A FRAMEWORK OF SUSTAINABLE DESIGN FOR THE REGION OF PALESTINE

A Thesis in Architecture

by

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Abstract:

Many definitions of sustainable design have emerged in the past twenty years, most of which focused on the environmental part of the design process. In recent years, especially with the emergence of sustainable design as an international trend, more attention has been directed towards the social and economic part of sustainable design for a building to be truly sustainable and able of fitting in any context, for the long run. This thesis explores into the different dimensions of sustainable design, studying what makes a building sustainable, and using that as a base to define sustainable design in the region of Palestine, a small country in the northern part of the Middle East and east of Mediterranean, to define a framework of sustainable design.

The framework achieved at the end of this study uses the vernacular as a passively sustainable prototype of sustainable design, for its environmental, socio cultural and economic complexity of a building, integrated with modern active techniques, that helped define the framework and helps define the future of the vernacular as a sustainable structure in different regions of the world.

To define the framework, a case study is chosen in Nablus; a city in the core of the West Bank (Palestine). This already built case study is examined for its energy use, and social qualities, and later
transformed into a courtyard structure, with the same occupancy and spatial praxis. Later the two buildings are compared, to examine the ability of the courtyard structure to serve as a sustainable building from all facets of the sustainable process.

At the end of this study, the main features of the courtyard house are going to be extracted into a framework of sustainable design, to help start acclimating the region to sustainable design.
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Chapter One:

Defining a framework of sustainable design in Palestine:

Introduction:

As we move towards the second decade of the twenty first century, architects are becoming more aware of the importance of energy efficiency and sustainability through the design and construction process, and what comes with that of the sensitivity towards the numerous environmental threats the construction process precipitates on the ecosystem. Such awareness created a sustainable design movement across the world, in some countries more than others, and while this revolution sweeps more into different regions of the world and the Middle East in particular, it becomes imperative to define a framework of sustainable design that works within those unique contextual and social structures. To define this framework, one must define goals to be achieved in a sustainable building, in different areas of the world; definition becomes more sensitive and specific to the cultural and economic factors.

This thesis tries to adopt a broader socio economic definition of sustainable design, one that fits more into the regional contextual adaptation of the design process, and use this definition to find a module
of regional sustainable design. The region explored into in this study is the region of Palestine, a small country on the east Mediterranean, the study explores into the integration of passive systems that exist in the vernacular, with modern active techniques, this integration, with the added socio-cultural and economic regional sensibility, will provide a basis for a framework of sustainable design in Palestine.

**Research Questions:**

As mentioned in the introduction, the question of this thesis is: how to define a framework of sustainable design for the region of Palestine. In efforts of organizing our research through this thesis, more specific questions are asked here, which will be answered one by one through the scope of this study, this will help narrow down the variables connected to the main goal of this study. One of the main questions that come into mind thinking of defining a sustainable design framework is: what is our definition of sustainable design? For us to define a framework of sustainable design, the start should be with defining our understanding of the word sustainable, and our expectations of a sustainable building. This question is going to be answered next in this chapter, starting with a look at the different definitions in the past 20 years, and then looking at one of the most comprehensive definitions, and how it can be more fitting for the region of study.
Another question that comes into mind concerns the regional architecture, how can the architect decide what is culturally and socially fit for a community? In chapter three, we delve into the architecture of Palestine, the vernacular and the contemporary, to form an image of the recurrent architecture prototypes in the region, and what type of architecture would be defined as sustainable, through the history of the region in the literate sense of the word, and in the climate adaptability capabilities of the building, and how can this type of architecture be used to be compatible with modern way of living in that region?

One of the other main questions this thesis seeks to answer is, what goals we seek to achieve following the framework? After defining our concept of sustainable design, our understanding of it should lead to defining our goals for the region of study, and the building we’re using as a case study. Defining those goals is going to be explained through the third and fourth chapter, leading to chapter five defining the framework.

Answering those questions through this thesis will help answer the main research question systematically and in an organized manner, next we start with the definition of sustainable design.
Sustainable Design, a Definition:

In the past twenty years, the definition of sustainable design has been shifting and expanding as a universal science that embodies the greater environmental responsibility, and while the term sustainable design is becoming more and more “in fashion”, the term “sustainable design” seems to be inadequate of describing the philosophy behind it, in the dictionary the word sustainable is defined as something that is “able to be maintained”\(^1\), and while architects need the term to mean more than to maintain or preserve, a common ground on the meaning of the term is yet to be found. One of the first attempts of defining sustainability was issued by the world commission on environment and development, which has put forth a definition of sustainability as “meeting the needs of the present without compromising the ability of the future generations to meet their own needs”\(^2\). This definition makes an attempt to define sustainability generally and concisely; still it fails to specify the ethical roles of sustainable design on the architecture of the place and consequently the built environment.


Canadian architect and green building advocate Jason McLennan created an interesting discussion in the sustainable design world with his 2004 publication The Philosophy of Sustainable Design, one of the few publications that delve into the evolution of sustainable design. McLennan believes that a truly sustainable building is “one that has no negative operational impacts on the environment and few embodied ones”. McLennan reinforces the notion of sustainability as a philosophy and not just physical component of environmental design; sustainable design is not about features but is “a design philosophy that seeks to maximize the quality of the built environment”.

But this definition and many others although show the environmental responsibility are inconclusive to the meaning of the word sustainable, the main shortcoming of this definition is how specific their view on the matter of what environmentally conscious design is, and its short sight to see beyond the physical form of the building and how it relates to the other aspects of an architectural building. This affected how architects embraced the concept of sustainable design, in all its limitations as the building principle of what to be achieved in an environmental conscious building.

There are many reasons for this incapability of sufficiently defining sustainable design, one is the fact that the movement is still young and defining itself, sustainable design is considered to be a new discipline that is still adjusting its growing capacities. Other main reason would be the fact that the term sustainability is seen as an environmental “logo”\(^4\), which is also a reason for the lack of ethical consciousness within those definitions.

When the premise of sustainable design expanded regionally many issues came into light. How can enforcing such architecture types, in many regions and cultures around the world, be sustainable, when the cultures identity and social behavior does not fit into the building and the context in general, thus failing to achieve its main goal of fitting within the ecosystem.

But for a designer to be able to design a built environment that is truly sustainable, ones that fit into their context and survive within their culture, he need to develop a deeper understanding of sustainability, one that could fit into different economic and cultural paradigms, and still serve its

\(^4\) Jabareen Yosef, A new conceptual framework for sustainable development, Environ Dev Sustain, 2008 pg 179-192
purpose within the environment. Although sustainable design is still a vague term, in the aims of defining a framework of sustainable design, this thesis will try to define the term sustainability, or at least define our expected goals of a sustainable building.

An article in the Bread of the world magazine discussed sustainability and stated that sustainability "Requires meeting the basic needs of all people and extending opportunities for economic and social advancement. A development initiative is considered sustainable if, in addition to protecting the environment and creating opportunity, it is able to carry out activities and generate its own financial resources"\(^5\). And this is where the definition becomes more specific and responsive

Samuels Mockbee’s definition of “sustainable design” shows more sensitivity towards the “sense of place” and cultural aspects of sustainability:

"Sustainable architecture involves a combination of values: aesthetic, environmental, social, political, and moral. It's about using one's imagination and technical knowledge to engage in a central aspect of the practice -- designing and building in harmony with our environment. The smart architect thinks rationally about a combination of issues including sustainability, durability, longevity, appropriate materials, and sense of place. The challenge is finding the balance between environmental considerations and economic constraints. Consideration must be given to the needs of our communities and the ecosystem that supports them."  

This definition shows other dimensions to sustainability, those dimensions although not visible, define our built environment and help custom build the built environment for different cultures and economical strata's around the world. Today there are many definitions that seek to include those factors,

Which principals synthesize into three main pillars of sustainability:

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6. David E. Brown, Mindy Fox, Mary Rickel Pelletier (Eds.), Sustainable Architecture white papers (section four: Building dreams: an interview with Samuel Mockbee) Earth Pledge, New York 2004 p. 208
Environmental factors.

- Economic factors.

- Social factors.\(^7\)

Those three pillars will be explained in the following:

**Environmental Factors:**

The main goal of environmental sustainability is to cure earth from the degradation humans activity inflicted on earth, and since construction consumes large amounts of materials and energy and produces tons of waste, sustainable construction “which could be defined as the creation and

responsible management of a healthy built environment based on resource efficiency and ecological principles.\textsuperscript{8}

Environmental goals of sustainable construction: is one of main aspects of maintaining a healthy environment around us.

- Resource consumption: reduce embodied energy and resource depletion.
- Energy efficiency: ensure that the design conserves as much energy as possible.
- Waste management and pollution prevention: make sure that building construction and operation produces minimal destruction to the global environment, and ensure that materials and building systems do not emit toxic substances and gases into the atmosphere.
- Enhancing the natural environment: achieve a design that is efficient, long lasting and protects and restores local air, water, soils, etc.

Social Factors:

Social responsibility in Sustainable Design is “the social preconditions for sustainable development or the need to sustain specific structures and customs in communities and societies” ⁹. The environmental aspects of sustainable design are the prominent visual features and the main concern of sustainable design, yet it just addresses the physical form of a community, but a community is much more than its physical form, a community comprises of people and the places they live in, thus forming a social environment as much of a physical one. And since the physical form of a building shapes how individuals, communities and societies live with each other and interact, it becomes imperative to consider the social factors of a design that is set to be sustainable.

A socially responsible sustainable building is one that provides:

- Basic need for housing
- Identity, sense of place and culture

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Well being, health and safety

Quality of life

Shared values, equity and social justice.

**Economic Factors:**

Different principles shape the relationship between the economic factors with other factors of a sustainable construction project, human needs are met through the production of commodities, therefore economy shapes the society and the environment, and most environmental degradation was exploitation for an economic benefit.

And while the economy dominates the environment and society, the environmental degradation has become a serious impediment to economic growth of any given society. But regardless of the interlocking factors of sustainable development, the economic value/cost/payback of a sustainable project ends up being the deciding factor of any development.

Sustainable economic construction features.

creates an additional value to a property.
Reduces cost through efficiency improvements on the system qualities, and reduced energy and 
raw material input.

keeps a building functional with minimal maintenance over time.

saves on lifetime property worth, with considerations to upfront costs of construction.

The social and economic factors of a community are closely knit in almost all aspects of life, 
“Economic Growth, environmental protection, and social equity should be interdependent, mutually 
reinforcing national goals, and policies to achieve these goals should be integrated”\textsuperscript{10}

For a building to be truly sustainable it has to respect that equilibrium of the environmental-social-
-economic factors of a place, and this is where the definition of a sustainable building materializes, it’s 
when the three main factors of sustainable design intersect and contribute equally to one another.

\textsuperscript{10} Daly E. Herman: beyond growth: the economics of sustainable development. Beacon Press 1996. P. 13
Chapter Two:

Review of Literature:

Within the modern discourse of sustainable design, and the different design approaches adopted to solve the environmental problems, as mentioned in chapter one (The vernacular as a passive sustainable structure adopted within this thesis as one), the definition and hence the approach to solving design issues remains vague, and cannot be generalized over other distinctive climates and environments. While discourse centered on traditional regional architecture and its relation to sustainable design, are distant from understanding the need to infuse regional architecture with modern sustainable techniques, in efforts to upgrade the vernacular up to the current times, and achieving the most out of what a sustainable building could be.

A personal Perspective on sustainable design stems from realizing that most passive sustainable design techniques are available locally, if we look into the indigenous techniques natives applied to the built habitat to adapt to the surrounding environment. Those techniques available in traditional vernacular architecture are passive techniques. While very significant to designing a sustainable building, they are not enough to address the significant problems architecture in Palestine faces, and
needs to address from conserving and reusing water, to using different resources on site to provide ventilation, heat, and possibly generating energy. The need to find a local sustainability and its integration with mainstream modern sustainable design techniques possibly is the suitable approach to sustainable design in Palestine. Some literature recognizes the need to reiterate traditional architecture into new buildings \(^{11}\), but it lacks the innovation to interpret what’s behind the aesthetics of the elements. Other literature in the Middle East pushes the idea of sustainable design as carried out in developed countries, to be the solution to the depletion of nonrenewable resources worldwide, an approach that ends up being an imitation as well. Very little literature recognized the potential in integrating multi-disciplines to enhance and fit the local sustainable criteria \(^{12}\).

**Sustainable Design and the Courtyard House:**

An interesting case study on the daylight performance of a courtyard house discusses the importance of introverted designs in hot climates to control the interior environment of the house, the study “Analysis of Daylight Performance of a Courtyard House: a case study of prototype house in Rihadh

\(^{11}\) See Regional Architecture and Sustainability, Page 17.

\(^{12}\) See Integration within Sustainable Design, Page 22.
city” by Dr. Amjed A. Maghrabi states that “from the environmental point of view, the main purpose of
having a courtyard house is to control the thermal performance as well as to provide daylight for
spaces that do not have openings on the externals walls”\textsuperscript{13}, Dr. Amjed concludes that the courtyard
house design concept is beneficial in terms of daylight performance.

In another study that traces the evolution of the Palestinian courtyard house by Dr. Eman Assi
“Typological Analysis of Palestinian Traditional Court House”, Dr. Eman tries to answer questions like
why courtyard types in the Palestinian contemporary houses disappeared and how does that reflect
sensitivity to the Palestinian culture. In the study Eman discusses the fact that the courtyard house
has been very successful in providing a comfortable internal environment, providing calm and air
during the long, hot dry weather, and that this environmental benefit was wrapped within the social
concepts instilled within the community at that time, like privacy, and providing a secure space for
women of the house to move freely without fear from the women or their husbands of being seen by
neighbors. Eman discusses the reasons why the courtyard house is not used as a housing prototype
in Palestine anymore, where she describes it as “an evolution of adaptation”. She describes the
cultural aversion to keep using the courtyard house as a prototype because of a reevaluation of the

\textsuperscript{13} Maghrabi A. Amjed:” Analysis of Daylight Performance of a Courtyard House:A Case Study of Prototype
House in Riyadh City,Saudi Arabia”. Um Al Qura University, College of Engineering and Islamic Architecture.
expectations associated with the generative power of type. Eman concludes by stating that using past types as the courtyard house “can produce conceptual tools and make architectural language richer” and that those types of the past have great value on the premise that “the architect should be able to require a total vision of the environment and not just a partial solution to its problems at every scale”.14

Regional Architecture and Sustainability:

The Globalization of architectural styles, building technologies and urban spaces has dramatically impacted city design in the developing world. These forced inputs and their negative outcomes, are discussed in the book “Designing Sustainable Cities in the Developing World”, by Roger Zetter and Georgia Butina Watson. Two of those negative outcomes are the main concern of this book, which are the two pillars of vernacular architecture. First is the adaptation of architecture to the culture, and the second is related to the identity and culture of the place. His perspective on vernacular architecture is of particular interest of this thesis, how it dropped out of favor in the developing world, and the problems that resulted out of that, as he describes it “built environments which are culturally

rooted, locally produced and technologically adapted in time and space, are being rapidly eroded. Their potential responsiveness to the needs of a changing social and functional world is largely ignored. Instead, unique built environments are being removed from their context and replaced by global forms and designs which are poorly adapted to local needs and conditions”15.

The book suggests solutions in a set of defined key principles, one of which refers to the way design should be removed from its monumental value and treated as design theory to address needs of local communities. The book “Towards Sustainable Building, part 2 Integrating Expert and Common knowledge for sustainable housing management”, by Emilia Conte and Valeria Monno also states that the call for sustainability became essential when we realized that our world was in serious state of environmental emergency. The author proceed to note that realization of the necessity to agree on global sustainable development through the Rio de Janeiro summit, “179 countries present from all over the world felt it necessary to agree on global sustainable development” led to defining the local sustainable development as “the development that delivers basic environmental, social, and economic services to all, without threatening the viability of the ecological systems and communities

upon which these services depend”\textsuperscript{16}. One other important point the book brings to attention is “the many varying factors interacting in a sustainable development, a single path for everybody to follow does not exist”, promoting the need to “try different local sustainable actions intelligently” defining a new approach to “sustainable collective growth”\textsuperscript{17}. The chapter shows an alternative to global sustainable practices, noting that sustainability has many definitions which are vague and ambiguous, and that “the great differences among places in the world have led towards the concept of local sustainable development as a contribution to global sustainability”\textsuperscript{18}.

Another book that stresses the need for a new ecological architecture approach is “Technology, Tradition and Survival – Aspects of Material Culture in the Middle East and Central Asia” by Editors Richard Tapper and Keith McLachlan. The book stresses on the danger of “technological advances

\textsuperscript{16} Maiellaro Nicola: “Towards Sustainable Building, part 2 Integrating Expert and Common knowledge for sustainable housing management”, Springer. 2001 pg.11
\textsuperscript{17} Maiellaro Nicola: “Towards Sustainable Building, part 2 Integrating Expert and Common knowledge for sustainable housing management”, Springer. 2001 pg.12
\textsuperscript{18} Maiellaro Nicola: “Towards Sustainable Building, part 2 Integrating Expert and Common knowledge for sustainable housing management”, Springer. 2001 pg.25
bringing the possibility of global ecological disaster” and asks to reflect on “the alternative
technologies that have existed in the past and sometimes, however precariously, survived”\textsuperscript{19}.

Editor says it is too easy to assume that the traditional technologies in which he refers to as
“preindustrial” have no place in an industrializing world. And that is a way to ignore “the centuries over
which they have often evolved and adapted to the local conditions, and the central role they have
commonly played in the history of western technology” \textsuperscript{20}. The book seeks to promote a “wider
knowledge of these technologies and material cultures”; the study of material culture and traditional
technologies in the book is divided into two different kind of material culture, one “the technology
including tools, skills and associated knowledge and traditions” and the other “the Products
themselves as commodities of valuables” \textsuperscript{21}. Over decades Middle East has been among the areas of
the world most affected “by the process of deterioration and globalization” especially in “the oil rich
countries” where they set aside traditional technologies and adopted new one sometimes without the
consideration of the “long term sustainability or aesthetics of the social and cultural

\textsuperscript{19} Tapper Richard, Mcclachlan Stanley Keith:"Technology, tradition and survival: aspects of material
culture in the middle east and central asia". Taylor and Francis, 2005 pg. 1
\textsuperscript{20} Tapper Richard, Mcclachlan Stanley Keith:"Technology, tradition and survival: aspects of material
culture in the middle east and central asia". Taylor and Francis, 2005 pg. 1
\textsuperscript{21} Tapper Richard, Mcclachlan Stanley Keith:"Technology, tradition and survival: aspects of material
culture in the middle east and central asia". Taylor and Francis, 2005 pg. 2
Implications”. The book also implies the importance of integrated systems as “Adaptation of new technologies to old is often possible and desirable” but the author claims that “old technology itself proves superior, from many points of view, to the new”.

Going back to our definition of sustainable design in chapter one, definition already underlined the importance of the triple society-economy-environment system of relationships, with many technological, political, and institutional effects, so that development can be considered sustainable if it meets a correct social-economic-environmental equilibrium, which dynamically evolves with time meeting changeable needs. Considering the social-economic-environmental reality is so differentiated in the world that, even though some countries with more mature economies succeed in implementing a few processes of sustainable development, there are as many and more countries with transitional and developing economies where the priority goals of development is not always consistent with

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22 Tapper Richard, Mclachlan Stanley Keith:”Technology, tradition and survival: aspects of material culture in the middle east and central asia”. Taylor and Francis, 2005 pg. 2

23 Tapper Richard, Mclachlan Stanley Keith:”Technology, tradition and survival: aspects of material culture in the middle east and central asia”. Taylor and Francis, 2005 pg. 4
sustainability, and therefore there is a risk of easily repeating environmental, social and economic mistakes already made by other and which somewhere else, people are trying to correct.\textsuperscript{24}

Integration within Sustainable Design:

This integrated approach is discussed in Ossama Abdou’s paper published in Medina Magazine “Green Architecture: A Holistic Approach”, Abdou starts by noting that “the green approach to architecture is not a new approach. It has existed since people first selected a south-facing cave rather than one facing north” in the means of achieving comfort in a temperate climate. What is new is the realization that “a green approach to the built environment involves a holistic approach, and that green design can work its wonder through an organic building that would integrate art, natural materials, sunlight, green plants, energy conservation, tranquility, and water. Noting that this can only occur through a highly integrated and trans-disciplinary design process.”\textsuperscript{25} this article points out a set

\textsuperscript{24} Maiellaro Nicola: “Towards Sustainable Building, part 2 Integrating Expert and Common knowledge for sustainable housing management”, Springer. 2001 pg.11

\textsuperscript{25} Abdou Ossama:”Green Architecture: A holistic approach” Medina Magazine, 2000 pg. 28
of green principles to “show the range of solutions that exist to overcome individual problems in buildings” these principles could be considered an outline for the integrated framework:

1- Conserving energy

2- Working with climate

3- Minimizing new resources

4- Respect for site

5- Respect for the natural environment.

Ossama elaborates in his principles to his holistic approach “the idea that man and nature are one, and that this nature interaction is generously displayed in vernacular examples of architecture”. but states that to achieve “energy efficiency designs” use of “intelligent building controls” with the aim of “using minimum energy” is integrated , Abdou concludes with the concept of “Holism”, as a method of
achieving the green built environment, which “artfully fuses the best of architectural, sociological, and cultural aspects.” 26

**Sustainable Design in Palestine:**

Modest research in the field of sustainable design in Palestine has been done in spite of the dire necessity for it. One study conducted by the Ministry of Housing in Palestine by Architect Mohammed Abaid, “New Architectural Design with Climate Design Tool – Increasing Housing Comfort in Palestine with Climate Design” this study provides information about the history, architecture and climate of Palestine. Building materials and construction in Palestine are included as well. The study introduces a building model case study with the aim to find “optimal principles for passive heating and cooling for multi-stories building in (Gaza City- Palestine)” 27 where the influence of various parameters on the indoor temperature is examined through computer simulation, the case study analyzes different parameters from insulation to ventilation, shading, Orientation and color of the facade.

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26 Abdou Ossama:”Green Architecture: A holistic approach” Medina Magazine, 2000 pg. 21
27 Abaid Mohammed:”New Architectural Design with Climate Design Tool – Increasing Housing Comfort in Palestine with Climate Design”, Ministry of Housing in Palestine 1998. Pg.1
The study concludes with the belief that “once armed with a comprehensive and somewhat scientific understanding of climate design, architects can begin seriously and effectively the process of integrating those principles into a contemporary architecture, that is at once respectful of climate vernacular architecture, and established culture in the same time”. That such amenity benefits the newly emerging nations of the developing world, as “One needs to trace the path of development by studying the results of traditional and modern tools. The traditional tools can give broad specifications for building design in a region, with particular climate”, while this is one of the only writing stating the need for integrated methods in sustainable design, the study verify the need for in depth studies.

One last survey reported by Mohannad Hadid studies the different contemporary building styles in Palestine and its adaptation to the Palestinian climate.

Results of the survey in summary:

• No special contemporary architectural elements were used in West Bank and Gaze Strip for energy saving, or reducing thermal loss.

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• Building technology in Palestine pays little attention to climate and most people build their houses without referring to any engineering consultancy, in addition to that most designers do not consider climate as one of the main design criteria in their buildings.

• On the other hand, traditional architecture provides the architect with the experience of climate-adapted building learned through generations of trial and error

• Although traditional buildings and traditional building methods have always paid some respect to the climate and its ingenious solutions, it is strongly believed that these buildings and solutions should be studied, evaluated and developed not copied.

In conclusion not enough literature or research has been done to experiment sustainability and its different modules, in Palestine or its surrounding regions in the east Mediterranean. The available literature affirms the need for more research on the area of sustainable design in the Middle East and the implementation of sustainable design in that area. Although it seems easier to copy the prototypes of developed countries, it seems obvious that those prototypes do not work in different cultural and social environments like the Middle East and specially Palestine.
Chapter Three:

Local sustainability: The Case of Palestine:

Historical background:

Palestine is the name the Romans gave to the region, derived from the Greek name Palastina, or the land of the philistines. Palestine lies on the western edge of the Asian continent and the eastern end of the Mediterranean Sea. Its location is considered to be a crossroad between Africa, Asia and Europe, in addition Palestine is held holy by Christians, Jews and Muslims, some of the most important events in each religion have taken place there, especially the city of Jerusalem, which is why it’s been a battle ground for nations through history. Palestine today lies under the Israeli occupation, leaving modern Palestine with the two territories.
of West bank and Gaza (see figure (2)). It is bound to the north by Lebanon and Syria, to the west by the Mediterranean Sea, to the south by the Gulf of Aqaba and the Egyptian Sinai Peninsula, and to the east by Jordan, for a total area of 6020 km$^2$. As most of the Palestinian territories remain under the Israeli occupation. From the 6020 km$^2$ of the Palestinian land, Palestinians control less than a 1000 km$^2$.

To be able to understand the full scope of the case study proceeding next, this section will discuss the different elements that shape the special case of Palestine, from the climate, to politics, economy and architecture, after forming an image of the region, and the current struggles facing its community, we'll establish a link between the vernacular and sustainability from the three branches of sustainable design: environment, social and the economy.

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History:

Historical Palestine, which is the whole region to the east Mediterranean of south East Asia, lays in a crossroad of the three continents of Africa Europe and Asia, which made it a focal point for commercial travels and religious influences to pass by the region. The Canaanites were first to inhabit the area, through 3000 B.C., where they developed their own alphabet and then language in the area. The Canaanites started to weaken through the fourth century B.C and were followed by a new occupier, the Hebrew Semite tribes from Mesopotamia30, who decided to invade Palestine after their tribes were expelled by Egypt in 1270 B.C, the Hebrew tribes resided in hills of Palestine, till they were able to completely diminish the Canaanites in 1125 B.C, and they stayed in the area till the Babylon’s defeated them in 586 B.C, where they destroyed Jerusalem and took over the region and alienated the Hebrew tribes out of Palestine.

The Babylon’s where followed by the Persian rule, where the great Sirius rules the whole area from Persia to Palestine in 539 B.C. the Persians allowed the alienated Hebrew tribes to come back and self govern the Palestinian regions they resided. Shortly after the Great Eskandar overthrew the Persian rule, the Macedonian leader, who took over Palestine and the Euphrates, forced the Greek

30 Land between the rivers (Ben Nahrain) which is a area between Tigris and Euphrates river system
rule on the area through the birth of the Christ in Palestine, but Jerusalem did not become Christian
till the emperor Helena visited Jerusalem and declared Christianity to be the main religion of the
region.

Roman ruling ended by Random Persian tribe attacks that ended with the Arab Muslim forces
opening Jerusalem and Palestine in 638 A.D. The Islamic invasion to Palestine extended for more
than 1300 years, in which most people converted into Islam, and while Palestine was considered one
of the holiest sites in Islam, Palestine was holy to most other religions, and it was an era of religious
freedom for all religions for a long time.

In 750 A.D Palestine turned into the Omawi and then Abbasi mandate, as the rest of the Arab world,
where the region suffered chaos and the many attacks from the crusades, the Famtimites and the
Slojecks, and the Ottomans.
The Ottoman Empire took over the region after defying the Mamluks in 1517 A.D, and they ruled the Arab desert, including Palestine till 1917 A.D, when the British took over and occupied Palestine in 1917-1918 A.D, during their mandate, the British promised Palestine to the Jewish (Belford Declaration)\(^{31}\) to help them establish their own state in Palestine. The promise prompted Jews to start moving into Palestine, especially after the Nazi holocaust, that grabbed world’s attention and sympathy, till May 1948 when Israel got into war with five of the Arab armies and defeated them, Israel occupied a big portion of the Palestinian land, then followed with another war in 1967.

\(^{31}\) The Balfour Declaration: November 2, 1917: During the First World War, British policy became gradually committed to the idea of establishing a Jewish home in Palestine (Eretz Yisrael). After discussions in the British Cabinet, and consultation with Zionist leaders, the decision was made known in the form of a letter by Arthur James Lord Balfour to Lord Rothschild. The letter represents the first political recognition of Zionist aims by a Great Power. (Israel Ministry of Foreign Affairs, www.mfa.gov.il)
where it occupied the rest of the Palestinian land, till this day Palestine remains under the Israeli
Occupation, Palestinians strive to gain their independence and have their own state.

**Geography:**

The land of Palestine is a well-defined geographical entity. It can be divided into four main regions,
from west to east: the coastal plane, the hills (Central Highlands), the Jordan Valley and the Dead
Sea/ Negev area, which is the lowest elevation on earth’s surface on dry land.

Palestine used to be a fertile land but recently water supply has been rare, the Jordan River is the
only river in the area, flows south to the lake of Tabaria and the Dead Sea, %85 of the Jordan River
and its water is controlled by the Israeli government, which projects even less of a water supply for
the Palestinians.
Climate:

Climate of Palestine will be discussed more comprehensively within the next chapter. In any case the climate of Palestine is one of the Mediterranean sub-tropical climates, it is located between 29°-33° north of the equator, where summers are long, dry and hot, and the winters are cold and rainy.

The rainy season extends from October to early May, and rainfall peaks in December through February. Rainfall varies considerably by regions from the North to the South. Highest rainfall is observed in the North and center parts of the country and decreases in the southern parts of Israel.

Politics:

Palestine is a region of political instability. It had a fairly unstable history since old times but specially since Israel decided to establish its Jewish country in the ancient land of Palestine in 1917 after the British Belford Declaration. Although most parts of Palestine are under the Israeli occupation, Palestine has defined itself as an independent country in 1988, and its territory is the West Bank and
Gaza Strip. It is now recognized by more than 100 countries around the world as it still strives to have its own state.  

**Economy:**

After almost four decades of occupation, the economy of the occupied Palestinian territory in the West Bank and Gaza continues to be subject to restrictive Israeli measures, and years of violent confrontations and war-like conditions took its toll on the economy and had serious ramifications on the growth, structure and functioning of the economy.  

**Culture and social structure:**

The culture of Palestine resembles the culture of the rest of the Levantine with a heightened political sense. Although it’s considered to be a diverse community, the main population is of conservative Muslims, with a strong Christian presence as well.

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The Palestinian culture is gravitated towards the main issues of modern Palestine. One being the struggle for its state independence and gaining security and sovereignty over its land, and the other resides in overcoming poverty and unemployment.

**Architecture:**

Palestine is a small country, but it has a great architectural heritage that reflects different layers of history. Many cultures have passed through the Palestine, which have translated in the architectural expressions. The three main cities in Palestine (Jerusalem, Nablus and Hebron) are great examples of the traditional Levantine cities similar to those described in traditional Islamic towns in the history of the Middle East. Subsequently the urban fabric in Palestine follows the main module of a traditional Islamic city; a centralized organic grid overlaid a main axis to emphasize the main circulation paths of the market leading to the city center.

*Figure (4): Palestine during the British mandate. (Jaffa)*
Palestine fell under the British mandate till the end of the nineteenth century and was occupied by Israel in the beginning of the twentieth century. Architecture of the past century in Palestine was greatly influenced by the colonial style that was influenced and enforced by the occupier; also a change in building materials and methods of construction reflected a change in the building form as well. This change imposed a change on the architectural form and city form itself, creating confusion in the city image as a whole and identity of the Palestinian architecture as a part.

**Urban Fabric:**

The urban fabric of the Palestinian cities resembles the history of its land, a mesh of different cultures and architectural attitudes, but the main design of the traditional Palestinian city is considered to be centralized, all the main streets in the city lead...
to the main center, which is usually the commercial and business center. This type of planning comes from years of traditional Islamic city planning meshed into the modern architecture. The traditional Islamic city, used to be designed around the center of the city, which had main commercial nerves, connecting to a major religious structure, usually a mosque or a church in some Palestinian cities, symbolizing that religion was the main focus of people’s lives, and each individual in the city whether working in the commercial branch of the city or other, should be able to hear the call for prayers, and attend the mosque at all times of the day.

When the traditional borders of the city dissolved, the modern city extended out of the traditional nerves to the outside, keeping the same central structure intact. The Palestinian city today still respects the same central religious structure that existed for hundreds of years in Palestine.

The Vernacular:

As mentioned in the definition of the term “vernacular architecture”, the vernacular reflects the traditional materials and construction methods that existed for hundreds of years in the region, and was affected by many passing cultures, from the Romans to Byzantines and Crusades and many other cultures that left their footprints in the progress and maturity of the Palestinian vernacular. It is
noted that within those Palestinian architectural prototypes are mainly found in cities rather than villages, as they were the main connecting hubs within the Palestinian history for travels and commerce.

One of the most interesting things concerning the vernacular, especially in Palestine, where the cities are as old as the human civilization, layers of history has sculpted the architecture to its best. The vernacular cities represent the society that created them but also embody the higher values to which their people subscribed. Their ideas and values of the old fashioned the courtyard house just as comparable ones elsewhere shaped the detached villa or terraced (row) house. ³⁴

Studying the vernacular shows that there is a strong link between sustainability and the vernacular, traditional architecture embodied the concept of sustaining architecture through time, as an innate understanding of how to connect to the environment and how to use its resources. Not only that but the vernacular has proven efficient in maximizing its adaptability to the climate through trial and error, and proven most fit to the culture and social structure it exists in.

The Palestinian vernacular has many types but one of the prominent one in Palestine is the courtyard house.

**The Religious Building:**

The Levant area and specially Palestine has been a significant zone for religions, specifically the three book religions (Islam, Christianity, and Judaism), it’s been known that the first temple in history was founded in Jericho in the prehistoric age. The prophet Solomon built his temple in Palestine (947-981 B.C), The Christ was born and crucified in Palestine, and in those locations two of the most famous churches (the church of nativity, and the church of Holy Sepulcher) were built. Also the prophet of Islam Mohammed has a prophecy of having a journey from Mecca to Jerusalem, and ascending into the Seventh Heavens and returning back to Mecca in the same night. The Aqsa mosque and the dome of the rock were built in the same location of that ascent.

*Figure (7): Temple of Solomon.*
Religious Architecture in Palestine shows diversity in the beliefs and cultures passing by, and it can be considered a timeline of different architecture types, from the prehistoric times to the Greek and medieval architecture, to Roman and Byzantine, and ending up with the Islamic era.
The Public Building:

Public buildings in Palestine vary from religious buildings, Turkish Baths, caravansaries, soap factories, commercial compounds, olive presses, schools, shrines, etc.\textsuperscript{35} In Jerusalem Mamluk schools, Tiqeieh, and Ribat were very known for their courtyards in the middle and the large scale rooms around, while Turkish baths had a different layout to accommodate its special function (hot and cold rooms), shops were built in rows to form the market of the city, like Hebron, Nablus, Gaza, and Jerusalem old cities\textsuperscript{36}. Commercial markets were designed to be multi-use buildings so they would have commercial functions on the ground floor and connection to houses from the side that connects to upper floors and inside courtyards.

The Residential Building:

Residential buildings in Palestine has gone through the changes of cultures and architectural attitudes through the ages, but the main difference of the architectural types available today, is its location. Residential buildings in cities, depending on their location, and the needs of their residents, was completely different than the needs of the country side, rural areas, or newer developments. In general through history those were the main residential prototypes available:

I: The Peasants House:

A simple structure, usually a rectangle or a cube, made of one or two stories, mainly built in the rural and village areas of Palestine, it can be built out of brick or stone depending on the financial status of the owners. The simple form of this structure usually comprises of one room, or two. While the more complex house,
the area of the house is usually larger and more elaborate, serving maybe the same number of people within the family compound.

The interior space of most simple peasant houses is divided into two parts. The family usually uses three-quarters of the inner space, while the rest of the space is used by the animals.\(^{37}\)

II: The Palestinian Courtyard House:

The emergence of the courtyard house came from an urban planning philosophy within the area of the Levant, and Palestine, as to building city quarters, with main religious landmarks, markets and businesses, occupying the city nerves, and promoting connectivity within the quarters, while keeping the houses within those nerves, introverted and private, and that’s how the courtyard hose emerged.

In their paper (Planning Jerusalem) Elisha Efrat and Ellen G. Noble state:

“The long established neighborhood beyond the Old City developed through years of accretion. Instead of displaying the conventions of modern city planning, they often reflect the personalities of their founders and original inhabitants who generally had a common origin and who formed a close-knit social group.”

The courtyard house is a solution that follows the urban structure of the city, which is based on a central plan with an inward solution. The general shape of the plan is usually rectangular. Most essential are the straight, closed lines of the outer walls.

Inner walls and partition walls are mostly of the same build and thickness as the outer ones. Straight walls and straight angles are common. The central open court is the most characteristic trait. It determines the whole layout of the building, both in size

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and function. The court opens on a row of four rooms and halls on all four sides (see Figure 15).

A large main entrance is contrary to the very character of this architecture. As a matter of fact, these buildings were never provided with a central front entrance. A small side-entrance or rather an “around the corner” entrance is the rule. Inner entrances are very rarely located at the ends of the walls, but nearly always somewhere along their length, quite frequently in the middle of the wall.

Quite a common adjunct of these large buildings is a drainage system. Also quite common is a double row of rooms (viz., one row of rooms and one row consisting of a long hall and small rooms) on one side of the court.  

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The Vernacular and Sustainable Design

Since the courtyard house comprises of spaces aligned around an open space, this allows for maximum daylight to enter the rooms:

Ventilation, Evaporation and Passive Cooling:

As the traditional Arab courtyard house usually exist in hot arid climates, air movement and ventilation becomes one of the main features of the courtyard house. Within the traditional Palestinian courtyard three main principles exist to ensure a strong airflow through the building:

- The arrangement of spaces around the courtyard makes it easier to create a strong cross ventilation between the outside and in.
- The water fountain that usually exists in most traditional courtyards in Palestine helps create air movement in the courtyard through evaporation. Evaporation of water in the fountain forces

Figure (17): Cooling and Evaporation features of the courtyard house
warm air to elevate up in the courtyard forcing cool air to descend from the roof and sides of the courtyard down.

- Within the courtyard floor, creating shaded areas ensures a steady flow of air by convection; this disposition creates another case of ventilation by convection, as in the less shaded area, the hot air rises from the floor and draws the cool air out from the courtyard through the shaded area.

- On the other hand, during the winter months, when any kind of draft lowers the temperature and creates discomfort, the closed building envelope of the courtyard creates a closed shell and protects the interior space from the cold air currents.

- During the nighttime the courtyard loses heat by irradiation, and the coolness of the floor, walls, and furniture lasts until late afternoon.

*Figure (18): Mashrabiya and shading in the courtyard*
Shading

The extensive use of shading in the region comes from climatic and cultural reasons. In a subtropical climate like Palestine shading becomes imperative to regulate the interior spaces. Also from a cultural point of view shading devices protect the privacy of the residents. A Mashrabiya, which is a widely used wooden lattice structure, is the traditional shading device widely used in courtyard houses, and performs the following functions:

- Controls the passage of light to the inner spaces
- Controls air flow
- Reduces the temperature of air by preventing solar rays from entering the space.
- Assures a great amount of privacy.
The Vernacular as a passive sustainable module and the modern definition of a sustainable framework (an integrative approach):

As discussed earlier, through an analytical approach the vernacular is proposed to be a sustainable structure that has respect for the ecosystems and great adaptability to the social standards of a given society. This provides a fundamental base point for approaching regional sustainable design in most regions of the world. When this approach is juxtaposed with the definition of a sustainable framework, five factors seem to apply to the vernacular's sustainable sensibility: land, materials, water, health and ecosystems. However, although the vernacular is a sustainable form, its lacks the ability to use the natural resources on site (sun, wind, earth, water, etc) to produce energy, which is one of the main goals of a sustainable design. This fact provides an opportunity for a new iteration of the vernacular, a vernacular that is infused with modern sustainable strategies, to achieve a modern interpretation of the regional sustainable architecture.
- Sustainability of the Courtyard House:

The Palestinian courtyard house was developed through the years to reflect the beliefs, traditions and culture of its people. It dates back to the beginning of the third millennium before Christianity, when Arab nomads used the concept of the courtyard during their movement in the desert. They set up their tents around a central space, which provided shelter and security to their cattle. With the advancement of the Arab-Islamic architecture, the courtyard became an essential typological element in most Middle Eastern cities.

The traditional courtyard house in Palestine is composed of a basement floor and a ground floor to provide for the main living spaces, which are usually accessed through a humble entry corridor that leads to a dynamic spacious inner space. Usually vegetation and a water fountain occupy the center of the space; it is the core of the house, and all the main activities of the household members are channeled through it. Additionally the courtyard is the main climate modifier for the whole building,
and all the inner spaces feed off the energy of the courtyard. Other floors comprise private areas of the house.

**Environmentally responsive features of the traditional Palestinian courtyard house**

1. The introverted form of the courtyard shields the building from the exterior elements, and helps create a protected microclimate inside the house.

2. Surface to volume ratio: the courtyard has a higher surface to volume ratio\(^{40}\). The benefit of a high surface to volume ratio is an increase in the opportunities of natural ventilation, and day lighting.

3. The slim linear form of the main spaces around the courtyard provides healthier, day-lit, ventilated spaces.

4. In the summer, the courtyard house, due to its proportions and orientation, provides a higher shadow density while providing enough daylight. Research has shown that inner spaces get enough daylight from the courtyard even when it’s shaded.\(^{41}\)

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\(^{40}\) Results show that the courtyard type has the higher surface to volume ratio (0.584). Cf. Brian Edwards *et al.*, 41.
5. Vegetation and water structures within the courtyard spaces help modify the micro-climate of the inner core through vapor, which helps lower the temperature of the air in the summer and force air to move within the courtyard as well (i.e., evaporative cooling).

Socially sustainable features in the courtyard:

Any successful sustainable project is one that promotes social sustainability. As previously discussed, the courtyard structure is a socially fit structure for the region of Palestine. Culturally the courtyard structure has been developing through the years, it maintained its strong connection with the social and religious aspects of the community, and it was adapted in this project as a successful social and culturally fit prototype as:

1. Culturally and socially the Palestinian community as most Arab and Muslim communities have an aversion to privacy. This aversion comes from the Islamic teachings within the community to cover up

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Concerning the mean shadow density, high values recorded in the streets are beneficial in hot-arid regions as they provide protection to pedestrians and to the horizontal street surface from solar radiation. Therefore as increased shadow density values can be interpreted as potentially positive, the courtyard type, which has the highest value, seems to be an advantaged configuration. As expected, high overshadowing also means low illumination values, and the courtyard type, with its narrow streets, ranks dramatically lowest. However, taken in the courtyard itself, an average luminance of 0.188 (compared with the low value of 0.099 in the street) proves that daylight is actually benefited from through the courtyard and not through the external façades of the courtyard type. This observation corresponds well with the reality of this introverted house type that interacts with the environment through the courtyard. Also note here that energy simulation simply takes into account light falling directly from the sky, and not that reflected from the ground and buildings, which in some cases can give a significant daylight contribution. Cf. Edward et al. Pg 40.
one’s body and dress modestly. In one of his allocutions the Prophet Muhammad states: “I'da aradtum qada hawaijikum fa-ista'enu bi-essatree wa el-kitman,”, meaning, if you need to accomplish your needs, seek support using protection and silence. Thus visual and auditory privacy played a major role in the shaping of the Arab Muslim traditional buildings and has remained one of the major cornerstones of the Arab Muslim house. The traditional Arab house is one of those structures, and the introverted structure of the courtyard house, helps provide a shield from the outside, to give more freedom and privacy for the residents of the house.

2. The courtyard floor in the case study was designed to be a social gathering area. The courtyard is a public social gathering space, as it occupies the center of the house and therefore enforces family connectedness, a prominent social value in the Middle East.

3. The courtyard house has a modest exterior and a comfortable delightful interior, which corresponds with the cultural beliefs in modesty and the importance of inner beauty.

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42 Cherif Amor and Jani Vibhavari, "Privacy in Home Environment: A Comparative Approach between Gujarati and Arab Cultures," Texas Tech University and Louisiana Tech University,
4. The protective outer shell of the courtyard house design presents a contemporary advantage within the Palestinian community. As mentioned the region suffers from political instability. So the outer hard shell of the building, while opening the inside of the building, could present a social security benefit.

**Economically sustainable features of the courtyard house:**

1. Provides a comfortable living without the added costs of technical systems.

2. Provides a healthy micro-climate within the borders of the building.

3. Lowers operation costs.

4. Provides jobs and business opportunities through use of local materials and technologies.

5. Also applies passive design techniques derived from the vernacular which will help connect the inhabitants with a type of architecture they have a deeper connection with, thereby enforcing a deeper sense of identity and place. As Kroasman notes, “In vernacular architecture, not only the climatic problems were solved, but also the aesthetics, physical and social functionality were
considered. For generations, they had provided comfortable life conditions and microclimates as a result of the great architectural experience.”

The Palestinian Courtyard form has been polished for hundreds of years, to fit the culture, climate and economic characteristics of the region. Reflecting back on the main characteristic of a sustainable construction discussed above, the courtyard house seems capable of meeting the three main principles of sustainable design.

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43 Selda Kraosman, *Vernacular Design as The Teaching tool of the Ecological Architecture* (Mimar Sinan Fine Art University, Turkey)
Chapter Four:

Introduction

In Chapter one, sustainable design was defined as the interaction between the three axes of sustainable design: environmental, social and economical. In chapter three an integrated approach was proposed between the traditional vernacular, as a sustainable prototype, and modern active sustainable design techniques.

Within the main concept of the courtyard and its sustainable qualities within a community, and its special combined adaptability with the culture and the economy, this chapter proposes a design process as a

Figure (20): Framework chart
case study to test the proposed integrated framework of sustainable design. This project aims to show the transformation within a restricted space, from a contemporary extroverted structure in Palestine, into an introverted one (courtyard), to provide with a minimum difference in expenses.

**Project Profile:**

**Location:**

Nablus City of the West Bank of Palestine was chosen for the case study, Nablus is an ancient Canaanite city in the northern part of the West Bank, and is considered the commercial center of the region. The city dates back to 2000 B.C, when it was founded near a crossroads for merchants and commercial travelers between Africa, Europe, and Asia. Soon Nablus grew into one of the largest cities after Jerusalem in the region. Old Nablus, which is called “the old city

*Figure (21): Nablus Suburbs’ “newer developments”*
of Nablus”, is one of the oldest traditional cities in the world. It had layers of history as many nations have conquered through the area. It also had a distinct urban plan: the city had nerves of commercial markets that ends in religious trademarks, with residential quarters in between, all enclosed within the city walls, which bordered the city and protected it from attacks.

In the twentieth century, especially after the Ottomans left the city and the British mandate was established, the borders of the old city started to dissolve and new

*Figure (22): Nablus city aerial map* | Red circle: City Center. *Blue circle: Case study site*
developments, following the international style, as most buildings of the British and Israeli occupation era were, extended out of the city, to form a new urban reality, completely different from the identity of the old city (see figure 21 and 22).

The location of this case study, which is a residential building, is in the residential suburbs of Nablus, in a middle class neighborhood, two miles away from the city center.

The chosen site is positioned within newer middle class developments, and still connected to the main streets of the city; this helps with the area of the courtyard transformation. For the new concept to be applicable in the chosen area, it has to be positioned in an open urban area like the chosen site, so that the building would not be restricted within neighboring developments.

The transformation of the design was based on the courtyard house form as a sustainable design type; the main premise of the design is that the introverted form is more acclimated to many factors within the Palestinian realm, from the climate to the culture to the social structure, than the modern prototypes enforced in the community today.
Climate:

According to the climate classification world map of Koppen-Geiger, Palestine falls under the CSA climate classification, which is the Mediterranean climate. A Mediterranean climate is one that resembles the climate of the lands in the Mediterranean Basin. This climate is characterized by hot, dry summers and cool, wet winters. Palestine's location (34° 15' N, 35° 40'E) played a big part in the climate map of Palestine, in terms of the effect of the Mediterranean coast from one part, and the Sina’ desert from another, which creates unique dynamic and different temperature effects passing through the area. The topography of the area plays another part. High elevation cities like Nablus and Jerusalem
receive more of a moderate climate through the year, while low elevation areas like Jericho have higher temperatures through the year. Researches have said that the best way to describe the climate in Palestine is that it represents both the Mediterranean climate in terms of its breeze and precipitation, and also the arid Saharan climate high temperatures. Palestine’s temperature ranges from 30° – 90° F.

Nablus city, because of its high location in the mountains and its proximity to the coast, has a more moderate climate, as the rest of the West Bank. It has a long dry summer and a wet cold winter. Figure (24) shows the sun shading chart and the sun chart through the year. Reading the graph shows that from June 21 – December 21 shading is critical, while from

Figure (24): Sun Chart and Sun shading chart for Palestine
Left: Dec 21 – Jun 21
December 21- June 21 Solar gain is needed. This means that according to the climate both shading and solar gain are important, but in different times of the year, and hence regional building designs should provide for both.

As for ventilation (see Figure 25), the city gets most its wind currents from the Palestinian coast, and hence for maximum ventilation opportunities cross ventilations through the building should be directed towards the west.

The summer season extends from May to October (see Figure 26); during the summer months the temperature goes up to 90° F. Summer in Palestine is usually dry, as showers are rarely expected. The winter months extend from November till March with...
January being the coolest month, when the average temperature drops to 30°F. 70% of Precipitation in Palestine occurs mainly between December and March (see Figure 27). The relative humidity graph (Figure 28) shows the average annual relative humidity, which for most months humidity ranges between 40% to 80%, and reaches its highest rates during the months of December and January. In May, however, humidity levels are at their lowest.
The Psychometric chart in Figure (29) shows the different heating/cooling requirements through the years, and the opportunities for cooling and shading.

A study of the chart shows that in the winter months (November – April), wind protection and heat gain are the most important factors to pay attention to through the design process. While ventilation, shading and night flushing, becomes the priority.
in the summer months (June to October), the months October, April and May are considered to be
the optimum comfort zone months in Palestine.

**Case Study:**

With the goal of forming a framework of sustainable design for the region of Palestine, a site was
chosen in a Palestinian city. A residential building was already built on site, and then a new courtyard
building was designed on the same site, keeping the same variable of the existing building (same
number of apartments, apartments sizes, floor-to-floor height, and overall height as the building).
Next, both buildings were compared based on the building’s reaction to different climate variables
(sun, wind, water, etc.), to show that the properties of the courtyard house are sustainable and more

![Figure (30): Site topography](image)

![Figure (31): Case Study: site](image)
The project presented here, is a mid-rise residential building, in a middle-class, suburban neighborhood of Nablus.

Figure (30) show topography on site, sites topography is considered steep; the slope from one corner to the other is 12m. Figure (33) shows the annual sun chart on site. The wind in figure (32), is a western wind coming from the

climatically apt than the old building.

Figure (32): wind rose on site.

Figure (33): Sun chart on site.
Mediterranean Sea

**Urban Structure:**

As can be seen in figure (34), the neighborhood is considered to be a low density residential area, which was perfect for experimenting with the urban connection with the courtyard house, as the building does not have an existing urban fabric to connect to. The area has mostly residential buildings, small convenient stores, and a mixture of service-providing structures dotted across the area.

*Figure (34): case study location and urban density, existing building shows on site in blue*
Design:

The project chosen for the case study is a residential building in Nablus. The urban structure of the area reflects newer residential developments of the outskirts of the city (see figure 34), which permits more freedom in the transformation process of the structural form into an introverted space. The relationship with neighboring developments is not restricted by built structures; the courtyard house is a structure dependent on adjacent structures.

As many residential buildings in Nablus and Palestine, the main goal of the developer was to maximize the number of units sellable in the building, as land areas are usually limited and expensive in the city. The building’s form follows the borders of the setbacks to

Figure (35): Case study (existing building)
get a maximum built area. The building follows the contemporary international style infused with some influence from the Bauhaus, that became very popular in Palestine after the British mandate and the Israeli occupation entered the west bank in the beginning of the twenties century, as architects started to migrate from Germany and other parts of Europe to Palestine.

**Building Profile**

![Building perspective and site plan](image-url)
The building has five residential floors and a parking. Each floor has 2 apartments, with a total of 12 apartments. Apartments are designed for at least a family of two to a maximum of a family of six.

The construction industry’s adaptation of type way of building, regardless of the aesthetic of the building or personal preference toward this style, creates many shortcomings:
Figure (39): South Facade

Figure (40): East Facade

Figure (41): North Facade

Figure (42): West Facade
Environmental shortcomings

1- The building does not have any consideration for building orientation.

2- The building’s façade has minimum openings, ones that do not provide sufficient ventilation or daylight.

3- Looking at Figure (37), following the exact shape of the site forces the apartments to enclose many spaces in each apartment that do not get air, light, or sun, eventually turning into unhealthy moldy rooms.

4- Using all possible areas for construction purposes makes it impossible to have any green spaces on site.

Social shortcomings

1- The extreme tendency to use every inch on site for residential units spaces prevents the project from having any common spaces.

2- Having no common spaces as a factor, combined with the fact that the parking is open to the street, makes it an unsafe open area for kids to play in, which exposes them to different dangerous elements like running into the street, or just having them in an area which parents cannot monitor and overlook.
3- Whereas green spaces are known to provide psychological comfort, the lack of vegetation makes the living environment harsh and un-engaging.

4- The fact that the buildings openings are projected outside despite cultural resentment toward the exposure of private spaces to the outside, forces the residents to cover up their windows most of the time, or have to deal with the discomfort of being exposed.

**Economical shortcomings**

1- The design’s disregard of site considerations (sun, wind, orientation) produces an uncomfortable environment which projects expenses on heating and cooling that could’ve been avoidable.

2- Bad building techniques, like dripping faucets and bad wall insulation. Would also cause many expenses in heating and cooling.
Courtyard Design: Concept: Preview:

After describing the existing building on site, the following section will describe the process to develop a sustainable design at the same site with the following three premises:

- Achieve a combination of the three components of sustainable design in the building.
- Adopt the vernacular as a sustainable prototype.
- Integrate the sustainable prototype with modern active techniques.

As mentioned in chapter one within the definitions of sustainable design, a sustainable building in any region of the world must account for environmental, social, and economic contexts in order to be truly sustainable in specific regions of the world. Sustainable architecture, in the Middle East and Palestine specifically, need to be sensitive to cultural diversity. One of the main premises of this design is to explore a prototype of sustainable design that is culturally and economically fitting.

As discussed before, the courtyard house has been proven to be a sustainable structure, in terms of the passive sustainable techniques innately enused by the inhabitants of the house to adapt to the climate.

Modern Sustainable buildings mostly have both passive and active sustainable techniques, since the vernacular prototype is considered to be passive, it becomes imperative to infuse the building with modern active design techniques.

Figure (43): Concept Preview for the courtyard design.
Design Concept:

The form of the building exhibits the notion of introverting a shell from the outside in, to create a strong core inside that connects the apartments together, and creates a microclimate for its residents, figure (44) shows openings in yellow flipped from the outside into the inside spaces of the courtyard.

The introverted structure + the hard exterior shell

Existing old building, extroverted: openings and balconies open to the street

New Building: introverted structured

Figure (44): Design Concept
**Project Profile:**

As mentioned earlier, the basic concept of the courtyard design is to flip the building from the outside in, to create a core space inside the building. This inside space serves as:

- A social connectivity tool between the resident of the building.
- A private shielded space from the outside.
- A space that protects from the elements, and creates an interior microclimate.

Keeping up with the introverted space of the courtyard, the main entrance of the courtyard is a side subdued entrance that leads to the spacious courtyard (see Figure 50).
Figure (50): Entrance to courtyard building

Figure (51): Courtyard building residential floors typical plan

Figure (52): Courtyard building residential floors typical plan
Figure (53) shows the main communal floor of the building, the courtyard. It has a water fountain and some vegetation. And many open and private social spaces. The entrances to the apartments are hidden at the two corners of the courtyard to ensure more privacy for the residents.

Figure (53): Courtyards building floor
Sustainable Design Profile:

Sustainable features of the courtyard building

Orientation:

The inner courtyard's diameter is oriented towards the north-south axis, while opening up the courtyard space, which creates inner elevations to get southern exposure to each apartment on each floor.

Figure (54): Sustainable features of the courtyard building
- Form:
  a- Opened up a space in the core of the building, which creates a slim shell, slimmer shells permit more daylight and ventilation inside the units.
  b- The new courtyard space:
     • Creates a micro climate in the new inner space.
     • Creates a social space for residents.
     • Creates more privacy within the units.

- Natural daylight:
  This is achieved in the courtyard space by keeping the proportion of the courtyard area proportional to the height of the building closest to a cube as possible; the less the height is in proportion to the cube’s height the better it is for daylight and the worse for shading.

Figure (55): Sustainable features of the courtyard building II
- Ventilation:

The courtyard house can either use its shell to protect from outside wind in the winter, or it can allow for strong cross ventilation through its wall openings and also within the courtyard space itself. Water and vegetation promote more ventilation through humidification and evaporation. The evaporation of the pools of water in the summer forces air to move through the courtyard even if cross ventilation is not bringing any cool air on hot summer days.

- Shading:

One of the main features of the courtyard is to provide a lot of daylight within the residential units. Traditionally the courtyard spaces controlled daylight, with traditional wooden shading devices called Arabesque. The design explores a modern version of Arabesque shading.

- Materials and insulation:

The courtyard house can create a microclimate inside its walls. The microclimate enforced through closed well insulated walls, and this is created within the simple materials used in most Palestinian constructions, comprised of reinforced concrete and stone cladding, with a layer of rock wool or polystyrene.
- Water collection:

Water collection is one of the most innate features of the courtyard house. Since old times people used courtyard rooftop to catch rainwater in wells, as it was a simple way to provide their need for water through available resources. The courtyard uses its roof top to collect rainwater into a tank and the courtyard pool.

- Solar Panels:

The integration of solar panels is an effective way of providing energy security in the building, which is one of the most viable features a building in a region of political instability can provide. Pay back studies on solar panels are not sufficient yet to determine the amount of time it will take those PV’s to pay back their installation and maintenance costs.

Design Analysis

Comparison chart

To be able to compare the two buildings on the same site, some building features were kept constant through both buildings Figure (56).

<table>
<thead>
<tr>
<th></th>
<th>Old Building</th>
<th>New Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of Apartments</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>No. of Apartments per floor</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>Floor Area m²</td>
<td>391.00 m²</td>
<td>394.00 m²</td>
</tr>
<tr>
<td>Floor to Floor Height m</td>
<td>3.3 m</td>
<td>3.00 m</td>
</tr>
<tr>
<td>Building Height m</td>
<td>23.8 m</td>
<td>24.00 m</td>
</tr>
<tr>
<td>Apartments Areas m²:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apt I</td>
<td>116.00 m²</td>
<td>107.00 m²</td>
</tr>
<tr>
<td>Apt II</td>
<td>140.00 m²</td>
<td>144.00 m²</td>
</tr>
<tr>
<td>Apt III</td>
<td>129.00 m²</td>
<td>127.00 m²</td>
</tr>
</tbody>
</table>

Figure (56): Comparison chart
**Orientation:**

The main idea of the transformation of the project is to flip the building envelope internally, to create a core space in the middle of the building. This shift creates a hard outer shell, which has two facades.

*Figure (57): Buildings orientation*

- **In Red:** South West and South East facing
- **In Blue:** North West and North East facing
facing south, and the inside of the courtyard, with two inner facades facing south. As a rule of thumb it is best to orient the courtyard towards the south to get the maximum daylight and solar gain through the courtyard.

**Daylight:**

Opening up the space inside the courtyard, provides an amazing source of light in all the residential units, as can be seen in figure (58). A basic daylight study in Ecotect shows that the old building is not getting enough daylight, due to the small opening sizes and its boxy form. Compared to the courtyard, all the living spaces inside the courtyard receive plenty of daylight.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Illumination (lux, lumen/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public areas with dark surroundings</td>
<td>20 - 50</td>
</tr>
<tr>
<td>Simple orientation for short visits</td>
<td>50 - 100</td>
</tr>
<tr>
<td>Working areas where visual tasks are only occasionally performed</td>
<td>100 - 150</td>
</tr>
<tr>
<td>Warehouses, Homes, Theaters, Archives</td>
<td>150</td>
</tr>
<tr>
<td>Easy Office Work, Classes</td>
<td>250</td>
</tr>
<tr>
<td>Normal Office Work, PC Work, Study Library, Groceries, Show Rooms, Laboratories</td>
<td>500</td>
</tr>
<tr>
<td>Supermarkets, Mechanical Workshops, Office Landscapes</td>
<td>750</td>
</tr>
<tr>
<td>Normal Drawing Work, Detailed Mechanical Workshops, Operation Theatres</td>
<td>1,000</td>
</tr>
<tr>
<td>Detailed Drawing Work, Very Detailed Mechanical Works</td>
<td>1500 - 2000</td>
</tr>
<tr>
<td>Performance of visual tasks of low contrast, and very small size for prolonged periods of time</td>
<td>2000 - 5000</td>
</tr>
<tr>
<td>Performance of very prolonged and exacting visual tasks</td>
<td>5000 - 10000</td>
</tr>
<tr>
<td>Performance of very special visual tasks of extremely low contrast and small size</td>
<td>10000 - 20000</td>
</tr>
</tbody>
</table>

*Figure (58): Illumination table and different spaces*
Figure (59): Daylight Analysis on the Ground floor of the old building and the courtyard floor of the new building

Figure (60): Daylight Analysis on the third floor of the old building and the new building
Figure (61): Daylight Analysis on the Fifth floor of the old building and the new building
**Shadows:**

Two main elements control shadows inside the courtyard and the units: the envelope (form, orientation and proportions), and the amounts of openings and shading.

**Shadows in January**

Figure (62) shows shadows in one of the floors in January at 10:00 am, in the winter months apartments usually need maximum daylight and solar gain. In figure (62) Building A (the old building) shows little to no direct sunlight in the units. In Building B (Courtyard house), most units get direct sunlight.
Shadows in July:

Figure (63) shows shadows in July at 10.00 am. July is the month where solar gain should be restricted as much as possible inside the apartments to avoid overheating. The old building shows little solar gain in the eastern part of the apartment, and some minimal access on the west side, as shadows decline in the apartments that are without adding shading. In the courtyard, shadows in July are also minimal, which is due to the cubic proportions of the courtyard.
Shading:

Shading is a very important feature in the courtyard house; it ensures controlled daylight and solar gain access within the units. Traditional courtyards in Palestine and neighboring countries have used shading devices to control sunlight (Mashrabiya); they were traditionally made out of wood and displayed an intricate artistic pattern (see figure 64), the genius behind those shading devices is that the intricate designs, which to the casual viewer may seem purely aesthetic, ensure that sunlight of all angles cannot enter the inner space, while also providing extreme privacy for the residents in a culture where privacy is a necessity in old times as a part of the Islamic teachings.

Figure (64): Traditional Mashrabiya (Arabesque)
Inside the courtyard, as an introverted space, the concept spaces were opened to the courtyard to be able to provide sunlight and ventilation. But living in a climate like Palestine, where shading in the summer months is needed, while considering the fact that privacy is still a main concern within the culture, modern type shading devices inspired from the traditional courtyard house Mashrabiya were installed (see Figure 65). All shading devices were constructed with a perforated metal, which is lightweight and easy to construct, economical, and has low maintenance qualities. The metal
has a 0.70 m gap, which creates a buffer zone that can prevent heat gain inside the units.

**Ventilation:**

One of the main features of the courtyard building is its ability to close its shell to protect from the elements at winter times, and its ability to open up the envelope for maximum circulation in the hot summer times. For the circulation of the courtyard, the design is intended to keep slender long shapes for the apartment spaces to allow for maximum ventilation.

*Figure (66): Ventilation in the Old residential building (up) And ventilation in the courtyard house (bellow).*
through the building while installing small lean windows on the outer shell, which allow for maximum protection from the wind in the winter months.

To achieve efficient air circulation, two main features were implemented:

- Through the thin masses lining the courtyard, openings were placed on both walls of the unit to achieve a continuous line of air circulation through the apartments.
- In the courtyard space itself, a pool or a water structure helps promote humidification and evaporation through the courtyard; hot evaporate air moves up forcing cool fresh air to move down from the rooftop to the courtyard.

Comparing the dynamic of air within the courtyard with the old design, where air is not allowed to circulate through any of the spaces in all of the apartments, the cubic shape of the building forces the apartment configuration to have many spaces inside the cube that do not have access to natural resources. Figure (66) shows the plans and sections of both buildings, the diagram shows the impossibility of having any kind of ventilation through the old apartments.
Materials and insulation:

Over the last century, construction methods and materials have changed drastically. Traditionally thick stone walls and columns were used as a structure system, and while that system was heavy, space consuming and expensive, its thermal insulation used to be efficient. Within the contemporary architecture of Palestine, thin reinforced concrete walls of relatively low thermal insulation have replaced the old dome-roofed thick high walled buildings.

Palestine geologically is positioned between Great Syria and the Sinai Peninsula, which creates different geological formations diverse both in form and structure. This unique geological stratum usually consists of sandstone and limestone, which is available in abundance for masonry construction in Palestine. Within modern construction in Palestine the main construction materials used are:

- Reinforced concrete: reinforced concrete is used in most structures. Concrete is also used in hollow brick masonry walls, and in plaster partitions and paint finish.
- Stone masonry: used in some bearing walls, columns, and cladding.
- Cast Iron: used within reinforced concrete columns slabs and bearing walls.
Reinforced concrete is a structure of high stability and solidity in the area, but it lacks the proper insulation. In a study in Palestine on reinforced concrete structures with stone cladding it was found that energy loss in winter in local homes exceeds 6 times the amount of energy loss in buildings in the USA similar weather conditions.

Within the modification of the case study into the courtyard building, protecting the thermal envelope of the building through insulation was one of the main goals of the study. Figure (67) show a section through the old construction wall, with no regard to insulation and then with optimum insulation.

In a study performed on Ecotect, a thermal study shows that the cooling loads are considerably less in the new building due to insulation.
Figure (68): Thermal Analysis on both Buildings on Ecotect shows the New Building need less heating than the old one in the winter
Vegetation and Water:

Integrating vegetation into built environments within site design falls into the main goals of sustainability. In many places, Palestine one, land is environmentally damaged. Soil erosion, groundwater contamination, and other pollutants are damaging the health of the ecosystem. Therefore it becomes necessary for a sustainable building to provide plantation enforcement that can help aid the surrounding ecosystem. On a different note, vegetation can aid in providing passive sustainable features on side, as humidification, air filtration and shading, not to mention the healthy psychological effects having vegetation within the built environment.

Figure (69): Vegetation in the courtyard
Vegetation and water had always been the main features of the open courtyard space. It helped aid the ventilation process through the courtyard as mentioned before, and is considered to be a meditating space and a social gathering area.

In most cities the urban built environment, little attention is paid to integrating green spaces, especially in residential buildings, which is the case in the old building on site used as our case study, where no consideration for vegetation shows on site. In contrast, in the courtyard building the main courtyard area, which serves as a social gathering area, was infused with a large water structure and vegetation.

Energy Integration Analysis:

Within this residential building case study three active techniques of sustainable design were integrated within the courtyard, in the aims of enforcing the building with electrical power, thermal energies and water:

- Photovoltaics.
- Solar water heating systems.
- Rooftop water catchment.
PVs and Solar Water Heating Systems:

Palestine has a high potential of solar energy around the year, with an average solar radiation of 5.46 kWh/m².day. Thus, PVs can be a very promising energy producing feature for the region; Palestine receives a relatively high quality of solar energy all over the year. The goal of integrating PVs into the courtyard is to study the extent to which we can plan for solar energy as an economical and reliable source of energy in the future.

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44 Hafeetha Mai, “Planning for Solar Energy as an Energy Option for Palestine,” (An-Najah University, 2009), 37
Solar water heating systems have been used in Palestine since the 70s is known to be a cheap and effective way to heat water through the summer and even winter months. Solar heating within the courtyard as a system can be installed on its own, or may be integrated within the rooftop Solar Panels. The present commercial solar cell converts solar energy into electricity with a relatively low efficiency, less than 20%. More than 80% of the absorbed energy is dumped to the surroundings again after electric energy conversion. To raise the energy efficiency, many researchers attempted to develop hybrid PV and thermal (PV/T) collectors.

Within the courtyard design, the roof and south-facing facades were integrated with solar panels. The roof, which faces south, was inclined to a 32 degree angle, and

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46 See Chapter Five (Solar Water Heating) for more details
integrated with a solar water heating system, to a total area of 168.00 m2. While the south facing elevations were covered with solar panels for a total area of 421.00 m2.

The residential use of PVs in Palestine has not been studied, and therefore it’s not possible to determine the long term economical value of adopting their use as an independent energy system. Nevertheless, it is imperative to start integrating PVs as an energy producing alternative within residential buildings for the following reasons:

- Energy is a security issue in Palestine and providing a secure source of energy can enforce people’s rights for basic energy stability.
- Palestinians currently buy their electricity from Israel at the most expensive energy prices within the region. Installing solar panels can help the Palestinian economy gradually gain its energy independence.
- Although little to no precedent exist for the use of solar panels in residential buildings in Palestine, installing solar panels can set the precedent and help prepare the market to gain a place within the regional construction industry.

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48 See “Solar Panels” and “Energy” in Chapter Five
- Solar energy is a clean source of energy, and alleviating environmental degradation and contamination is one of the main goals of sustainable design.

PVs are installed on the façade of outer envelope to showcase the technology, and on the roof top on an optimum tilted angel of 32°. Both are oriented to the south for maximum solar exposure.

Figure (72) shows the potential of installing a PV System on the roof of the new building, according to a 5%, 10% and 15% efficiency systems, and it shows that there is a strong potential of photovoltaics on site.

<table>
<thead>
<tr>
<th>Roof Mounted PV System (Low efficiency):</th>
<th>28,654 kWh/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Mounted PV System (Medium efficiency):</td>
<td>57,308 kWh/yr</td>
</tr>
<tr>
<td>Roof Mounted PV System (High efficiency):</td>
<td>85,962 kWh/yr</td>
</tr>
<tr>
<td>Single 15' Wind Turbine Potential:</td>
<td>1,401 kWh/yr</td>
</tr>
</tbody>
</table>

*PV efficiencies are assumed to be 5%, 10% and 15% for low, medium and high efficiency systems

Figure (72): Study performed on Autodesk Vasari shows the photovoltaic energy Potential for the new building
**Water Collection:**

Water collection has been a fundamental part of the courtyard house; traditionally, collected water would be passively collected in a well and pumped later manually. Collected water was traditionally used to fill the courtyard fountain, water the vegetation and clean the house. As the main goal of collecting water within the courtyard is to increase water security as a resource, the quality of the water used must be potable. Therefore water collection within this case study needs to be installed with active systems (pumps and filtration systems).

Rain is the main source of water in Palestine; it is the feeder of groundwater aquifer, surface water, valleys and flowages. Rainwater is considered
as the main component of precipitation in the West Bank. Rainwater in the area also shows considerable inter-seasonal variation. The rainy days in the West Bank are estimated between 40-70 days year. The recorded average of Palestine's rainfall is about 615 mm\(^49\).

The catchment system comprises of the concrete area of the roof, which is connected by pipes to a filtration system connected to an underground cistern (see figure 73), according to a paper conducted on the quality of roof rainwater for house hold supply in Jordan\(^50\), this water harvesting system should be as close as possible to potable water quality, to make sure the water is of potable quality, an amount of chlorine can be added according the amount of water collection in the cistern.

Possible estimated net runoff harvested within this system is calculated through this equation:

\[
\text{Net Runoff} = \sum \left( C_i \times A_i \right) - \sum \left( R_i \times A_i \right)
\]


Catchment area (m²) x rainfall (mm) x runoff coefficient (see figure 74) = net runoff (liters)\(^5\)

\[ 588.00 \times 615.00 \times 0.70 = 253134.00 \text{ liters} = 253.13 \text{ m}^3. \]

According the Palestinian Hydrology group (PHG), an average Palestinian family of 7.49 people, needs an average of 23.06 m³ a month (see figure 75)\(^5\). According to this estimate, the water savings can cover a whole family for a year.

\(\text{ Connected Areas} \quad \text{ Unconnected Areas} \)

<table>
<thead>
<tr>
<th></th>
<th>Average family size 7.49 persons</th>
<th>Average family size 8.36 persons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average monthly water use in summer</td>
<td>26.06 m³</td>
<td>18 m³</td>
</tr>
<tr>
<td>Average monthly water use in winter</td>
<td>20 m³</td>
<td>13 m³</td>
</tr>
</tbody>
</table>

\(\text{Figure (75): Family monthly water use in Palestine}\)
Building Energy Use Comparison:

Using the Autodesk analysis tool Vasari and Green Building Studio, the two buildings were analyzed for energy use. The two buildings use the same structural system, same material over all, with the exception of the added insulation and window type. The Analysis showed, see figure (x), a substantial decrease in energy use from 159 kWh/sm/yr in the old building, to 136 kWh/sm/yr in the new building in electricity, also fuel use was decreased from 543 ML/sm/yr, to 342 MJ/sm/yr. This gives a very clear indication that the features added to the new building, has helped decrease its energy use by a substantial amount, see figure (76).

Figure (77) shows the annual energy use/cost of both buildings at the top, with a difference of almost $8000 in the overall cost of electricity/cost. In the second graph the overall cost of fuel is reduced by almost $4000. Figure (78) at the end shows some graphs concerning cooling and heating loads in the first diagram at the top, where it is clear the new building uses much less electricity for cooling. The second graph shows fuel use in both buildings, and it shows that the old building uses more simulated fuel than the new building. Finally, the monthly electricity consumption graph shows that
the old building uses up more electricity than the new building per month. All those figures and numbers clearly show that the new building is far more sustainable in terms of its energy use in comparison to the old building. This proves that the passive sustainable structure of the courtyard can be adopted as a sustainable prototype. More research could further enhance the building’s efficiency and sustainability.
**Figure (76): Energy use comparison between the old building to the right and the new building to the left**

<table>
<thead>
<tr>
<th>Location</th>
<th>Jerusalem, Israel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather Station</td>
<td>12942425</td>
</tr>
<tr>
<td>Outdoor Temperature</td>
<td>Max: 30°C Min: 2°C</td>
</tr>
<tr>
<td>Floor Area</td>
<td>3,505 m²</td>
</tr>
<tr>
<td>Exterior Wall Area</td>
<td>28,850 m²</td>
</tr>
<tr>
<td>Average Lighting Power</td>
<td>6.48 W/m²</td>
</tr>
<tr>
<td>People</td>
<td>52 people</td>
</tr>
<tr>
<td>Exterior Window Ratio</td>
<td>0.24</td>
</tr>
<tr>
<td>初始 Energy</td>
<td>50,709,769 kWh</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Jerusalem, Israel</th>
</tr>
</thead>
<tbody>
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<td>Weather Station</td>
<td>12942425</td>
</tr>
<tr>
<td>Outdoor Temperature</td>
<td>Max: 30°C Min: 2°C</td>
</tr>
<tr>
<td>Floor Area</td>
<td>2,766 m²</td>
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<tr>
<td>Exterior Wall Area</td>
<td>22,954 m²</td>
</tr>
<tr>
<td>Average Lighting Power</td>
<td>7.13 W/m²</td>
</tr>
<tr>
<td>People</td>
<td>53 people</td>
</tr>
<tr>
<td>Exterior Window Ratio</td>
<td>0.18</td>
</tr>
<tr>
<td>Textual Cost</td>
<td>50,000,000 $</td>
</tr>
<tr>
<td>Fuel Cost</td>
<td>50,709,769 kWh</td>
</tr>
</tbody>
</table>

| Electricity Efl | 106 kWh/yr        |
| Fuel Efl        | 342 MMBtu/yr      |
| Total Efl       | 511 MMBtu/yr      |

| Electricity Efl | 109 kWh/yr        |
| Fuel Efl        | 343 MMBtu/yr      |
| Total Efl       | 1,142 MMBtu/yr    |

| Life Cycle Electricity Use | 12,226,933 kWh |
| Life Cycle Fuel Use        | 36,313,889 MJ  |
| Life Cycle Energy Cost     | 552,232 $      |

| Life Cycle Electricity Use | 13,204,842 kWh |
| Life Cycle Fuel Use        | 44,989,303 MJ  |
| Life Cycle Energy Cost     | 571,457 $      |

*10-year life and 6.1% discount rate for costs

| Roof Mounted PV System (Low efficiency) | 26,654 kWh/yr |
| Roof Mounted PV System (Medium efficiency) | 8,308 kWh/yr |
| Roof Mounted PV System (High efficiency) | 56,940 kWh/yr |
| Single 15 Wind Turbine Potential | 1,481 kWh/yr |

| Roof Mounted PV System (Low efficiency) | 21,482 kWh/yr |
| Roof Mounted PV System (Medium efficiency) | 47,508 kWh/yr |
| Roof Mounted PV System (High efficiency) | 66,287 kWh/yr |
| Single 15 Wind Turbine Potential | 1,481 kWh/yr |

*Efficiencies are assumed to be 6%, 10% and 15% for low, medium and high efficiency systems*
Figure (77): Energy use and cost comparison graphs, the graphs to the right represent the old building and the graphs to the right represent the new building.
Figure (78): Energy use and cost comparison graphs, the graphs to the right represent the old building and the graphs to the right represent the new building.
Socially sustainable courtyard features

Social adaptability is one of the most influential aspects of sustainable design; social structures differ in different parts of the world, which makes regional sustainable design a must to enforce respect to the community and culture which the building exists in.

Social Structure of the Palestinian community:

The diverse Palestinian community as an identity is influenced by many factors, one being the occupation, as Palestine has always had a strong foreign military presence (i.e. the Ottoman Empire, the British mandate and Israeli occupation, etc). Religion has a dominant role in defining a person and community in a whole identity.

Figure (79): The courtyard inner space as a space of social interaction.
Architecture in Palestine has been influenced by the rapid and drastic economic, social, cultural and political change that took place in Palestine during the second half of this century.

To understand the change the courtyard needs to undertake, an analysis of the social change within the past 62 years is in order. The basis of the culture of the Palestinian community is a conservative Muslim community, and those teachings show within the structure of the courtyard house. In the past century the political and social changes, forced the community to either reach a religious extreme, or somehow divert away from religion to a more socially liberal point of view.

The Palestinian population is moreover subject to an imposed chronic social fragmentation due to the Palestinian political differences and confrontations.

Muslims are the predominant religious group in Palestine, comprising three quarters of the Palestinian community, and Islamic practices still prevail in the community. Especially in the beginning of the twentieth century when the Ottoman Empire still had a strong influence on the Islamic structure of the community. After British Mandate and Ottoman rule, Palestine was affected by many social changes. These changed took place under the umbrella of the European Colonialism, within this section, we’ll look at the Palestinian cultural landscape at the time of the traditional
courtyard house (Ottoman Empire at the end of the nineteenth century), and then examine the social change that occurred a century later after the British Mandate and Israeli occupation:

- Religion: the religious structure in Palestine, which is predominantly Muslim, has shaped the form and functions of the courtyard house, the Islamic structure of the society has been really strong within the Ottoman Empire, and it has shaped the old cities of Palestine according to those teachings, and subsequently the courtyard house and its manner its functions are set. One of the main religious features apparent in the courtyard house, is the need for privacy, as privacy is related to covering up one’s body and not sharing beauty with the rest of the world, it translates into the architecture starting from the private alley in the street, to the indirect entrance of the house, that leads into an open space that is exclusive to the residents of the house and excluded from the world.

- Economy: The Ottoman Empire controlled the whole region of the middle east, and Palestine as a part of it, was open to the other regions surrounding it, and provided that some of the most recognized and cherished religious buildings in the middle east (the Dome of the Rock and the sepulture church) were located in Palestine, and the fact that Palestine is located in a
strategic point between Asia and Africa, helped boost the local economy and the local businesses in most Palestinian cities. The strong economy showed within the courtyard house, as a structure the courtyard house provided a huge open space for its residents, which is usually one big extended family, with a water fountain and a large green space, and large whole living quarters that provides open spaces for the residents, this structure for a one extended family residence is considered to be for more wealthy people.

- Women:

Women within the Ottoman Empire in Palestine, have been marginalized within the community and considered to be valuable mainly as a mother and a housewife, she has always been protected within the closed walls of the courtyard house, which also means protection from contact with non-family male members.

- Family:

the traditional family structure that lived in the courtyard, is the extended family, which mainly is comprised of the head of the family, which is the grandfather and the grandmother and their children and their families, each family that lived in the courtyard house would had their own living
quarters, with a common shared cooking and meeting place for all the family members, which enforced the family connectedness and enforced family ties. It also enforced the strong family structure where the grandfather can decide for the family and all the other members would have to comply. Which is a typical Arab patriarchal family system.

- Politics:

Palestine has always been an area of political instability, within the ottoman empire, and although Palestinians were not satisfied with their existence under the ottoman control, they kept their peace till the British mandate came into the region and threw out the ottomans out of the whole region in world war I.

**Contemporary Palestine and social change:**

Within the past century many social, economical and political changes affected the Palestinian community, which translated into the current architectural identity and expression of Palestine.

The demise of the Ottoman Empire and the rise of the British mandate (which after 1914 promised Palestine to the Jewish People to construct their first Jewish state), instigated the Palestinian/ Israeli conflict, and subsequently the struggle changed the face of the Palestinian community over the years.
The new change within the Palestinian community, forced some of the Palestinian vernacular types to disappear and other prototypes to appear to the surface, the same social paradigms were affected in the process:

- Religion:

The political conflict has a direct connection to religion, going through wars and hardship affected a big percentage of the Palestinian community to become even more religious. And while the architecture prototypes started to change according to available technologies and different architecture influences merging into the region, the religious Palestinian would still find a way to make his living space accommodated to his religious beliefs, for example; the need for privacy is a concern within the Islamic teachings, and hence a Palestinian religious family would find a way to cover all their windows with curtains and shutters all year round, even if it wasn’t healthy for the inner environment, to protect their privacy within a residence that has its windows extroverted to the outside.

On the other hand, a new generation of liberal thinkers, ones who diverted away from religion started to form a more substantial percentage within the community. This new generation
embraced the societal change, and wanted to live in modern living spaces, that represented the new wave of thinkers.

- Economy:

Being in a war zone imposes closers, physical constraints and strict regulations on commercial activity. Which caused a huge economical degradation in Palestine, many Palestinian families could not afford to live in big spaces with large interior open areas like the traditional courtyards, and with the emergence of new architectural prototypes inspired from the west, and the availability of new building technology in the area. Families started to relocated to cheaper smaller apartments with less living spaces.

- Women:

The political struggle in Palestine and the emergence of modern liberal concepts into the society, combined with the economical degradation, started to change the women’s role in the community, from protected housewives that were veiled within the walls of the traditional courtyard, into women who had to work to support their husbands, and some of them had to support their whole family after many men were killed during altercations with the Israeli army.
- Family:

Within the societal changes that occurred on the Palestinian society, the family structure was a big change, the extended family structure completely dissolved into a nuclear family with an independent financial structure. Since the space needed for a nuclear family is different than the space needed for an extended family, the architectural form and functions changed according to the new paradigms and newer architectural forms started to form the new city skyline.

Politics:

Since the Israeli occupation to the Palestinian territories in 1948, and taking over the west bank in 1967, the fight for the Palestinian state independence oriented the community and its goals around it. Society’s priorities all shifted around providing freedom for the Palestinian citizen, and pulling forces to achieve that goal. This keeps architecture and aesthetic within the city image in general on the back shelf. Architecture was considered to be the business of shelter.
A new courtyard house within a new social perspective:

The Palestinian community has experienced many social changes in the past century, where the architectural expression also shifted and changed into a contemporary architectural one that exists as a collection of disconnected themes.

The courtyard house as a building prototype needs to accommodate the cultural and social changes that occurred within the Palestinian community to be adopted as a new building prototype.

Within the new design of the courtyard house, many changes were considered to adapt to a new way of living and a new social structure, previously the social change was discussed within (Religion, Economy, Women, Family structure and politics), within this social analysis, we'll look at those factors and how they were treated within a new design of the courtyard:

- Religion:

As discussed before, religion within the Palestinian community is a very important factor; through the struggles and hardships of the Palestinian community many groups of the community became more attached to their religious beliefs, while others have diverted into a more liberal detached
point of view. One of the main factors to be considered within the design of the courtyard is respect for religious Islamic beliefs and mainly resident’s privacy, without forcing residents to isolation and preventing them from having any contact with the outside world. In the new courtyard design, Privacy was respected by converting the dynamic of the space to the inside of the courtyard, instead of having to share your openings with the rest of the city, the unit has one facade overlooking the courtyard, that is shared with 11 other units, which is more private just as a count of numbers.

On the other hand, providing the utmost level of privacy was provided through shading with curtain walls inspired from the concept of the Mashrabiya (look at page (x) for more details), flexible curtain walls, give the option of shielding your space from any visual contact with other residents of the courtyard.
On the other hand it is important to keep this type of privacy which can also be considered by other residents a forced isolation an option, and allow for a visual connection with the outside. This was achieved by having an open façade behind the curtain walls that is open to the courtyard (see figure (80)), once the light weight movable shading devices are moved.

- Economy:

The courtyard structure used to be an exclusive home for an extended family, since it is not feasible within the current Palestinian economy for a single family to afford to build such a
structure independently; same benefits are offered within a residential building with 12 families enjoying the same features of the courtyard house.

- Family Structure:

As mentioned the courtyard house used to exist as a housing unit to an extended family, but in recent times this structure has dissolved into a modern nuclear family structure, the new design of the courtyard, has 12 units designed for a nuclear family.

- Politics:

Palestine is a politically unstable area, altercations and shooting can happen in the middle of the streets of residential neighborhoods, the design of the courtyard has a hard protective shell on the outside, this shell provides shelter and a shield from the outside, which can be a major safety factor for a residential building in that area.

Also providing a safe area for people to socialize and congregate away from the street and into the protected floor of the courtyard itself, is a safe way to promote social connectedness and community interactions within a safe environment for the families and their children.
Chapter Five:

Design Framework:

Guiding principles for the sustainable courtyard design:

This section discusses the process of producing an integrated sustainable building based on the courtyard sustainable form. This specific collection of technologies comes from a sensitivity to complex problems presented in this study, and reflects back on both the definitions of sustainable design in chapter one and the design of the courtyard building in chapter four.

Figure (81): The Integrated Framework Diagram
The Courtyard form:

One of the main objectives of the courtyard concept is to protect the inner environment from the sun in the summer and allow maximum radiation in the winter. This goal is dependent on the ratio of the form and the specific area-to-height ratio is what distinguishes the courtyard in this part of the world.

Table (1): Rectangular courtyard forms.
The ratio

As previously noted, climate in Palestine is recognized by the hot dry summers and the wet cold winters; in such a climate it is important to shade the building in summer, and provide maximum sunlight in winter. It is impractical to suggest a specific ratio for the inner space of the courtyard, but it is possible to achieve an optimal shaded area in the summer and a well sunlit area in the winter. Thus, it becomes imperative to provide a range of ratios that provide that balance. In a study conducted by Ahmed S. Muhaisen, the author suggests a range of ratios that would help provide a shading reduction average of 35% in the summer, and 50% more sunlit area in the winter. Shaded areas in Table (1) refer to the suggested ratios for similar areas of the Middle East; R1 is the ratio between the courtyard's floor perimeters to the courtyard's height, and R2 is the width to length proportion.

The table presented above (see Table 1) represents the different rectangular forms of the courtyard, with highlighted areas representing the appropriate ratios for the climate of Palestine. Ratio used in

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the test design is between (R1:4 R2:0.9) and (R1:4 R2:0.8)’ within the design of the inner space of a courtyard, the higher the courtyard form is, the deeper and the more shading it provides. Within the Mediterranean climate of Palestine, the optimal height for a courtyard is the one that is closer in form to a cube, since a cube shape, highlighted in blue in Table (1), provides enough shading within the summer months, and still lets in sunlight during the winter. The higher the height proportion of the courtyard becomes, the more shadow it produces, which is more appropriate for the arid climate of the Arabian Desert. The lower the height proportion of the courtyard is the less shading and more sunlight it lets in, which is more appropriate for colder climates.
Orientation:

Figure (82): Jerusalem City, urban orientation

The courtyard’s orientation is usually greatly affected by the boundaries of the piece of land and its alignment to the street. In traditional cities in Palestine the streets were oriented towards the west or along a north-south axis to facilitate wind movement in the pedestrian street and into houses, as wind
comes from the Mediterranean Sea (west). As a rule of thumb, the orientation of the courtyard should be directed towards maximum use of sources of energy on site (wind, sun and light),

**Materials:**

Most of the changes in the building styles and materials in the Middle East are due to the economic and cultural dominance by the west. The occupier’s quest for raw materials led to widespread abandonment of traditional crafts and use of material widely used in the Ottoman Empire. Today the main building materials used in Palestine are stone and unbaked mud brick. Three main types of stone are used, depending on the region of the country. Along the Mediterranean coast *kurkar*, a silicous limestone is used for building. It’s cut from the nearby outcrops, which makes it readily available, but it is affected by the weather easily and it’s not easy to cut. In the northern part of the Jordan Rift Valley and around the Sea of Galilee, basalt blocks are used in construction. Basalt is extremely hard and is consequently difficult to cut or carve. As a consequence basalt is often used in combination with limestone which is used for architectural details. The best quality building stone comes from the central hilly region. In this area various types of limestone can be found. Limestone is fairly easy to cut and does not erode as much as *kurkar* stone. Limestone cut and dressed to a fine finish is known as ashlars masonry and is used in some of the finest buildings in the country.
Limestone occurs in a variety of colors from white to honey yellow and pink; some of the best examples can be found in Jerusalem, Hebron, and Nablus. In addition, various types of marble are obtained from the hills around Jerusalem, whilst Dolomite (hard limestone with magnesium) is used in areas of Galilee.

**Insulation:**

As mentioned before, one of the main goals of the courtyard house is to have a protected microclimate within its walls. Traditionally this was achieved by increasing the thickness of the stone walls, and having the outer shell of the courtyard enclosed. While having a hard shell to protect the inner environment mostly relies on the design itself, the composition of that outer wall has a great effect on the performance of that shell in protecting the inner microclimate.

*Figure (83): Insulation thickness and annual cost in Palestine.*
In a study on optimizing insulation thickness for buildings using life cycle cost. A set of recommended wall thicknesses and materials is recommended for providing optimal thermal resistance in buildings. The study discusses the different possible insulation thicknesses in walls, compared to different life cycle costs involved (see figure 83). The study concludes with recommending using Polystyrene or Rock wool as an optimal insulation material within concrete structures, with a thickness between 0.05-0.07 (see Figure 84).

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Figure (84): Insulation thickness and annual cost in Palestine.

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Ventilation:

The thermal performance of a courtyard house is highly connected to its ventilation. Since early times the movement of air inside a dwelling was used to obtain cooling. On the other hand, the protective outer shell of the courtyard house when sealed protects the interior from the cold winds of the winter.

To achieve effective ventilation through the courtyard, three factors provide optimum air movement:

- Open floor plans from wall to wall facing the courtyard, providing openings on both sides of the space. Having an open passage between the openings on both walls forces air to move through the building and into the courtyard (see Figure 85).
- An open air flow should mainly be harvested through the building to force a stronger air flow within the courtyard.
- Pool or water fountain inside the courtyard: the water fountain inside traditional courtyards is not merely there for aesthetic reasons. Evaporation or humidification of water, vegetation in the courtyard, and radiation, forces air to rise upwards forcing cool air from the sides of the courtyard to sink down.

**Courtyard Vegetation/Garden:**

One of the major downfalls of contemporary architecture in Palestine is its complete disregard for the environmental and psychological effects of integrating vegetation into the architecture. But gardens and green spaces were a main influence on the composition and functioning of the courtyard. It’s the area where people meet and socialize, and it’s considered to provide social tranquility and meditation, which is a part of the whole concept of an introverted structure that provides tranquility, protection, and privacy. On the other hand the climate modification qualities it projects on the living space are quiet effective. Vegetation promotes humidification within the space and is an effective shading tool within the courtyard; also, trees can filter the air passing through the courtyard.
In his essay in the book “Courtyard Housing: Past, Present, and Future,” Maher Laffah discusses vegetation in the courtyard house and studies the right implementation of vegetation through his study of gardens in various courtyard houses. The results of the study show that within the courtyard house, 25%-35% is the recommended amount of vegetation area within the total area of the courtyard, (see Table 3).\(^{56}\)

### Water Collection:

The region of Palestine is in dire need

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of water resources. The need for water supply represents a social and environmental necessity, but no matter how much of water resources are available to a region, water catchment is still a must as a way to decentralize the management of natural resources, which is also a very valid security concern for Palestine. The main resource for water supplies in Palestine is the ground water reserves, which is a scarce resource, and most those reserves (almost 85%) have been controlled by Israel. So it is absolutely imperative to integrate a water collection system within any construction.

There are great opportunities for rainwater catchment in Palestine, as winters in Palestine are usually wet. Within a sustainable project it is highly recommended to install a water catchment system in order to:

- Enforce natural resources security.
- It’s an economically effective mean to provide for costly features on site, like courtyard vegetation irrigation.
- Providing good quality water free of contamination.
- Provides enough water for the courtyard pool, which is used in the climate modification process of the courtyard.
- Set a trend within the community of the value of water harvesting.
- Rainwater harvesting can reduce dependence on ground water.

Rain catchment systems are simple and cheap, and regardless of their sophistication rainwater harvesting systems generally have four common components:

- The capture area for rainfall (roof).
- A holding cistern.
- A conveyance between the roof and the tank.

*Figure (86): Water collection in the courtyard*
A method to draw upon the storage for use (pump).\textsuperscript{57}

Photovoltaic Panels (PVs) and solar water heating:

In a Palestinian community, energy security is a huge issue; it is one of the most important features of a sustainable building to provide energy when other measures fail. The electricity network is considered to be a serious problem in Palestine there is also limited electrical power generation capacity in Palestine as most of the used power is supplied by Israel, which means that Palestinians have to pay way more for their electrical usage (see Table 4)\textsuperscript{58} despite the fact that Palestinian electrical use is considered to be minimal compared to an Israeli: a Palestinian uses 675

\begin{table}[h]
\centering
\begin{tabular}{|l|l|}
\hline
Price of Electricity & 0.73 (NIS/kWh) \\
Price of Gasoline & 6.5 (NIS/liter) \\
Price of Diesel & 5 (NIS/liter) \\
Residual Fuel Oil #6 & 4.5 (NIS/liter) \\
Price of Kerosene & 5 (NIS/liter) \\
Price of Firewood & 450 (NIS/ton) \\
\hline
\end{tabular}
\caption{Electricity prices in Palestine}
\end{table}

\textsuperscript{57} See page 118 for details on system requirements and water conservation projections.
kWh/year compared to 5200 kWh/year for an Israeli. Indigenous energy resources are quite limited to solar energy for photovoltaic and thermal applications (mainly for water heating), as potential for wind energy seems to be limited to the mountains of elevation above 1000 m, and geothermal technology could be feasible only as source of energy for heating and cooling. Production of energy through solar electrification has great potential in Palestine, Solar radiation in Palestine amounts to 5-4 kWh/m2-day high on horizontal surface, and the it ranges from 2.63 kWh/m2-day in December to 8.4 kWh/m2-day in June. These figures are encouraging to exploit solar energy for electrification and other applications such as water heating. Solar water heaters (SWH) are extensively used in the residential sector in Palestine; almost 70% of the households use solar family systems. Utilizing solar water heating had begun actually in Palestine since 1970 and it now occupies a high percentage of roofs in many Palestinian cities to provide households with their daily hot water

59 Yaseen Basel, “Renewable Energy Applications in Palestine, “Palestinian Energy and Environment Research Center (PEC), pg, 56
60 Ibrik Imad, “Potential of Renewabe Energy in Palestine and our regional needs,” Energy Research Center-An-Najah National University, Nablus Palestine.
requirements. The thermosphone open loop system of SWH is the mostly used type for domestic use (see Figure 87). As a sustainable method of providing hot water, this framework recommends the continuation of the thermosphone use in residential buildings.

The system suggested for this framework is an integrated solar panel and solar water heating, as mentioned in chapter four, the present commercial solar cell converts solar energy into electricity with a relatively low efficiency, less than 20%. More than 80% of the absorbed energy is dumped to the surroundings again after electric energy conversion. To raise energy efficiency and lower the initial cost of installing two separate systems that would use twice the space and twice the resources, a combined solar panels and solar heating system is used within this framework, the combined system generates electric power while collecting heat to produce hot water, the overall efficiency thus increases.

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There is little research in Palestine discussing the value of the installation of PVs in residential buildings, and calculating paybacks becomes really hard since it depends on importing prices and projected taxes, which could vary greatly according to the political situation and closures.

But in spite of the difficulties of exploring into a new technology in residential buildings, installing PVs is one of the fundamental parts of the framework for many reasons:

- There are great opportunities for solar energy in Palestine, as the daily average of solar radiation intensity amounts to 5.4 kWh/m2 a day, also the annual average of total sunshine duration amounts to 2850 h. 65

- Energy security in residential buildings, as mentioned energy security is a huge issue in Palestine, a photovoltaic system will help provide some of that valuable commodity.

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- Within Palestinians quest for independence, it becomes important to prohibit Palestinians energy dependence on Israeli companies.
- Electricity prices in Palestine are the highest in the region; exploring into PVs installation in residential buildings, although not immediately, will pay back on the long run and help promote like businesses in the area.
- Also integrating PVs into residential construction business, will promote easy installation in remote areas and villages that do not get electricity regularly.
- Environmentally, PVs are a clean source of energy, and it will promote less CO2 emissions.

Payback projections:

In terms of pay back studies economic evaluations and analysis of installing PV’s in Palestine has not been done yet. In a study done at An-Najah University, the researches states “guaranteeing of economic feasibility depends mainly on selecting the appropriate application and on design of the solar system.”66 This makes it impossible to give a solid payback check formula.

Conclusions

The combination of suggested passive and active technologies presented within this framework, under the umbrella of the introverted courtyard design, can adapt and evolve if followed with more experimentation with the integrations of different technologies into a Palestinian, regional, sustainable building style. Furthermore, the analysis presented in this thesis provides a valid ground to denounce the current residential construction trend as inapt of preserving within the community as a sustainable form. The framework presented in this thesis is a combination of technologies that are most fit for a specific community like Palestine from a vast amount of passive and active Sustainable design strategies available. But the proposed mix of technologies cover ground the features of a sustainable building within a Palestinian social and economical backgrounds.
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