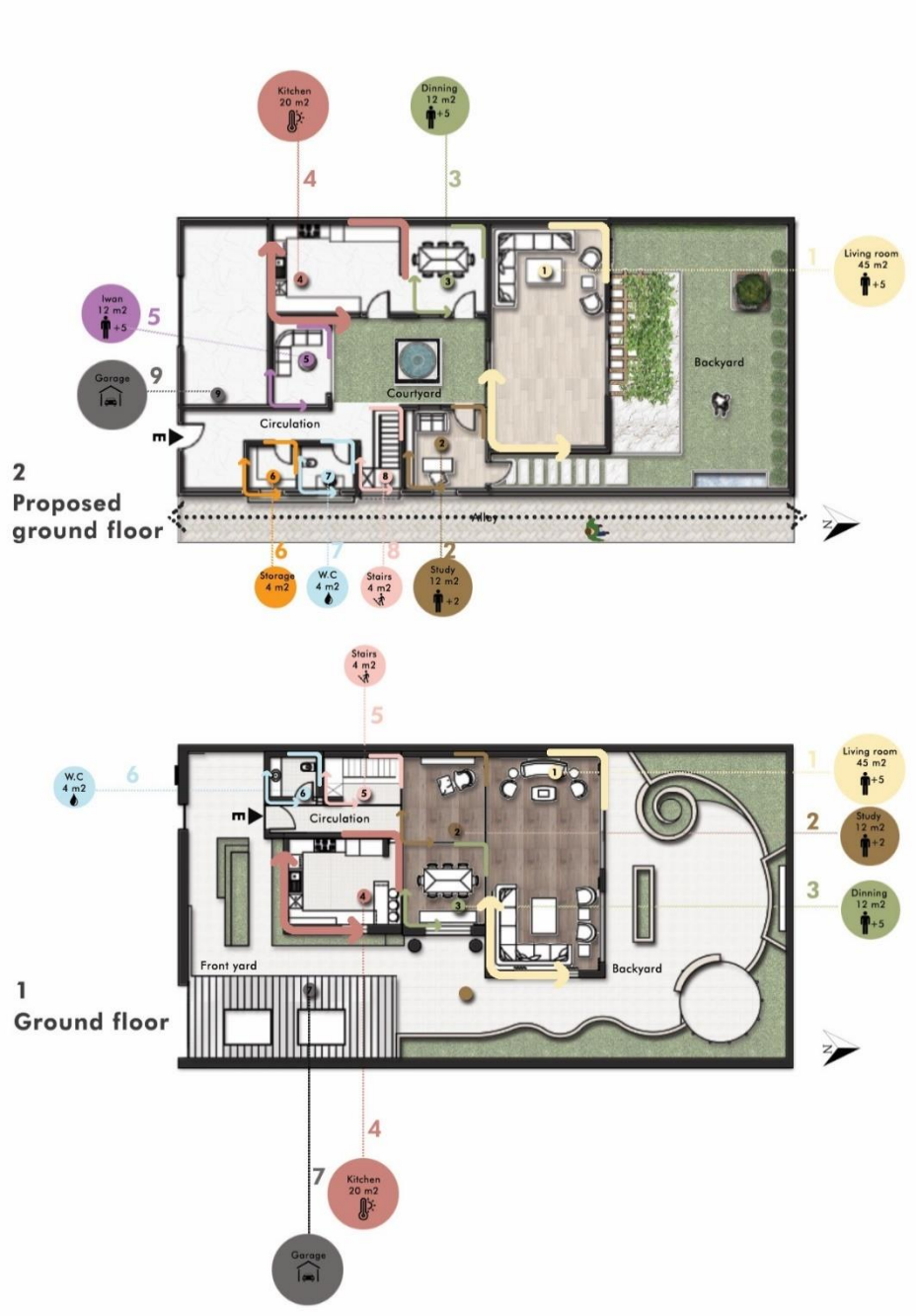


Figure 81. Ground floor and proposed ground floor (Author's own)

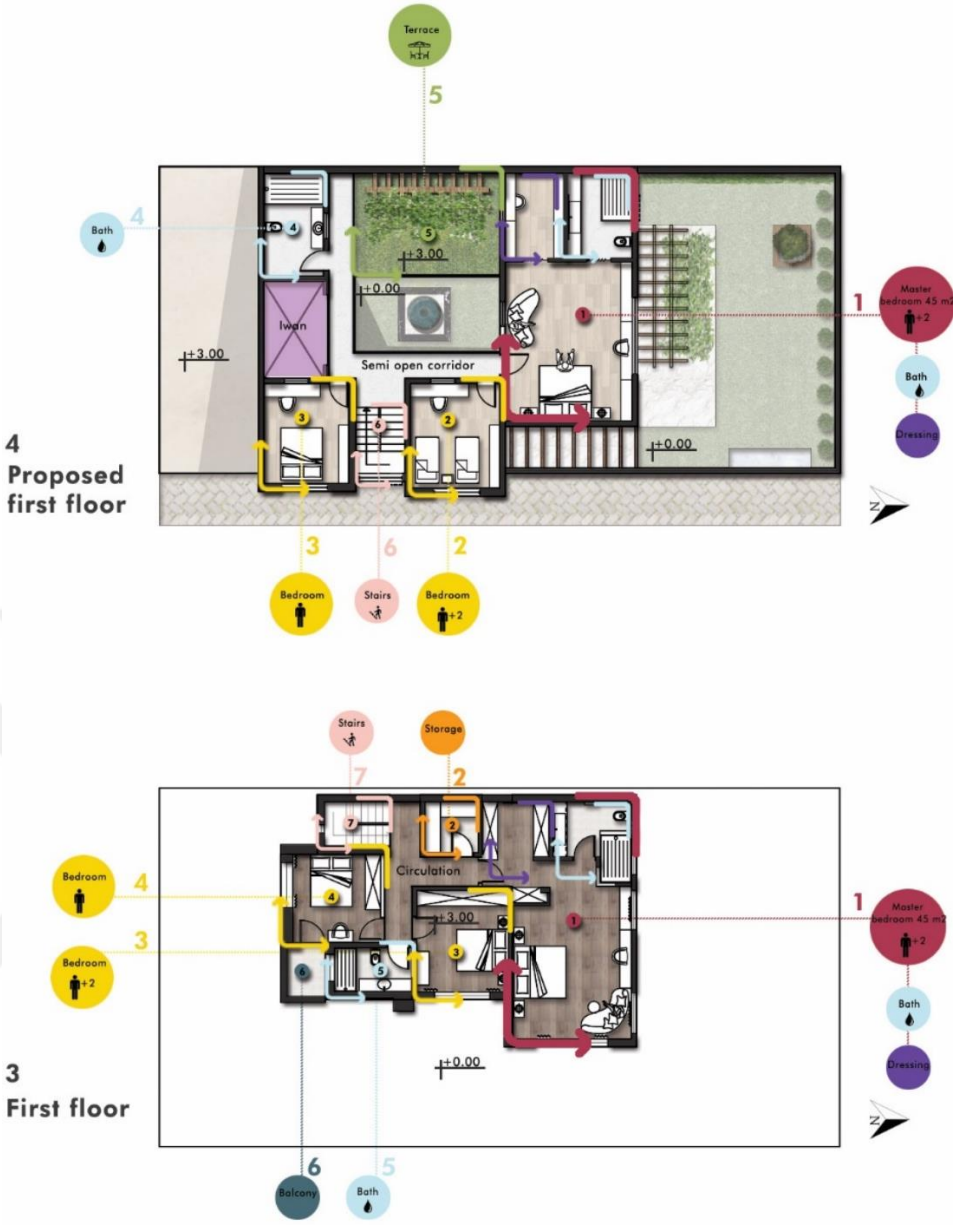


Figure 82. First floor and proposed first floor (Author's own).

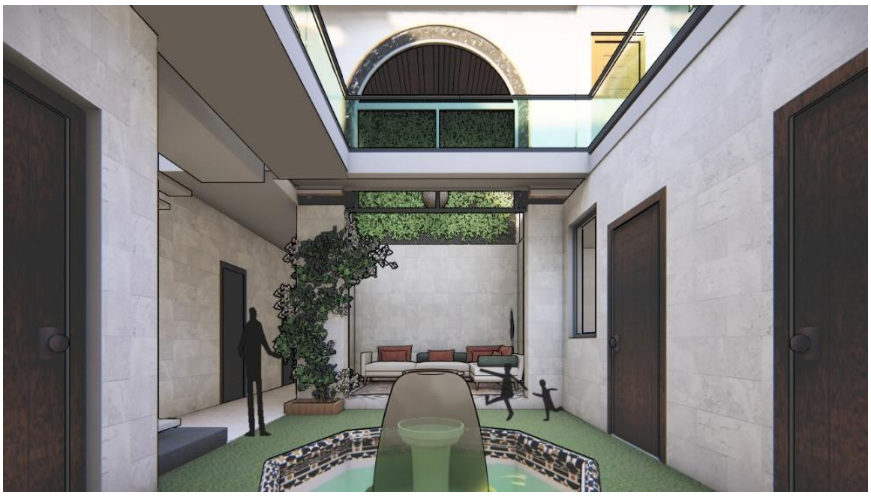


Figure 83. Semi-Opened Gathering Space "Iwan" (Author's own).

4.2.2.1.3 Proposed envelope. The building envelope should maintain proper conditions inside the house, ensure thermal comfort, and visual comfort. Accordingly, the following proposed aspect would help achieve the desired conditions by maintaining the actual height of the house,

- The walls of the ground floor are covered with local stone "Rihaybani", limestone and basalt stone. Furthermore, light-coloured plaster is used for the inner walls and the first floor's walls.
- Bigger inner oriented wall openings towards the courtyard are considered to reduce heat gain and ensure daylighting and smaller outer openings with shading devices (Mashrabiya).
- The approximate glazing percentage for different walls' orientation is, 50% for the southern walls, 70% northern, 30% eastern, and 0 % western since the western wall is attached with the neighbours.
- The floor of the central courtyard, the backyard, and the terrace are covered with grass and groundcovers to reflect heat during the daytime. Moreover, the transpiration of plants manages to reduce air temperature and humidify it.
- The semi-opened corridor provides extra shade for the courtyard whereas the cantilevered façade of the two bedrooms creates shade for the alley as found in the analysed examples of the vernacular houses *(Figure 84)*.

Figure 84. Implementation of the cantilevered facade, Mashrabiya and Bernoulli effect to enhance thermal comfort (Author's own).

- The height of the backyard is 3 meters to create shaded spaces and maintain privacy.
- Planting vines on the western wall of the backyard to reflect solar radiation and reduce heat where a wall fountain is implemented to the eastern wall to humidify the air. Moreover, a screen block fence is considered in the northern wall of the backyard to allow the summer breeze in *(Figure 85)*

Figure 85. Backyard with high fences, green spaces, and screen block to allow summer breeze (Author's own)

- A shading device (pergola) is added to the terrace to reduce the sun and maintain privacy *(Figure 86).*

Figure 86. First floor's terrace (Author's own).

- E-cooler screens are added between the kitchen and dining room as a partition wall to reduce heat and humidify the air *(figure 87).*

Figure 87. E-cooler screens between the kitchen and dining room. (Author's own)

4.3 Findings

The dissertation investigated the architectural and urban practices in Damascus from the Roman era until today to shed the light on passive strategies and the identity of the region that affect energy efficiency directly. Indeed, the identity of the place, the dynamics of the inhabitants and the vernacular techniques that the indigenous Damascenes were following are of central importance for achieving energy-efficient buildings. Despite this, little attention has been paid to these three aspects in literature to achieve the goal of NZEBs.

The findings of the thesis reveal that the vernacular courtyard house in Damascus is an Indigenous house design evolved over centuries to produce "homes" for the inhabitants that cope with their needs and merge with the surroundings. Moreover, the dissertation discussed comprehensively the socio-cultural aspect and people's daily life behaviours in the region where it finds out that people's beliefs, traditions, and comfort are the key elements to shape energy-efficient homes. Chapter 3 discussed People's attempts to achieve "the image of Aiden", and the constant human quest to reflect their identity on the built environment to achieve comfort levels. Consequently, these attempts are living proof that answer the dissertation's questions.

On the other hand, modern urban planning and architectural practices in the city have neglected the vernacular elements that firstly shaped Damascus. Nowadays, the urban plan of Damascus is following alien masterplans that cannot cope with the city's climate and image. Wide streets that are usually designed for cars, large opened hardscaped squares, high rise (copy-paste) apartment buildings with transparent facades and without considering the occupants' desires and behaviours are very common in the modern part of the city which is causing a high level of energy consumption and pollution since houses lack any kind of passive and climatic responsive strategies.

Additionally, the interview with the representative villa's users showed that they were unsatisfied with their house performance in terms of thermal and visual comfort; hence, they tend to rely on the active heating, cooling and lighting systems most days of the year as shown in *(Figure 77)* to maintain their comfort level. Besides, they constantly mentioned that "they are feeling exposed in their own house" where privacy was not considered by the architect when planning it which caused a serious problem to tackle.

The Damascene vernacular house remains a living part of the architectural heritage of the region, a comprehensive design that the new architects should learn from and evolve their designs according to it. The elements, space organization, envelope and decorations of the vernacular Damascene house are all symbols through which the generations of Syrians have projected their identity and achieved sustainability in their homes. Therefore, vernacular elements should be revived and evolved to be integrated into contemporary houses.

This dissertation revealed significant findings regarding the studied fields of the research; identity, regionalism and energy efficiency. The following points are presenting the major findings of the study,

- Human settlements represent the relationship of people with nature and their interaction with the environment. The evolution of human settlements involves relying on both the built environment and the surrounding environmental elements. Accordingly, the evolution of Damascene vernacular houses and the improvements in the construction and passive techniques relied on using local resources and responding to the surrounding environment.
- The urban plan of the old city ensured separated residential and commercial zones to ensure comfort levels since bakeries and other shops influence ambient air temperature and air quality. Moreover, the street network consists of three types of streets as presented in Chapter 2 to improve thermal comfort and privacy by creating separated shaded alleys for pedestrians. However, these aspects are absent in the modern part of the city where wide unshaded streets (for cars) are very common in the city. Consequently, it affects the microclimate of the city and the streets encourage hot-dusty winds. Furthermore, commercial and even industrial shops can be found in the residential neighbourhood of the city, which affects the inhabitants' psychology, comfort, and health.
- The image of Aiden that Damascene people were fascinated with which created their dwellings in the first place is absent in the modern houses. The findings of Chapter 2 emphasize this point, people used vegetation, courtyards and water elements to recreate the image of the paradise that would enhance the surrounding environment and the microclimate. The sensible and psychological comfort was fulfilled in the vernacular houses of Damascus

where modern houses usually do not consider these aspects as explained in Chapter 3. Balconies and low fences backyards are very common in modern houses since they are outwardly oriented. Nevertheless, they are usually neglected and not used since they violate the privacy of the inhabitants and create undesirable thermal conditions.

- Damascene houses included many passive strategies that cope with the climate and the dynamics of the inhabitants. For instance, the units of the house were organized following the daily life of the inhabitants at the same time the design of the house ensured privacy, thermal comfort and visual comfort as discussed in Chapter 2.
- The vernacular architecture and urban fabric of Damascus is a reflection of the inhabitants' dynamics, beliefs and identity. Consequently, the enhancement of the buildings and urban performance is due to the common belief of the inhabitants that discourage harming actions to the surrounding tangible and intangible elements including the identity. Damascene vernacular houses are products of the acquired experiences that has been passed down to successive generations to evolve their strategies in designing regional houses that serve the users and the climate. However, the modern part of the city imported alien designs, which are affecting energy consumption since modern houses lack any kind of passive strategies. Hence, people are relying on active energy-consuming systems to restore their comfort.
- Abandoned vernacular strategies can be improved to be integrated into contemporary designs. Moreover, contemporary designs and advanced technologies that manage to reduce energy consumption and ensure the users' comfort should be implemented, such as smart lighting, sun responsive louvres, Mashrabiya, etc.
- Local materials and contemporary construction techniques should be considered to mimic the construction of the vernacular houses and their thermal performance but in lighter weight construction where different types of insulation can be considered. Additionally, using local materials would reduce the embodied energy and it will create buildings that merge with their surroundings. The correlation between materials and the passive strategies should be emphasized in the design; For instance, in the case of Damascus

passive strategies and materials should resist heat and reflect solar radiation. Furthermore, new effective materials can be also implemented to enhance thermal comfort such as phase-changing materials.

- The correlations between the tangible and intangible elements of architecture have a significant impact on its development process and efficiency. Since architecture is 'inhabited by the spirits' and it gives life to the people and their places. Hence, architecture and building performance are affected by the users' daily life habits, identity, and psychological fluctuations as was explained in the representative analysis. The growing uncomfortable and estrangement feelings were caused by the design and performance of the representative house since it couldn't cope with their daily life habits and identity. Accordingly, unpleasant coping mechanisms were developed by the occupants due to the inefficient design of the house; for instance, open spaces of the house were neglected where closed inner spaces are being used instead. Thus, more energy is being consumed during the year since the house relies on active systems.
- The correlation between architecture, the inhabitants and the environment was corrupted when foreign designs replaced the local ones; hence, unfortunately, *"the condition of absolute placeness"* describes the modern part of the city, which has distorted the identity and the image of the city. Moreover, it affected the environment and energy consumption directly.
- Finally, the design process should include a comprehensive analysis of the tangible and intangible elements that form the site including interviewing the user(s) to collect information related to their daily life habits, background and desires. Furthermore, the site should be investigated in terms of the climatic conditions to propose proper design strategies and alternatives, which would reflect the user(s), the surrounding environment and respond to the climate.

Accordingly, we can indicate that there is a direct connection between the region's resources, the identity (dynamics of the inhabitants), and energy efficiency. Thus, architects should consider this triangle to achieve an energy-efficient regional home.

Chapter 5

Discussion and Conclusion

5.1 Discussion

This dissertation explained that architects should reference experiences and vernacular architecture's characteristics to evolve contemporary buildings and reflect the region. Additionally, the study addressed four research questions relating to regionalism, identity and vernacular strategies as effective tools in reducing energy consumption and improving the city's image. In an attempt to answer the research questions, a deep analysis of the city's architecture was conducted. Moreover, the study presented the found theories related to identity, people's dynamics and behaviours to emphasize the correlation between the theory and practice fields to provide energy-efficient regional architecture. Different data collection tools were employed to elicit data including modelling, drawings, and interviews.

The prime findings obtained related to the first question, reveal that contemporary designs in Damascus should be a developed model of the vernacular architecture in the city, hence, alien inefficient designs are problematic. The imported foreign urban planning and architectural practices have created a gap between old Damascus (vernacular houses) and modern Damascus (contemporary houses), the past and present, the community and the person, sustainability and architecture. Indeed, to close the gap, regional climatic responsive strategies were suggested in chapter 4 to enhance the image of the city and reduce energy consumption.

The results of the second question of the study show that abandoned vernacular strategies should be improved using advanced technology tools and added to the contemporary designs to enhance the building performance. The new design proposal in chapter 4 recommended including some of the vernacular elements in the representative modern villa to enhance privacy, thermal comfort and visual comfort; such as including the Iwan, courtyard, Bernoulli Effect and Mashrabiyas.

The results of the third question urge architects to design buildings that resemble the region and its inhabitants. The relationship between architecture and space is not limited to the physical dimension, but also the metaphysical. Thus, a

balanced correlation between these two dimensions manages to produce self-efficient architecture and create a unique halo as was discussed in detail in the third chapter in terms of identity and architecture. Passive and energy-saving strategies should develop their mechanisms following users' behaviours and habits, as was the case in the vernacular examples. The discussed process of adaptation in chapter 3 and the concept of the spirit of a place "what a thing wants to be" should be evolved and included in energy-efficiency strategies since the identity and the backgrounds of the users have a significant impact on their behaviours in a place and their techniques to restore the state of comfort and belonging.

The fourth question of the study is answered in chapter 4, which has revealed that people's techniques in the modern houses of Damascus are relying on active systems and consume energy to achieve comfort levels. Hence, apparently, the circle of adaptation in these houses is defective due to poor architectural and urban designs that ignored the surrounding environment and local's dynamics as was discussed in chapter 3. Consequently, this problem is tackled in the suggested design strategies and the new design proposal to find the answer to the fourth question by linking the identity of a place, the dynamics of the occupants and energy efficiency in the suggested strategies.

Accordingly, the following points are recommended findings that would help to close the gap between the "vernacular" and "modern" and to link the discussed triangular aspects,

- Architects and urban planners should analyse the cultural and climatic backgrounds that shaped the city. Moreover, the design process should include the identity of the place and the dynamics of the users to find a connecting point that manages to achieve energy efficiency by investigating the climate and the occupants' daily life habits.
- The urban plan of the city should be evolved following the vernacular where more alleys and pedestrian roads should be considered than streets. Therefore, roads, alleys and streets should be shaded and surrounded by green spaces to encourage people to walk in such a climate. Besides, narrow alleys and evergreen trees manage to maintain houses' privacy where windows cannot be overlooked from a far distance like the case of modern Damascus streets today.

- The hardscape of the urban squares, which are very popular in the modern part of the city should be reduced and more green spaces should be integrated to reflect solar radiation. Moreover, large open plazas can be replaced with public parks.
- Streets and houses should be oriented in a way that reduces solar radiation in summers and increases it in winters, dusty winds should be blocked and summer breeze should be allowed. Moreover, water bodies should be integrated with the urban elements and houses
- Houses should create a row in some orientations where attached and semi-attached houses are preferable to maintain a desirable temperature and privacy. Besides, row buildings encourage an inner oriented fenestration system and courtyards which is a vernacular abandoned strategy that should be revived and integrated into singular families houses and residential buildings.
- Houses' spaces and units should be organized after analysing the site and people's desires and daily life habits since energy consumption is directly related to the climate and people's behaviours.
- It is highly noticed that the facades of the modern houses in Damascus are disharmonious which affect the image of the city and the users since openings were implemented without analysing the site. Thus, nowadays windows and balconies could not comply with their main functions, besides they are violating privacy and influencing the performance of the house in terms of energy saving.
- The recently found front yards and backyards in modern houses should be replaced with courtyards or modified to create shaded spaces and maintain privacy. Therefore, low fences should be replaced with high ones and a semi-open gathering space should be integrated to encourage using the yard and reduce energy consumption.
- Green spaces and local plants should be considered as a part of the planning process and one of the passive strategies process that improves the performance of the building envelope.
- Additionally, the selection of the materials affects the performance of the building envelope. Consequently, the used materials in the vernacular

houses should be analysed and considered in contemporary designs where new buildings should rely on the regional resources that fit more with the environment and respond to the climate efficiently.

- Indeed, privacy is required in each region and through different eras. Privacy levels should be achieved by interviewing the users and analysing the site. Some of the vernacular aspects could be considered to achieve it such as the angular entrance, inner orientation, windows screens (Mashrabiya) that are discussed in previous chapters.

5.2 Conclusion

This dissertation builds on the existing literature to shed insights into design practices, which has shown the importance of vernacular architecture and identity concepts in achieving energy efficiency and regionalism. Despite the growing interest in studying energy efficiency in architecture and its strategies, it seems to be less focus has been shown in literature in proving that the identity of a place, people's daily life habits and homemaking process are major strategies to save energy. The main problem that faces contemporary architecture in Damascus and that gave this study urgency is the weak connection between the vernacular dwellings and modern dwellings in general, and the ignorant of the region's dynamics, identity and resources to achieve energy efficiency in particular.

As discussed in chapter 3 the main aspect that is influencing contemporary architecture and urban planning in Damascus is the locals' and architects' fascination with foreign modern designs and their eagerness to follow them. Accordingly, inefficient energy consuming designs that cannot serve the region's dynamics and the environment are produced. Thus, reviving and improving abandoned vernacular strategies, and including the occupants in the design process is suggested in chapter 4 to tackle the mentioned problem.

In conclusion, the dissertation analysed the physical and metaphysical dimensions of the vernacular and modern dwellings in Damascus to achieve its aims and answer its questions. In order to achieve the aims of the dissertation, a design guide and a new design were proposed. Consequently, the design proposal is the product of the deep comprehensive analysis and the collected data. Furthermore, the dissertation elaborated the positive correlation between regionalism, identity and energy efficiency, and it has revealed several

recommendations and directions for future energy-efficient designs and research on identity and energy efficiency.

The study employed a mixed-methods research design, using both qualitative and quantitative data. The study revealed significant findings regarding the impact of identity and regionalism on energy efficiency. However, this dissertation has some limitations that must be taken into account and addressed in future studies. The political conflict in Syria has affected the quality and quantity of research in many fields including architecture. Hence, some of the discussed topics in the thesis were hard to be found, such as the current energy performance in modern residential buildings. Accordingly, the study relied on the collected data from the conducted interview with the representative case's users to evaluate the energy consumption situation of the house.

Incorporating additional methods to investigate energy saving by using energy simulation software could be one possible direction for future research to simulate the performance of the house's elements in different climatic conditions during the year, where best solutions under real typical conditions could be provided for Damascene contemporary dwellings.

Finally, the study investigated singular family houses and proposed a new semi-attached design for a singular family based on an existing representative case and an interview with the current occupants. Hence, future studies could investigate and propose a new energy-efficient regional design for apartment buildings where a larger number of occupants with different backgrounds and behaviours could be interviewed to decide related passive regional strategies that could be implemented to the building to save energy.

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APPENDICES