Palestine Polytechnic University

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Master Program of Architecture – Sustainable Design

IMPROVING HOUSING SUSTAINABILITY AND AFFORDABILITY IN PALESTINE: A DESIGN FRAMEWORK FOR APPLICATION

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Thesis submitted in partial fulfillment of requirements of the degree

Master of Architecture- Sustainable Design

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ABSTRACT

Housing sustainability and affordability in Palestine have become increasingly critical in recent decades. Given the complexity and multifaceted nature of the problem, a comprehensive approach is necessary to address the challenges, including a lack of public awareness, funding, political insecurity, and an ineffective regulatory framework. Despite the persistent shortage of sustainable and affordable housing options in Palestinian cities, it is crucial to adopt an alternative approach to housing provision. The primary goal of this study was to provide design considerations for appropriate and suitable sustainable housing, as well as to develop a design model for sustainable and affordable housing provision in Palestine. To achieve this goal, a comprehensive literature review was conducted worldwide to identify assessment indicators from the critical success criteria, success factors, challenges, and drivers for achieving sustainable affordable housing. Based on the previous findings, an assessment model with 70 indicators for housing sustainability and affordability performance was developed and validated to ensure that are considered during the design process. Since Palestinian cities are affected by both individual and regional factors, a more in-depth study was conducted in Hebron city. This study analyzed case studies to establish local design considerations in sufficient detail to ensure appropriate design responses for this specific region. This Thesis presented the findings of a scoping study that investigated the various factors influencing the design and delivery of affordable and sustainable housing in Palestine. This factor was identified at each stage of the design process and, if implemented, has the potential to significantly contribute to the provision of appropriate sustainable and affordable housing in Palestine. The findings of the research are intended to assist architects, engineers, and organizations in making decisions for housing design implementation that result in sustainable and affordable housing.

Keywords: Sustainable housing, Affordable housing, Assessment model, Success criteria, Success factors, Indicators, Housing design process, Design strategies.

تحسين استدامة الإسكان والقدرة على تحمل تكاليفه في فلسطين:
إطار تصميمي قابل للتطبيق

نـور علـي ابـوريـش

المستخلص

أصبحت استدامة المسكن وقدرة الأفراد على تَحمُّل تكاليفه في فلسطين محطً اهتمام كبير في السَّنوات الأخيرة، حيث تعتبر قَضيَّةً مُعَقدَةً ومتعدِّدة الجوانب، مِمَّا يَستدْعِي اِتِّبَاع نَهْج شامِل لمعالجة التَّحدِّيات التي تواجهها، بما في ذلك نقص الوعي العام والموارد الماليَّة وعدم الأمن السِّياسيِّ وعدم وجود إطار تنظيمي فَعَّال. نظراً لانعدام الخيارات المستدامة التي يمكن توفيرها بأسعار معقولة في قطاع الإسكان في المدن الفلسطينية، كان من الضَّروريِّ السَّعْي إلى تطوير نهج بديل للمعالجة هذه المشكلة. تهدف هذه الدراسة بشكل رئيسي إلى تقديم رؤية مستدامة ومبتكرة للمساكن الملاءمة لاحتياجات السُّكَّان الاجْتماعيَّة والاقْتصاديَّة المختلفة، بالإضافة إلى تطوير نموذج يساعد على تصميم المساكن في فلسطين لتكون مستدامة وبأسعار معقولة.

قامت هذه الدِّراسة بإجراء مراجعة شاملة لِلدِّراسات اَلتِي تمَّ تقديمها في دول مختلفة حول العالم بهدف تحديد المعايير الأساسيَّة وعوامل النَّجَاح والتَّحدِّيات والدَّوافع المتعلِّقة بِتحْقِيق الإسكان المستدام وبأسعار معقولة، وبناء على نتائج هذه الدِّراسات، تمَّ تَطوِير نَمُوذَج تَقيِيم مُكوَّن من 70 مؤشراً، يعمل النَّموذج على تَقيِيم اِسْتدامة المساكن وقدْرتهَا على تَحمُّل التَّكاليف. ولضمان استجابة نموذج التَّقْييم اَلذِي تمَّ تطْويره لِمتطلَّبات المنْطقة المحدَّدة في فلسطين، تمَّ تطبيق دراسة أكثر تفصيلا في مدينة الخليل من خلال تحليل الحالات الدِّراسيَّة من حيث استدامتها وقدرتها على تَحمُّل التَّكاليف بِالنِّسْبة لِلسُّكَّان في المدينة، بالإضافة إلى تحديد اعتبارات ومراحل تصميم المساكن المحلِّيَّة بِشَكل كَامِل ومفصَّل.

تسعى هذه الدِّراسة إلى تَسلِيط الضَّوْء على نتائج دراسة شاملة تبحث في العوامل المتنوعة التي تؤثر على تصميم وتطبيق الإسكان الميسر والمستدام في فلسطين، حيث تم تحديد هذه العوامل المختلفة اَلتِي تُؤثِّر على كل مرحلة من مراحل تصميم المسكن، والتي ستساهم بشكل كبير عند تطبيقها في تحقيق مساكن مستدامة وبأسعار معقولة في فلسطين، تساهم نتائج هذا البحث في مساعدة المهنْدسين المعْمارِيِّين والْمصمِّمين والْمؤسَّسات المخْتلفة فِي اِتِّخاذ قرارَات أَفضَل أَثنَاء عَمَليَّة تَصمِيم المساكن، بهدف تحقيق الاستدامة وتوفير أسعار معقولة.

DECLARATION

I declare that the Master Thesis entitled “Improving Housing Sustainability and Affordability in Palestine: A Design Framework for Application” is my own original work, and herby certify that unless stated, all work contained within this thesis is my own independent research and has not been submitted for the award of any other degree at any institution, except where due acknowledgment is made in the text.

Student Name: Nour Ali M. Abureesh

Signature:____________________________ Date:____________________

DEDICATION

This master's thesis is dedicated with profound love and gratitude to the cherished individuals who have shaped my life and supported me on this academic journey.

For my beloved late father, Dr. Ali Abureesh, sometimes our heroes don't make it to the end, but your wisdom continues to illuminate my path, and your memory is a constant source of strength.

To my lovely mom, Maysa, your boundless love and unwavering encouragement have been my source of strength.

To my dear husband, Hareth, your steadfast support, patience, and understanding have been my driving force.

To my gorgeous daughter, Mayar, You have made me stronger, better, and more fulfilled than I could have ever imagined.

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To my father-in-law and mother-in-law.

To everyone who supported me, even with a smile…

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List of Abbreviations

ICESCR	The International Covenant on Economic, Social, and Cultural Rights
GDP	Gross domestic product
COVID-19	Coronavirus disease 2019
HUD	The Department of Housing and Urban Development
LEED	Leadership in Energy and Environmental Design
BREEAM	Building research establishment environmental assessment method
GSAS	Global Sustainability Assessment System
GM	Green Mark
CEPAS	Comprehensive Environmental Performance Assessment Scheme
BEAM	Built Environmental Assessment Method
LEED-ND	LEED for Neighborhood Development
CASBEE	The Comprehensive Assessment System for Built Environment Efficiency
CASBEE-UD	CASBEE for Urban Development
GNI	Green Neighborhood Index
ECC	Earth Craft Communities
KPIs	Key Performance Indicators
COPRAS	The Complex Proportional Assessment
MCDM	Multi-Criteria Decision Making
SS	Social Aspects of Sustainability
ES	Economic Aspects of Sustainability
EN	Environmental Aspects of Sustainability
PMV	The Predicted Mean Vote
PPD	Predicted Percentage Dissatisfied
LCCA	Life Cycle Cost Analysis
WLC	Whole Life Cost

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CHAPTER 1

INTRODUCTION

1.1. BACKGROUND

The human right to housing has long been recognized by the international community, as evidenced by the International Covenant on Economic, Social, and Cultural Rights (ICESCR) and the Universal Declaration of Human Rights (Human Rights Commission, 2023). According to Pero et al. in 2016, housing is a human right as well as a basic human necessity. It is a fundamental requirement for individuals, communities, families, and nations not just for social, psychological, environmental, civic, economic, and physical aspects, but also for national development, both locally and worldwide (Gupta, 2022). In contrast, challenges in acquiring housing are associated with negative consequences such as limited access to basic housing services and health, poor educational outcomes for children, and social marginalization (Adabre, 2021). Therefore, all governments need to prioritize ensuring housing affordability (Golubchikov and Badyina, 2012).

Housing has become a crucial economic issue in recent years (Dorling, 2014), as it not only fulfills the basic human need for shelter but also contributes significantly to the economic growth and development of low-income families (Dewilde, 2022). A house is more than just a shelter for many low-income families, stable and affordable housing provides an opportunity for these families to break the cycle of poverty and improve their lives (Uwayezu and Vries, 2020). Access to quality housing has been shown in studies to improve health, academic achievement, economic possibilities, and community cohesiveness (Hernández, 2016). Failure to address this issue would have devastating consequences (Gupta, 2022).

1.1.1. Global housing conditions and problems

Despite widespread recognition of housing-related rights in legal systems at the international, regional, and national, the human right to adequate housing is violated more severely than any other right (Leckie, 2001). According to the World Bank, more than 1.6 billion individuals worldwide don't have adequate housing and have restricted ability to obtain essential services such as electricity, sanitation, and water (UN Human Rights Office, 2023). In developing countries, about 600 million people living in urban areas and 1 billion people living in rural areas reside in cramped housing with insufficient electricity, absence of proper sanitation, low-quality water, insufficient electricity, and no waste management services (Human Settlements Program, 2020). Furthermore, about 150 million individuals around the world are homeless, and 25% of the population lives in unsafe environments that endanger their safety, well-being and health, and success (Peppercorn, 2016). 15 million people are forcibly evicted each year (UN-Habitat, 2023). Access to adequate housing will be required by approximately 3 billion individuals by 2030, which accounts for around 40 percent of the global population, as estimated by UN-Habitat (Beard et al., 2016). That means there is a daily need for 96,000 new accessible and affordable housing units.

Housing is an essential human need, However, a scarcity of affordable housing for purchase or rent contributes to a global crisis of housing. Housing costs in most countries have risen much quicker than incomes as demand has outpaced supply (Dickler, 2021). Residential real estate is estimated to be worth 260 trillion US dollars - more than the global gross domestic product (GDP) several times over -, Homelessness is on the rise, while the value of real estate continues to rise, making it more difficult for those in greatest need of housing to obtain it (McRae, 2022). Millions of homes around the world are unoccupied (Kyama, 2023), often in disrepair, as the value of the homes rises and people sleep outside (McRae, 2022). Suppose urban migration and income growth continue at their current rates. In that case, more than 100 million low-income households will be forced to choose between living in inadequate housing and straining their finances to meet housing costs by 2025 (Reid, 2023; Woetzel, 2014). In a recent survey of 200 cities around the world, it was discovered that 90% of the cities' living expenses were too high to afford, while the average household income was less than one-third of the average house cost (Kallergis et al., 2018). Efforts towards developing more affordable housing are currently under way in many countries including the United States, Africa, Scotland, and India. Inadequate availability of land, materials, labor, and lending are all factors contributing to the housing crisis. This has increased costs and reduced profit margins for builders (Maye and Moore, 2020). COVID-19 is thought to have exacerbated the housing crisis by encouraging renters and buyers to seek larger living areas during closures (Chun and Grinstein-Weiss, 2020; Dubey et al., 2022).

Two of the most significant factors impacting quality of life are the quality and cost of one's housing. For most households, housing is both the most expensive and the largest investment

(Burchell and Listoken 1995). Increasing housing costs indicate that households have less money for spending on other essentials such as transportation, bills, groceries, and caring for their families. As a result, getting by is more difficult. Homelessness is also exacerbated by unaffordable housing (Kallergis et al., 2015). Workers with low incomes are forced to live farther from their jobs due to a lack of affordable housing, resulting in "long and costly commutes and reduced productivity" (Masterson, 2022). Individuals and families may face psychological, educational, and financial challenges if they are unable to afford housing or live in overcrowded and unhealthy conditions (Bratt, 2002; Dunn, 2000). When multiple substandard families congregate in one area, the impact of each housing challenge is amplified, with negative consequences (Aliprantis et al., 2013; Galster, 2005; Tighe, 2010). In addition, these concentrations of poverty are frequently associated with concentrations of ethnic and racial minorities (Beech et al., 2021; Guo et al., 2018; Quillian, 2012). As a result, getting by is more difficult. Homelessness is also exacerbated by unaffordable housing (Kallergis et al., 2015).

1.1.2. Housing affordability

Affordability is a worldwide issue that has a direct impact on people's well-being. It is estimated that around 80% of cities worldwide do not have affordable housing options for the majority of their population (Sparrentak, 2020). Affordability refers to the ability people to buy services and basic goods such as shelter, food, and healthcare. Housing affordability is broadly defined as households' ability to purchase or rent adequate housing without compromising their ability to meet essential living costs. Housing is insufficient if the cost threatens or jeopardizes the occupants' enjoyment of other human rights (Bąyefsky, 2000). The reality, however, is more complex, both in terms of the metrics used to measure housing affordability and the policies implemented to make housing more affordable (Adema and Plouin, 2021).

There is no international agreement on how to define or assess housing affordability, and no single measure completely covers the range of issues about households' ability to purchase an adequate home in an appropriate location at an affordable cost. During unresolved debates, researches on economic criteria for affordability assessment have received burgeoning attention. Different metrics could be utilized to assess the affordability of housing, each with advantages and disadvantages. These involve “housing price-to-income and expenditure-to-income ratios, residual income, housing quality, and subjective measures of housing affordability” (ÓECD, 2021).

Affordability is defined by the conventional price ratio criterion as the ratio of housing costs to incomes. This criterion defines affordable housing as housing expenses (basic utilities, maintenance, insurance, property taxes, and mortgages or rents) that are less than 30% of household budgets or income (Adabre, 2021; Anącker, 2019; Litmąn, 2023; Tighè, 2010). The Department of Housing and Urban Development (HUD) defines a cost burden as a household paying more than 30% of its income for housing (Habitat for Humanity, 2022). Many experts define affordability as spending less than 45% of household income on combined housing and transportation costs, given that households often face tradeoffs between these expenses (CNT, 2008).

Bógdon and Cąn (1997) argue that the measure of affordability based on the percentage of income does not consider the actual financial constraints that households face. Stone (1994) proposed an improved measure where residual income after housing expenses are deducted is the focus, and whether it is enough to cover other expenses or basic needs. This led to the term "shelter poverty" coined by Stone (2006), which assesses household income for covering housing and non-housing expenses while maintaining a decent living standard. However, these two affordability measures have a disadvantage as they do not account for the household's tastes or preferences. Therefore, additional indicators such as "quality-based" and "subjective indicators" have been proposed to better understand the determinants of housing satisfaction (Bogdon and Can, 1997). Nonetheless, these approaches have been criticized for being more difficult to compute and problematic to use than the price-to-income approach, as quality and affordability standards are inherently subjective, with perceptions and expectations varying widely across individuals, countries, and cultures, making cross-country comparison complicated (Adema and Plouin, 2021; Ezennia and Hoskara, 2019; Marissa, 2021).

Affordable housing is a critical policy concern in many countries around the world. Affordability issues are frequently caused by changes in household composition, population growth, aging, a scarcity of suitable construction land, a significant increase in demand relative to supply, and rising housing costs (Masterson, 2022). Low-income households typically devote the majority of their disposable income to housing expenses, which have outpaced overall inflation since 1996 (OECD, 2023). In order to address this complex issue, governments are implementing national or geographically targeted affordable housing programs (Azevedo et al., 2010). The goal of these programs is to provide subsidized housing to social groups whose housing needs cannot be met by the market (Czischke and van Bortel, 2018; Zheng et al., 2020).

Despite the establishment of several affordable housing programs, there is dissatisfaction about whether low-income households' housing affordability has gotten better (Reid, 2023). According to Charoenkit and Kumar (2014), increased spending on non-housing issues has harmed housing affordability. This results in a massive waste of public resources (Mulliner et al., 2013). Furthermore, housing deficits can be either qualitative or quantitative (Masterson, 2022).

Affordable housing should not be described as low-cost housing, because low-cost housing can result in poor building quality, such as insufficient space or poor building materials. Low-cost housing will indirectly increase householders' monthly living expenses. For example, inefficient building materials will raise electricity, gas, and maintenance bills, not to mention the negative effects of inefficient designs and materials on residents' health and the surrounding environment (Wells et al., 2020). This fact makes lowering housing costs a serious issue. Such issues highlight the importance of finding innovative design solutions that reduce housing costs without sacrificing quality (Itma, 2019). Aside from economics, affordable also means physically appropriate and suitable for human habitation: in other words, an overcrowded and unhealthy house cannot be considered affordable (Habitat for Humanity, 2022). Rather, other sustainability issues such as housing design, employment opportunities, transportation routes, location, and neighborhood environment should be considered (Dewita et al., 2018).

According to Moore and Doyon (2023), sustainability is a foundation of housing affordability because it reduces spending on health care, transportation, and energy bills. Therefore, in addition to building solutions (health safety, ecological, environmental, water efficiency, energy efficiency, and resource), sustainable housing policies should address affordability, social justice, and the economic and cultural impacts of housing (Golubchikov and Badyina, 2012). Better public amenities and services can also contribute to a strong sense of belonging (Chiu, 2009). As a result, incorporating sustainability into affordable housing is critical to improving housing affordability over time.

Sustainability is a concept that involves decreasing greenhouse gas emissions, improving air quality by utilizing substances that are non-toxic, using less energy, and reducing natural and environmental resource impact. Even if certification is not the ultimate goal, the development of certification systems and evaluation tools will assist in analyzing the performance level of affordability and sustainability based on specific standards customized to local requirements within a country. It is critical to examine the social, economic, and environmental concerns, as well as affordability while examining the concepts of sustainable and affordable housing.

Furthermore, the housing sector consumes the most energy and contributes significantly to worldwide emissions of greenhouse gases. In Palestine, a developing country, 60% of electricity is used to power homes (PCBS, 2021). The housing sector's resource consumption pattern is harmful to society, economy, and the environment. If left unchecked, the consequences may be increased. Building energy consumption can be reduced by up to 80% by implementing appropriate sustainability practices. Hence, the global demand for sustainable housing has become essential for enhancing the life quality of middle and low-income households while also protecting the environment (Gólubchikov and Bądyina, 2012). As a result, It is critical to bridge the gap between sustainable and affordable housing (Adabre, 2021).

1.1.3. Sustainability Achievement in Affordable Housing

According to the World Green Building Council, sustainable and affordable housing is defined as "resilient housing that is adaptable to climate change, respects and protects the lifecycle vision of meeting current and future needs, while encouraging sustainable choices and enhancing the quality of life, all within an economically accessible manner" (WorldGBC, 2021).

1.1.3.1. Economical sustainability in affordable housing

The primary goal of affordable housing applications is to increase low-income households' housing affordability. Economic sustainability in affordable housing requires taking into account the initial acquisition cost, house operation cost, transportation cost, and future transportation cost (Chąn and Adąbre, 2019; Isalóu et ął., 2014). Reduced the costs of energy and transportation allow low-income households to spend more of their little money on non-housing requirements (Gólubchikov and Bądyina, 2012; Ibèm, 2011). This could both provide more available people for employment and increase employment opportunities (Gan et al., 2017). To ensure that these initiatives may be developed indefinitely, affordable housing should take into account the economic viability of developers. While developers can utilize cost-cutting tactics (such as using locally accessible materials and processes), developers must have consistent financial incentives in order to ensure financial sustainability (Adabre, 2021). Finally, according to Pullen et al. (2010), The desirability of affordable housing (how programs fulfill and surpass consumers' expectations) is an essential economic sustainability measure (Adabre, 2021).

1.1.3.2. Environmental sustainability in affordable housing

Reducing greenhouse gas emissions and tackling climate change are the main focuses of environmental sustainability. Implementing green technologies, sustainable materials, and renewable energy and resources can help achieve these goals. Environmental sustainability indicators such as footprint reduction, a healthy and comfortable indoor environment, efficient waste management, durability and reliability, effective resource utilization, water efficiency, and energy efficiency can help reduce biodiversity loss (Fóhry and Wèlls, 2013). For low-income households, environmental sustainability is crucial as their budget is limited and their physical and mental health is likely to be negatively impacted without financial assistance. Special attention must be paid to the disaster resistance of affordable housing in developing countries that are more vulnerable to natural disasters, and proper land use planning is necessary to prevent settlement in risky areas. Mixed land use is highly recommended for affordable housing as it improves accessibility, lowers transportation costs, and aids in efficient land use (Gan et al., 2017). Incorporating adaptability and flexibility in affordable housing is a strategy for sustainable affordable housing (Turcotte and Geiser, 2015). Adaptability allows for meeting residents' changing needs while avoiding environmental disruption and increased resource consumption (Pullen et al., 2010). Access to green public spaces is a significant factor for a healthy and comfortable living environment, as it has many beneficial effects on health and well-being. However, it is often overlooked in affordable housing programs (Araji and Bahjat, 2021).

1.1.3.3. Social sustainability in affordable housing

In the field of affordable housing, social sustainability revolves around ensuring equitable distribution and utilization of housing resources, emphasizing both horizontal and vertical equity (Chiu, 2009). It advocates for an open distribution process in which all eligible low-income residents can actively participate (Pullen et al., 2010). The growing demand for environmentally friendly housing serves as a barometer for the second aspect of social sustainability performance.

This can be accomplished through increased public awareness of the benefits of living in sustainable structures and supportive policies (Fatourehchi and Zarghami, 2020). Because they are publicly funded, affordable housing initiatives provide excellent opportunities to demonstrate the benefits of sustainable living and construction (Telma, 2023). The quality of housing and the surrounding neighborhood environment have a direct connection to the aspect of social sustainability performance (Gan et al., 2017). Affordable housing programs must meet the diverse needs of their residents (Ibem and Azuh, 2011). Furthermore, it is critical to incorporate local cultural elements and aesthetic values into housing design (Muazu and OKTAY, 2011).

Pullen et al. (2010), for example, proposed that affordable housing programs, particularly in terms of dwelling size, gain acceptance from surrounding communities and local governments. The availability of various housing types can promote community interaction and encourage better social relationships (Winston and Eastaway, 2008). Community involvement is emphasized in affordable housing programs, providing benefits not only in terms of improved social connections but also in addressing residents' current and future needs (Ross et al., 2010).

Ensuring tenure security, effective property maintenance, and management are also critical in instilling a sense of belonging and stability in the community (Araji and Bahjat, 2021). Turcotte and Geiser (2015), on the other hand, emphasize the importance of addressing worker health and safety concerns during building maintenance and management, as well as fair compensation practices (Gan et al., 2017).

1.2.RESEARCH SCOPE AND PROBLEM IDENTIFICATION

Currently, the Occupied Palestinian Territory is divided into two distinct regions. The West Bank consists of the governorates of Hebron, Bethlehem, Jerusalem (East Jerusalem), Jericho, Ramallah and Al-Bireh, Salfit, Qalqiliya, Nablus, Tulkarm, Tubas, and Jenin and covers an area of 5,661 km^2. The Gaza Strip, on the other hand, is located near the Sinai Desert, has a land area of 362 km^2, and is located on the eastern edge of the Mediterranean Sea. It is bounded to the south by Egypt and to the west by the Mediterranean Sea (Habitat III, 2014).

In 1993, a peace agreement was signed in Oslo that granted Palestinians temporary control over divided areas of their land. In the West Bank, there are three zones: A, B, and C. Area A is under

Palestinian security and civil control and includes Palestinian city centers, except for Hebron Area B includes Palestinian inhabited regions that are located not within Area A and are under Palestinian civilian control, with security management shared by Palestinians and Israelis. Nonetheless, Israel retains only the power to enter Area B at its discretion to conduct "security operations". Israel has civil and security control over Area C, which accounts for 61% of the West Bank. consequently, land lots are becoming increasingly expensive and limited (Hantash and Salah, 2009). As a result of this relatively peaceful period, the majority of Palestinian cities (zone A) have undertaken a wide range of housing projects, resulting in an increase in normal density and atypical urbanization in residential areas (Itma, 2014). Primarily due to movement and development restrictions and limitations.

1.2.1. Housing challenges in Palestine

Given the region's complex political, economic, and social conditions, Palestine's housing situation presents a multifaceted challenge that requires a comprehensive approach that considers the Palestinian people's unique needs and challenges. Political threats, physical impediments, legal and administrative constraints, and intentional demolition of existing infrastructure all present unique challenges to the Palestinian housing sector. Furthermore, high unemployment and limited opportunities impede the Palestinian territories' economic development. Housing production is restricted to for-profit and non-profit private sector corporations funded by donors, and housing finance mechanisms are still in their early stages. The problem is exacerbated by high bank loan interest rates and a lack of clear guidance frameworks.

Housing affordability is another significant issue in the Palestinian housing sector, which is exacerbated by the region's complex conditions. Notably, the West Bank faces significant challenges in providing affordable housing to its residents, particularly those with low and middle incomes. Despite a rapidly growing population, there is an insufficient supply of residential units to meet the population's needs. Housing strategies and projects aimed at vulnerable populations, particularly low-income individuals, are extremely rare. Furthermore, low-income housing financing programs are limited, restricting access to suitable housing and necessitating self-financing (Itma and Wasim, 2023). With a monthly income of $1,000 and a housing unit price of USD 60,000 in 2015, affordability remains a major concern for approximately 60% of the

Palestinian population. The Palestinian private housing market provides approximately 15,000 units per year, but only 5,700 construction permits are issued each year, resulting in nearly 10,000 units per year of unmet demand (Quartet Office, 2015).

Housing costs are relatively high in Palestine due to two main factors. Firstly, there is a constant increase in demand which drives up prices. Secondly, the price of raw materials and land continues to rise (HUDC, 2016). Both of these factors make it difficult for the housing sector to provide Palestinian families with affordable housing. Construction Cost Indices for Residential Buildings in West Bank have risen by 20% in 2023 compared to 2014, exacerbating the problem (PCBS, 2023). The Palestinian housing sector consumes 45 percent of all electrical energy and 21 percent of total energy. Furthermore, in 2014, this sector accounted for 42.2 percent of total water consumption (PCBS, 2015).

Moreover, some areas' housing conditions are deplorable, with inadequate infrastructure, a lack of basic services, and overcrowding. This is due to a shortage of resources, as well as challenges to maintaining and improving existing housing.

1.2.2. Sustainable Housing in Palestine

The construction industry in Palestine faces significant challenges in implementing sustainable practices due to a variety of factors such as insufficient public awareness, political instability, a lack of funds, and an inadequate regulatory framework. The primary sustainability challenges in the housing sector include ineffective use of renewable energy sources, non-existence of rainwater collection and reuse systems, use of non-eco-labeled building materials, inefficient domestic waste recycling, insufficient public transportation and cycling facilities, limited green spaces, unaffordable housing, insufficient community services, and a focus on cost and aesthetics over sustainability. These factors limit the sector's ability to adopt sustainable practices, and it is critical to address these issues in order to promote sustainable development in the Housing construction sector (Hussein et al., 2010).

As a result, it is critical to address the issue of affordable housing while also creating a healthier environment for Palestinians.

1.3. RESEARCH SIGNIFICANT

Affordability and sustainability in housing can be challenging to achieve, but they are critical for a well-being housing environment. Proper housing planning and architectural design are essential factors in reducing costs and ensuring sustainability (Bragança et al., 2014). One approach to achieving this balance is to use an integrated design approach that establishes sustainability standards and takes life-cycle cost analysis into account (Subramanian, 2005; Tabrizi and Sanguinetti, 2015).

To achieve sustainable and affordable housing in Palestine, innovative approaches that reduce construction costs while prioritizing building qualities and interpersonal interactions are crucial. Architects have an essential role in directing affordable design toward a more sustainable approach. It is critical to remember that affordable housing is not necessarily low-cost housing. As a result, sustainability principles should be incorporated into affordable housing designs in order to achieve a balance between affordability and sustainability.

1.4. RESEARCH AIM AND OBJECTIVES

This research aims to develop a comprehensive design framework that can be utilized in Palestine to provide sustainable and affordable housing solutions. The framework encompasses various aspects of sustainability such as environmental, social, and economic factors, along with affordability, which are tailored to the specific requirements and limitations of the local environment of Palestine. The primary goal is to enhance the living standards of Palestinian communities by offering practical and scalable solutions for sustainable and affordable housing. To accomplish this goal, the research outlines the following objectives.

1. Determine the performance criteria, factors, and indicators for housing sustainability and affordability.
2. Developing and validating a Housing Sustainability and Affordability Assessment Model. The evaluation tools have the general advantage of assisting in the evaluation of building sustainability and affordability.
3. Application the Assessment Model on specific Case Studies at the local level, and modify it accordingly to suit the unique housing conditions present in Palestine.

4. Reviewing design strategies for delivering success factors and indicators of affordable and sustainable housing in Palestine.
5. Present the findings as design strategies in all stages of housing design process within a framework of sustainable and affordable housing design.

1.5. RESEARCH QUESTIONS

1. What are the essential success criteria and factors that contribute to the performance of sustainable and affordable housing?
2. How can determine if housing is sustainable and affordable? And What methods can be used for assessment?
3. What are the challenges and barriers to providing affordable and sustainable housing in Palestine?
4. What are the design strategies that can be implemented to achieve sustainable and affordable housing in Palestine?

1.6.RESEARCH LIMITATIONS

Regardless of the study's relevance, some limitations should be mentioned.

- Conducting a comprehensive survey of specialists to explore the feasibility of generalizing research findings regarding housing affordability in Palestine faced a significant challenge due to the limited availability of experienced professionals and specialists with domain expertise in the field.
- The housing sustainability and affordability assessment model uses a set of assumptions and index scores. However, the model's use of simplified options may understate the complexities involved, so it's essential to consider the model's limitations while interpreting the results.
- The Hebron Municipality did not provide the necessary plans and drawings of buildings, making it difficult to identify and interview the designers responsible for their construction. This lack of cooperation presents a challenge in conducting proper assessments and evaluations of these structures.
- Some homeowners have refused to conduct indoor environmental assessments or collect accurate data.

- The literature on housing affordability and sustainability in Palestine is scarce and needs further exploration.

1.7. RESEARCHSRCH STRUCTURE

The first part is a conceptual study of the thesis, which is discussed in Chapter 1. It provides an overview of the research and identifies the conceptual model upon which it is based. The conceptual study is mainly concerned with global housing conditions and problems, housing affordability, affordable housing sustainability, and Palestine's current situation. After discussing the research background, it presents the problem identification, research significance, aim and objectives, research questions, and limitations. The chapter concludes with a comprehensive overview of the research structure.

The second part is the theoretical study in the second chapter, which was devoted to the required literature review and definitions. The second chapter begins with a sequential review of housing affordability measurement and green building rating systems for assessment. The chapter concludes with the development of a model to evaluate the performance of housing sustainability and affordability.

The third part is practical study, which is presented in chapters 3, 4, and 5 and is the thesis's core. The research methodology is presented in Chapter 3, and the validation of the sustainable and affordable housing assessment model is discussed in Chapter 4, where three cases of sustainable and affordable housing are studied and discussed. In Chapter 5, a sustainable and affordable housing assessment model was adapted to local contexts by analyzing the economic and environmental issues of two housing projects in Hebron, Palestine, and employing the sustainable affordable assessment model to evaluate their sustainability and affordability in order to identify existing issues and problems. Chapter 6 discusses the design strategies for delivering success factors and indicators of sustainable and affordable housing in Palestine.

The fourth part is the final chapter includes the current study's final reflections and recommendations, which present the findings of a scoping study that examined the various design factors and strategies that will influence the delivery of sustainable and affordable housing in Palestine during the project design stages.

CHAPTER 2

THE ASSESSMENT OF HOUSING SUSTAINABILITY AND AFFORDABILITY – Developing an Assessment Model

2.1. INTRODUCTION

The previous chapter discussed the background study, as well as the problem identification, research aim, objectives, significant, limitations and a summary of the research process for the study. This chapter includes a literature review on achieving sustainable and affordable housing through the Design stage, which necessitates a review of success criteria, success factors and indicators to achieving sustainability in affordable housing.

For adequate evaluation of the achievement of housing sustainability and affordability goals, a set of standard assessment criteria or indicators must be identified. These indicators or criteria serve as the standards or principles that allow judgment about project success to be made (Lim and Mohamed, 1999), guiding construction professionals and policymakers in appropriately allocating resources (Chàn et al., 2002). Furthermore, assessment criteria are required for comparing the degree of performance of similar projects (Róbert and Chąn, 2017). In the literature, numerous assessment criteria have been proposed. Whereas general assessment criteria are relevant to all construction projects (Atkinsón, 1999; Chąn and Chąn, 2004), specific assessment criteria are needed for assessing the sustainability and affordability of housing (Adabre and Chan, 2020; Ezennia and Hóskara, 2019; Saidu and Yeom, 2020).

2.2.HOUSING AFFORDABILITY MEASUREMENT

Housing affordability measurement can shape perceptions of the scope of the problem and help determine where housing investment should and should not be directed. As a result, they must present an accurate picture of reality. In various contexts around the world, a variety of affordability measures have been developed and implemented (McCórd et ął., 2011; Mulliner, 2012). These measures provide a comprehensive understanding of housing affordability and accessibility for individuals and families. Housing price-to-income and expenditure-to-income ratios aid in determining the financial burden of housing costs on households based on their income levels. Residual income considers the amount of money left after deducting necessary expenses, indicating the ability to afford housing. Furthermore, housing quality measures assess the condition and suitability of housing units, whereas subjective affordability measures capture people's perceptions and experiences with their ability to afford suitable housing.

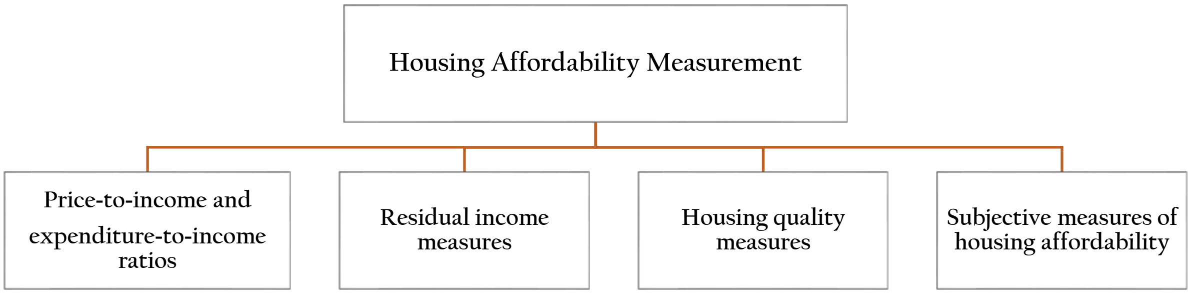


Fig. 2. 1: Housing Affordability Measurement (OECD, 2021)

2.2.1. Price-to-income and expenditure-to-income ratios

Housing affordability measures, such as the owner-occupier house price-to-income ratio and the rent-to-income ratio for renter households, are based on assumptions about how much should be paid for housing in relation to household income (Mulliner, 2012; Whitehead and Williams, 2017). These ratios offer a high-level view of the relationship between price and income fluctuations in markets or countries, indicating whether housing becomes more or less affordable over time (OECD, 2021). Individual household housing expenditures are measured using expense-to-income ratios, which identify vulnerable populations, regions, as well as income levels. The 30% affordability threshold and the housing overburden rate are widely accepted affordable housing targets, but these limits are arbitrary and do not apply to all income levels (OECD, 2021).

2.2.2. Residual income measures

Residual income measures seek to determine a household's income after housing expenses, with a focus on non-housing expenses (OECD, 2021). The shelter poverty indicator determines whether a household's disposable income is sufficient to cover a specified basket of non-housing expenses (Stone et al., 2011; Stone, 2006). These measures are useful for identifying low-income households, but they have drawbacks such as reliance on temporary income (Bogdon and Can, 1997; Mulliner et al., 2013), the lack of a simple method for calculating non-housing expenses (Ezennia and Hoskara, 2019; Gabriel et al., 2005), and the potential misdiagnosis of the general cost of living issues as housing issues. They may also necessitate the collection of extensive additional data (Ezennia and Hoskara, 2019; Gabriel et al., 2005).

2.2.3. Housing quality measures

Housing quality indicators aid in determining affordability throughout assessing overcrowding and deprivation rates. These measures are most relevant to the lower-income distribution because lower-income households are more probable to live in substandard housing. However, the most important characteristics for assessment differ across nations and cultures. Due to the negative environmental effects of urban sprawl, interpreting dwelling size indicators may necessitate trade-offs between social and environmental goals (OECD, 2021).

2.2.4. Subjective measures of housing affordability

Housing satisfaction can be improved by incorporating subjective affordability measures. In countries where households allocate more income to housing, there is a high level of satisfaction with good, reasonably priced housing. However, levels of satisfaction may differ depending on country, culture, and personal beliefs (OECD, 2019). In countries where homeowners have already paid off their mortgages, housing affordability metrics may be misleading. Affordability issues can be revealed by housing quality indicators, with many outright-owner households living in low-quality homes due to financial constraints (OECD, 2021).

2.3. GREEN BUILDING EVALUATION

Green building rating systems set performance thresholds to evaluate construction projects, including housing. These systems can be used by policymakers for baselining, benchmarking, and decision-making (Shan and Hwang, 2018), as well as by project teams to meet or exceed targets (Mattioli et al., 2018). Globally, rating systems such as LEED, BREEAM, GSAS, GM, CEPAS, and BEAM have been developed (Adabre, 2021). Green building rating systems establish specific evaluation criteria for various schemes (such as data centers, schools, homes, and hostels). Among green building rating systems, energy is the most significant criterion (Shan and Hwang, 2018). Still, researchers have criticized these systems for taking an insular viewpoint when assessing sustainability, ignoring social and economic aspects (Awadh, 2017; Zuo and Zhao, 2014). They are frequently used in stand-alone building assessments that are based on an initial environmental evaluation and ignore variations in occupancy and operational performance (Adabre and Chan, 2020; Fenner and Ryce, 2008). Despite their efforts to reduce environmental impact, green building rating systems fail to consider the sustainability indicators of economic and social aspects (Adabre, 2021).

Green building rating systems can aid guide sustainable environmental goals in affordable housing, nevertheless, economic and social aspects must also be considered for sustainable and affordable development (Adabre and Chan, 2020). Ye et al. in 2015 have proposed incorporating assessment criteria, such as the Building Sustainability Score, which covers every aspect of the construction lifecycle, into Green building rating systems. Other criteria identified by Ye et al. in 2015 include end-user and stakeholder satisfaction, as well as lower commuting costs. Security and safety are frequently overlooked aspects of social sustainability (Haider et al., 2018). As a result, green building rating systems such as BREEAM Communities, LEED-ND, Cascadia Scorecard, Green Star Communities, CASBEE-UD, GNI, ECC, and so on, have evolved to include neighborhood sustainability assessment tools. These tools offer an expanded viewpoint on assessing the sustainability of buildings and their surroundings. The importance of these tools is demonstrated by the fact that the majority of them are widely used in a variety of contexts or countries (Attia, 2013). However, there are issues with the selection of criteria as well as the subjectivity of weighting and scoring , making it hard to develop a one-size-fits-all tool for assessing sustainable and affordable housing (Haapio, 2012; Sharifi and Murayama, 2013).

In 2019, Chan and Adabre published a study on the criteria for assessing sustainable and affordable housing. Social sustainability criteria were categorized as "stakeholder satisfaction," "household satisfaction," and "quality-related." "Housing operation costs, energy and water efficiency measures, and housing costs" were all considered among the criteria of economic sustainability. Despite they presented a thorough set of both quantitative and qualitative affordable housing assessment criteria, their study focused mostly on assessment criteria of sustainability.

2.4. THE ASSESSMENT OF HOUSING AFFORDABILITY AND SUSTAINABILITY

The topic of project success is becoming increasingly popular in the field of project management. Two primary components determine project success that are project success criteria and factors. Success criteria are measurable standards, principles, and benchmarks that help assess a project's success, whereas success factors are a collection of independent conditions, circumstances, and elements that can enhance the probability of success. Success criteria are used for evaluating success, whereas success factors aid in achieving project objectives (Ika, 2009; Lamprou and Vagiona, 2018; Müller and Jugdev, 2012).

2.4.1. Success criteria for Sustainable and Affordable Housing

Critical success criteria, also known as Key Performance Indicators (KPIs), constitute significant criteria for determining project success (Sanvido et al., 1992). These KPIs reflect the project targets and assist developers and governments in effectively allocating resources to achieve these objectives (Adabre, 2021; Chua et al., 1997; Kylili et al., 2016). Although the project management triangle of quality, cost, and time is widely accepted as a key success criterion, some success criteria must be project-specific (Atkinson, 1999; Chan and Chan, 2004). According to several studies, the project management triangle standards are insufficient, necessitating the need for comprehensive identification of critical success criteria in the housing construction industry for project control and monitoring (Al-Tmeemy et al., 2011; Baccarini, 1999; Lim and Mohamed, 1999; Pinto and Pinto, 1991).

Lim and Mohamed investigated project success criteria from various stakeholder perspectives in 1999 and classified them into macro and micro perspectives. However, their classification revealed overlap between categories and failed to provide detailed criteria for construction companies or contractors. In the same year, Baccarini classified project success criteria based on the goal, objectives, inputs, and outputs as product success or project management success. While keeping Baccarini's classification, Al-Tamimi in 2011 identified three types of project success: project management success (commitment to quality, goals, budget, and schedule), product success (technical specifications, functional requirements, customer satisfaction), and market success (competitive advantage, reputation, market share, profits, and revenues) (Al-Tmeemy et al., 2011; Baccarini, 1999; Lím and Mohamed, 1999).

The success criteria for affordable housing are often narrowly considered, with an emphasis on cost affordability (Mullíner et al., 2013). This is due to unresolved debates and the fact that the Price-to-income ratio approach, which is widely recognized as a measure of affordability in international housing policies, has been criticized for failing to consider residual income and housing quality (Bogdon and Can, 1997). The shelter poverty approach, proposed by Stone in 1994, also rely on transient income and does not reflect long-term affordability situations.

While price affordability is vital criteria for success in affordable housing, it is not the only one. In 2006, for example, Seèlig and Phíbbs discovered that while housing price was a major consideration for renters, priority was given to dwelling features and other external factors, even if these priorities increased the housing rental cost. These essential cases demonstrate that price affordability is not the end of affordable housing and that focusing exclusively on this criterion may result in unmet client needs (Isalóu et al., 2014). Mullíner et al. in 2013 argue that, in addition to economic assessment criteria, "the environmental and social sustainability of housing must be taken into consideration" to improve community sustainability and life quality. Twenty-one criteria were used to evaluate an area's affordability using the COPRAS method of Multi-Criteria Decision Making (MCDM), but it failed to distinguish critical success criteria from critical success factors. Only five of the twenty-one criteria are critical success criteria: "house price in relation to income, rental costs in relation to income, safety (crime), housing quality, and energy efficiency". The remaining, on the other hand, are success factors (Adabre, 2021; Lim and Mohamed, 1999). Similarly, Gan et al. in 2017 sought key sustainability performance indicators (KSPIs) from three stakeholder groups: academics, government, and developers. From 42 affordable housing sustainability indicators, 24 KSPIs were identified conclusively using fuzzy set theory and variance analysis. In 2019, Chan and Adabre identified and validated 21 critical success criteria for developing sustainable and affordable housing. These criteria were divided into six categories: "household satisfaction, stakeholder satisfaction, housing operation cost, time measurement, location affordability, and quality-related performance". The findings were confirmed by industry and academic experts, highlighting the importance of taking these factors into account in the sustainable development of affordable housing (Adabre, 2021; Adabre and Chan, 2019a; Chan and Adabre, 2019).

The study by Chan and Adabre effectively differentiates between critical success criteria and critical success factors, which have been confused in previous studies. A set of critical success criteria for achieving sustainable and affordable housing was developed based on Chan's verified critical success criteria for sustainable and affordable housing as well as a comprehensive analysis of various studies on the evaluation and attainment of sustainable and affordable housing, including studies that differentiate between success criteria and success factors. However, some of the critical success criteria identified by Chan and Adabre are shared by multiple factors. The life cycle cost of housing facilities, for example (CSC08), includes both maintenance expenses (CSC09) and the costs of water and energy bills (CSC10), both of which can be considered critical success factors in reducing life cycle costs. Furthermore, efficient resource utilization, such as energy and water efficiency, is a critical success factor of environmental sustainability. As a result, it is critical to combine criteria that are related to the same goals and factors in order to ensure a thorough analysis of the project's overall performance. Table 2.1 presents a set of 19 critical success criteria for sustainable and affordable housing that have been identified. The criteria were carefully chosen based on their significant role in ensuring the success of sustainable and affordable housing.

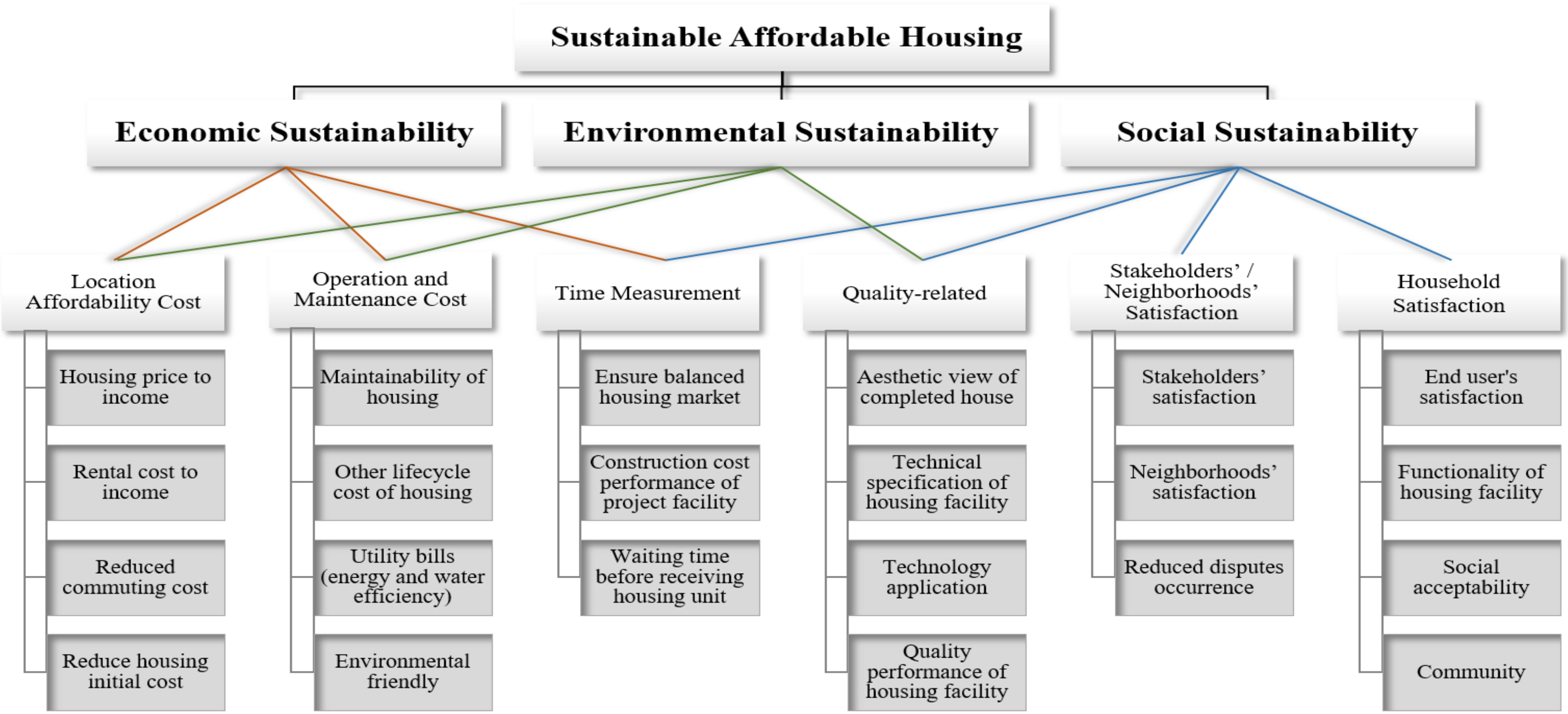


Fig. 2. 2: Sustainability Assessment Model Conceptual Framework for Affordable Housing (Adabre & Chan, 2020, edited by researcher)

Table 2. 1: Potential Critical success criteria for Sustainable Affordable Housing

No.	Potential Critical success criteria for sustainable and affordable housing	Refrences
01	Housing cost to income	(Adabre and Chan, 2020; Araji and Bahjat, 2021; Ezennia and Hoskara, 2021 ; Gan et al., 2017; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011; Pullen et al., 2010; Said et al., 2015; Saidu and Yeom, 2020; Wallbaum et al., 2012)
02	Rental cost to income	(Adabre and Chan, 2020; Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011; Pullen et al., 2010; Said et al., 2015; Saidu and Yeom, 2020; Wallbaum et al., 2012)
03	Reduced commuting costs	(Adabre and Chan, 2020; Chohan, 2022; Ezennia and Hoskara, 2021; Mulliner et al., 2013)
04	Reduce the housing initial cost	(Araji and Bahjat, 2021; Nair and Vergragt, 2005)
05	User satisfaction with facilities	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Chohan, 2022; Ezennia and Hoskara, 2021; Mulliner et al., 2013)
06	Housing facility functionality	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Mulliner et al., 2013; Saidu and Yeom, 2020)
07	Community and Neighborhood satisfaction	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017)
08	Social acceptance	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021, 2021; Gan et al., 2017; Itma and Wasim, 2023; Nair and Vergragt, 2005; Pullen et al., 2010; Saidu and Yeom, 2020)
09	Stakeholders’ and project team satisfaction	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chan and Adabre, 2019)
10	Reduced occurrence of disputes	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chan and Adabre, 2019)
11	Housing facility marketability	(Araji and Bahjat, 2021; Gan et al., 2017)
12	Time spent waiting for a housing unit	(Araji and Bahjat, 2021; Chan and Adabre, 2019)
13	Housing maintainability (cost of maintenance or retrofitting)	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Chohan, 2022; Gan et al., 2017; Khan and Fang, 2020)
14	housing lifecycle costs (energy and water Efficiency)	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Ezennia and Hoskara, 2021; Saidu and Yeom, 2020; Wallbaum et al., 2012)
15	Environmental friendliness	(Adamec et al., 2021; Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Manganelli et al., 2019; Emma Mulliner and Maliene, 2011; Saidu and Yeom, 2020)
16	Aesthetic view of the completed house	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Ezennia and Hoskara, 2021)
17	Technical specifications of a housing facility	(Araji and Bahjat, 2021; Chan and Adabre, 2019)
18	Technology transfer	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Chohan, 2022; Ezennia and Hoskara, 2021; Pullen et al., 2010)
19	Housing facility performance quality.	(Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021; Khan and Fang, 2020)

2.4.2. The stages of success in providing sustainable affordable housing

When assessing various stages, the stages to success of a product may be different. For instance, in the case of affordable housing, the stages to success begin with assessing the needs of the intended users, followed by project management, and finally product success (Pheng and Chuan, 2006). Project management entails managing the process to meet needs that extend beyond the needs of the intended users, resulting in successful projects (Cooke-Davies, 2002). However, measuring project management success comes before measuring product success because it is used primarily for monitoring and control.

Project success in affordable housing can be defined as both project management and product success. The effects of the final product determine product success, which should ensure household and project team member satisfaction with the completed house (Torbica and Stroh, 2001). Reducing life-cycle costs and public-sector management costs is critical to the success of a housing facility (Adabre, 2021; Ahadzie et al., 2008). The economic viability of housing is also determined by the cost of housing, rental costs, and transportation costs in relation to household income (Mulliner et al., 2013). Finally, the marketability of the housing facility is critical to its success (Al-Tmeemy et al., 2011).

Project management success is defined as achievement at the delivery or procedure stage of a sustainable and affordable housing project (Ahadzie et al., 2008; Al-Tmeemy et al., 2011; and Atkinson, 1999). At project completion, the quality of sustainable and affordable housing is directly related to household satisfaction, which is a product success factor (Al-Tmeemy et al., 2011). Integrating product and project management success demonstrates how project management success can influence product success (Adabre, 2021).

Finally, project success can be determined by the amount of time applicants must wait before being assigned to a housing unit and how an affordable housing project contributes to sustainable development (Ibem and Azuh, 2011). Furthermore, combining project management and product success results in successful sustainable and affordable housing availability to meet household needs.

The success criteria for providing sustainable and affordable housing, which identified and presented in table 2.1, have been classified into seven categories based on the stages of success, in addition to the criteria categories reviewed in previous studies. These categories were developed to account for the high correlation between some of the critical success criteria that were identified. Additionally, they assist in the evaluation process, enabling a more comprehensive understanding and analysis of the results. The classifications are as follows:

1. Economic viability and housing affordability
2. Household satisfaction
3. Project team and community satisfaction
4. Marketing and the waiting time
5. Housing life-cycle costs
6. Environmental effectiveness
7. Quality of housing performance

Each of these categories have a role in determining the success of sustainable and affordable housing projects. Economic viability and housing affordability are critical for ensuring project financial viability. Household satisfaction, as well as project team and neighborhood satisfaction, are critical in ensuring the well-being of residents and promoting a sense of community. Environmental effectiveness is vital for long-term sustainability and the carbon footprint reduction. Marketing and waiting time are crucial for attracting potential residents and keeping demand consistent. Housing life-cycle costs are key in ensuring the long-term viability of housing projects, and housing performance quality is critical in ensuring the comfort and safety of residents.

2.4.3. Success Factors for Sustainable and Affordable Housing

In order to achieve the goal of access to sustainable and affordable housing, various sets of success factors are used in housing policies (Peró et al., 2016). Some of the success factors, however, may result in "contrasting objectives and goals, with loss of efficiency and potentially wider negative effects on the economy" (Peró et al., 2016). Evidently, there are disagreements about the criticality of success factors when it comes to identifying a list of critical success factors for aspects of sustainable affordable housing markets (Adabre, 2021).

According to Rockart (1982), critical success factors are aspects of an activity that must produce favorable results in order for a manager to meet specific objectives. These elements are critical to project success and have evolved over time, giving rise to the concept of critical success factors (Boynton and Zmud, 1984). Because of evolving approaches in this domain, the housing affordability situation has become increasingly complex. To address these issues, a series of steps must be taken in order to direct housing programs toward major issues and create sustainable and affordable communities (Ezennia and Hoskara, 2021).

2.4.3.1.Success factors for the social (cultural) aspect of sustainability performance

Housing that is both affordable and socially acceptable is critical to fostering positive social conditions, community cohesion, and social inclusion. Extensive research has identified several key factors that contribute to socially acceptable housing, including size, function, affordability, safety, aesthetics, and cultural needs (Muazu and OKTAY, 2011). To achieve the social goals of affordable housing, adequate housing quality has to be ensured, spatial segregation needs to be addressed, and wealth and income disparities must be reduced (Wiedmann et al., 2016). However, according to Makinde in 2017, in Nigeria, socio-cultural factors such as safety are frequently neglected during the location and design of housing units, resulting in their abandonment.

It is essential to recognize that providing affordable and socially acceptable housing is both a moral and economic imperative. A lack of adequate housing can have significant social and economic consequences (Sidawi, 2008), including increased crime rates, reduced productivity, and decreased quality of life. Therefore, it is crucial to prioritize the provision of affordable and socially acceptable housing to ensure that individuals and communities can thrive (Ezennia and Hoskara, 2021).

2.4.3.2.Success factors for the environmental aspect of sustainability performance

Mulliner and Maliene in 2011 demonstrated that the provision of affordable housing is not just about affordability, but also entails ensuring social equity and environmental sustainability. In the context of the latter, considerations include the selection of materials, construction techniques, resource efficiency, energy conservation, and ecological footprint reduction (Haffner and Hulse, 2021). Air pollution and its impact on health are also important factors to be taken into account, as building materials contribute to indoor air pollution (Kolarik and Toftum, 2012).

Green affordable housing could improve low-income households' health outcomes, such as access to green public space (Roufechaei et al., 2014), which is frequently overlooked in affordable housing programs (Dempsey et al., 2012). These "green" housing involved the integration of design practices that enhance energy efficiency, employ non-toxic materials, reduce water usage, and maintain good indoor air quality (Fuhry and Wells, 2013; Steinemann et al., 2017). Furthermore, it is critical to prioritize disaster resilience (Charoenkit and Kumar, 2014) and mixed land use (Isalou et al., 2014; Turcotte and Geiser, 2015) in the provision of affordable housing. In conclusion, affordable housing projects should be designed and constructed with the utmost care to ensure that the built environment is safe, healthy, and sustainable (Lawal and Adekunle, 2018; Lento et al., 2011).

2.4.3.3. Success factors for economic aspect of sustainability performance

To achieve economic sustainability in affordable housing, a variety of measures must be implemented, including the creation of stable employment opportunities, the promotion of affordable housing, and investment in quality education and healthcare bill (Fuhry and Wells, 2013; Isalou et al., 2014). It also necessitates the use of environmentally friendly and cost-effective construction strategies and materials (Atolagbe and Fadamiro, 2014; Bredenoord, 2015; Hamid et al., 2018). Reduced transportation and energy costs allow low-income households to spend more of their income on non-housing necessities (Badyina and Golubchikov, 2012; Ibem and Azuh, 2011). The viability of developers is dependent on consistent financial incentives and subsidies (Pullen et al., 2010), whereas tax relief can reduce the affordability burden for low-income households (Wood and Stoakes, 2006; (Cai and Lu, 2015; Hall and Berry, 2006).

Facilitating housing access is a critical component of ensuring that people can obtain adequate housing through long-term financing. Individuals with low incomes, on the other hand, have historically faced numerous challenges in obtaining sufficient mortgage financing to purchase suitable housing units, as Subramanian noted in 2005. In 2013, Rolnik stated that both globalization and neoliberalism were driving a global shift in urban and housing policy agendas. As a result, housing has become a more popular investment resource in the global financial market, and housing commodification has significantly distorted the enjoyment of the right to adequate housing. One of the most significant challenges facing a growing number of countries around the world is achieving sustainable housing finance for low-income populations, which remains unresolved (Ezennia and Hoskara, 2021).

A comprehensive analysis of 30 studies focusing on identifying indicators for sustainable housing affordability was conducted to develop a model for evaluating sustainable and affordable housing. A qualitative assessment of sustainability criteria, factors, and constituents in the housing sector was conducted as part of this analysis, with additional information gathered from existing literature. A list of 70 potentially effective indicators for sustainable affordable housing performance was compiled based on this analysis, which is divided into 27 social (SS), 23 economic (ES), and 20 environmental (EN) aspects. Table 2.2 shows the indicators that were chosen based on their frequent and significant mention in the literature reviewed.

Table 2. 2: Success factors for social, environmental and economic aspects of sustainability performance

Social Aspects of Sustainability Indicators for Affordable housing		
Code	**Indicators**	**References**
SS01	Performance of housing units	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chan and Adabre, 2019; Chohan, 2022; Ezennia and Hoskara, 2021; Mulliner et al., 2013)
SS02	Meeting the needs of users and ensuring their satisfaction	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Chohan, 2022; Ezennia and Hoskara, 2021; Mulliner et al., 2013)
SS03	maintainability of housing units and facilities	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Chohan, 2022; Gan et al., 2017; Khan and Fang, 2020)
SS04	Achieve project Team satisfaction	(Araji and Bahjat, 2021; Chan and Adabre, 2019)
SS05	Accessibility to public transportation	(Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021; Mulliner et al., 2013)
SS06	Accessibility to green public spaces	(Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021; Gan et al., 2017; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011)
SS07	Adherence to project schedules	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chan and Adabre, 2019)
SS08	Reduced occurrence of disputes and litigation	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chan and Adabre, 2019)
SS09	Project Aesthetics	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Ezennia and Hoskara, 2021)
SS10	Technical specifications of housing units	(Araji and Bahjat, 2021; Chan et al., 2017; Chan and Adabre, 2019)
SS11	Application of building technology	(Araji and Bahjat, 2021; Chan et al., 2017; Chan and Adabre, 2019; Chohan, 2022; Ezennia and Hoskara, 2021; Pullen et al., 2010)
SS12	Marketing the housing project facility	(Araji and Bahjat, 2021; Chan and Adabre, 2019)
SS13	Construction cost performance of project facility	(Araji and Bahjat, 2021; Chan and Adabre, 2019)
SS14	Waiting Time before receiving housing unit	(Araji and Bahjat, 2021; Chan and Adabre, 2019)
SS15	Subsidies provision for housing	(Adabre and Chan, 2019b; Araji and Bahjat, 2021)
SS16	Equal and balanced distribution of housing units for households	(Araji and Bahjat, 2021; Gan et al., 2017)
SS17	Tenure security	(Araji and Bahjat, 2021; Bowen and Quintiliani, 2019; Ezennia and Hoskara, 2021; Gan et al., 2017)
SS18	Harmonious social relationship	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017)
SS19	Social acceptability	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021, 2021; Gan et al., 2017; Itma and Wasim, 2023; Nair and Vergragt, 2005; Pullen et al., 2010; Saidu and Yeom, 2020)
SS20	Safety performance	(Chan and Adabre, 2019; Wai et al., 2012)
SS21	Security	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Khan and Fang, 2020; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011; Saidu and Yeom, 2020)
SS22	Privacy	(Araji and Bahjat, 2021; Bowen and Quintiliani, 2019; Gan et al., 2017; Khan and Fang, 2020; Emma Mulliner and Maliene, 2011)
SS23	Suitability	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017)

SS24	Quality of housing units	(Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021; Khan and Fang, 2020)
SS25	Multi type and size of housing units	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Pullen et al., 2010)
SS26	Organizing the human scale	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021)
SS27	Desirability	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Mulliner et al., 2013; Nair and Vergragt, 2005; Pullen et al., 2010)
Environmental Aspects of Sustainability Indicators for Affordable housing		
Code	**Indicators**	**References**
EN01	Energy efficiency	(Adamec et al., 2021; Araji and Bahjat, 2021; Chan and Adabre, 2019; Chohan, 2022; Ezennia and Hoskara, 2021; Gan et al., 2017; Khan and Fang, 2020; Manganelli et al., 2019; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011; Nair and Vergragt, 2005; Pullen et al., 2010; Saidu and Yeom, 2020)
EN02	Housing environmental performance	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Charoenkit and Kumar, 2014; Ezennia and Hoskara, 2021; Saidu and Yeom, 2020)
EN03	Water efficiency	(Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021; Gan et al., 2017; Haidar and Bahammam, 2021, 2021; Khan and Fang, 2020; Manganelli et al., 2019; Mulliner et al., 2013; Nair and Vergragt, 2005; Pullen et al., 2010; Saidu and Yeom, 2020)
EN04	Selection of housing projects location	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chohan, 2022)
EN05	Mix land use Planning	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021)
EN06	Land use efficiency	(Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021; Gan et al., 2017)
EN07	Housing density	(Dempsey et al., 2012; Ezennia and Hoskara, 2021; Gan et al., 2017; Pullen et al., 2010)
EN08	Disaster resistance	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017)
EN09	Adequate living space within small size units	(Araji and Bahjat, 2021; Gan et al., 2017)
EN10	Housing quality (reliability and durability)	(Araji and Bahjat, 2021; Chohan, 2022; Gan et al., 2017; Mulliner et al., 2013)
EN11	Effective utilization of resources	(Araji and Bahjat, 2021; Bardhan and Debnath, 2016; Ezennia and Hoskara, 2021; Gan et al., 2017)
EN12	Waste management for housing project	(Adamec et al., 2021; Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Manganelli et al., 2019; Emma Mulliner and Maliene, 2011; Saidu and Yeom, 2020)
EN13	Local design	(Araji and Bahjat, 2021)
EN14	Functional efficiency	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Mulliner et al., 2013; Saidu and Yeom, 2020)
EN15	Functional and structural Space flexibility	(Araji and Bahjat, 2021)
EN16	Building material efficiency	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Bredenoord, 2015; Chohan, 2022; Ezennia and Hoskara, 2021; Khan and Fang, 2020; Nair and Vergragt, 2005; Pullen et al., 2010; Saidu and Yeom, 2020; Wallbaum et al., 2012)
EN17	Environmental design criteria	(Araji and Bahjat, 2021; Bardhan and Debnath, 2016; Chohan, 2022; Khan and Fang, 2020; Nair and Vergragt, 2005; Pullen et al., 2010; Saidu and Yeom, 2020)
EN18	Compact planning and design	(Araji and Bahjat, 2021; Dempsey et al., 2012)

EN19	Recycle and reuse construction material	(Araji and Bahjat, 2021; Chohan, 2022; Ezennia and Hoskara, 2021; Khan and Fang, 2020; Pullen et al., 2010; Wallbaum et al., 2012)
Economical Aspects of Sustainability Indicators for Affordable housing		
Code	**Indicators**	**References**
ES01	House Price in relation to income	(Adabre and Chan, 2020; Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011; Pullen et al., 2010; Said et al., 2015; Saidu and Yeom, 2020; Wallbaum et al., 2012)
ES02	Rental costs in relation to income	(Adabre and Chan, 2020; Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011; Pullen et al., 2010; Said et al., 2015; Saidu and Yeom, 2020; Wallbaum et al., 2012)
ES03	Reduced commuting cost	(Adabre and Chan, 2020; Chohan, 2022; Ezennia and Hoskara, 2021; Mulliner et al., 2013)
ES04	Reduced Housing Life cycle cost	(Araji and Bahjat, 2021; Chan and Adabre, 2019; Ezennia and Hoskara, 2021; Saidu and Yeom, 2020; Wallbaum et al., 2012)
ES05	Running costs for public housing	(Araji and Bahjat, 2021)
ES06	Site preparations costs	(Araji and Bahjat, 2021)
ES07	Minimize design standards to lower the costs	(Araji and Bahjat, 2021; Nair and Vergragt, 2005)
ES08	Mandatory inclusion of affordable projects in privet sector projects	(Adabre and Chan, 2019b; Araji and Bahjat, 2021)
ES09	Lower the interest of housing loans for developers	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Bowen and Quintiliani, 2019)
ES10	Improve the land supply from government to lower housing costs	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Bowen and Quintiliani, 2019)
ES11	Reduced Transportation costs	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011)
ES12	Infrastructures costs	(Adabre and Chan, 2019b; Araji and Bahjat, 2021; Chan and Adabre, 2019)
ES13	Formulate supportive housing policies	(Adabre and Chan, 2019b; Araji and Bahjat, 2021)
ES14	Ensure balanced housing market	(Araji and Bahjat, 2021; Gan et al., 2017)
ES15	Cost effectiveness	(Adamec et al., 2021; Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Gan et al., 2017; Saidu and Yeom, 2020)
ES16	Reduced Non-housing costs	(Araji and Bahjat, 2021; Gan et al., 2017; Emma Mulliner and Maliene, 2011)
ES17	Providing human resources for housing development	(Araji and Bahjat, 2021; Gan et al., 2017)
ES18	Mortgage availability and interest rates	(Araji and Bahjat, 2021; Ezennia and Hoskara, 2021; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011; UN-Habitat, 2014)
ES19	Availability and access to employment	(Araji and Bahjat, 2021; Mulliner et al., 2013; Emma Mulliner and Maliene, 2011; Saidu and Yeom, 2020)
ES20	Availability of housing accommodation	(Araji and Bahjat, 2021; Emma Mulliner and Maliene, 2011)
ES21	Financing system	(Araji and Bahjat, 2021)
ES22	Funding organizations	(Araji and Bahjat, 2021; Bowen and Quintiliani, 2019)
ES23	Value of housing units after use	(Araji and Bahjat, 2021; Pullen et al., 2010)

2.5. ASSESSMENT MODEL OF HOUSING AFFORDABILITY AND SUSTAINABILITY

In any project, success is the ultimate goal. It is the achievement of a set of externally observed goals (Ashley et al., 1987). With the evolving approaches in this domain, the issue of housing affordability has recently become more complex and diverse. To ensure that affordable housing programs are targeted at the major issues and can be used to achieve sustainable communities, it is critical to understand that there is no single solution to further reduce cost criteria and achieve enhanced energy savings, but rather a series of steps to address these challenges (Ezennia and Hoskara, 2021). It is also critical to consider the perspectives of the various stakeholders involved in the process.

As highlighted by Robert and Chan (2017), assessing the performance levels of comparable projects necessitates the use of critical assessment criteria and indicators. Various assessment frameworks have been proposed in the literature to this end. While general assessment frameworks may apply to all construction projects (Atkinson, 1999; Chan and Chan, 2004), specific assessment criteria and indicators are required to evaluate the sustainability performance of affordable housing (Ezennia and Hoskara, 2021; Saidu and Yeom, 2020). These performance criteria are intended to focus on the fundamental requirements of sustainability and affordability, as well as how these criteria and indicators can be incorporated into specific circumstances, cases, and contexts. It is necessary to develop a practical sustainability assessment model that recognizes the critical role of technology in delivery and implementation. The ultimate goal is to maximize social acceptance while minimizing environmental impact and cost of housing.

Several studies have identified critical success criteria, performance indicators for sustainability, and success factors for the development of affordable and sustainable housing. Gan et al. identified 24 sustainability performance indicators in 2017. In 2021, Chan and Adabre presented 21 critical success criteria and 30 success factors as guidelines for sustainable affordable housing development (C1-C20). While Araji and Bahjat identified 72 sustainability performance indicators for sustainable and affordable housing. Also in the same year, Adamec et al. provide a comprehensive tool to evaluate housing sustainability and design policies. Bowen and Quintiliani (2019) developed a social and environmental sustainability-based housing affordability strategy and evaluation model. In addition, multiple researchers have created models for evaluating sustainable and affordable housing. Pullen et al. (2010) identified some critical success criteria, while Ibem and Azuh (2011) developed a framework for assessing the sustainability of public housing programs. Haidar and Bahammam proposed in 2021 a new method for ranking priority criteria for low- and middle-income housing projects.

The development of an assessment model for sustainable affordable housing prioritized the three pillars of sustainability - economic, environmental, and social - as the primary targets. The model incorporates seven key categories of criteria that correspond to the sustainability goals. Indicators are tools for evaluating the requirements. They are made up of qualitative and quantitative performance data that can be compared and show a chronological shift (Rahdari and Rostamy, 2015). The previously identified critical success criteria, which were classified into seven main categories to facilitate the evaluation and analysis process, were used as key indicators for the assessment model in terms of sustainability and affordability to develop the housing assessment model. To assess these key indicators, the 70 previously identified critical success factors from the literature review were classified according to each of the critical success criteria, with each criterion involving a group of critical success factors that contribute to meeting this criterion. These factors are regarded as supplementary indicators for evaluation within the assessment model as shown in Table 2.3.

Table 2. 3: The Developing Assessment Model For Sustainable- Affordable Housing

Assessment Model For Sustainable- Affordable Housing						
No.	**Indicators**	**Code**	**Sub-indicators** / Issues to be considered under each indicator	**Case 1**	**Case 2**	**Case 2**
Economic Viability and Housing Affordability						
1	Housing price to income	ES01	House Price in relation to income			
2	Rental cost to income	ES02	Rental costs in relation to income			
3	Reduced commuting cost	ES03	Reduced commuting cost			
4		ES11	Reduced Transportation costs			
5		ES19	Availability and access to employment			
6		ES20	Availability of housing accommodation			
7		SS05	Accessibility to public transportation			
8		SS06	Accessibility to green public spaces			
9	Reduce housing initial cost	ES06	Site preparations costs			
10		ES07	Minimize design standards to lower the costs			
11		ES12	Infrastructures costs			
12		ES16	Reduced Non-housing costs			
13		ES17	Providing human resources for housing development			
14		ES21	Financing system			
15		ES22	Funding organizations			
16		ES05	Running costs for public housing			
TOTAL RATING						
Household Satisfaction						
1	End user's satisfaction with facilities	SS02	Providing Users' needs and achieve satisfaction on facilities			
2		SS27	Desirability			
3	Functionality of housing facility	EN14	Functional efficiency			
4	Community satisfaction	SS16	Equal and balanced distribution of housing units for households			
5		SS20	Safety performance of housing facility (crime rate)			
6	Social Acceptability	SS19	Social acceptability			
TOTAL RATING						
The Project Team and Community Satisfaction						
1	Stakeholders' satisfaction	SS04	Achieve project Team satisfaction			
2		SS07	Adherence to project schedules			
3		EN04	Selection of housing projects location			

4	Neighborhoods' satisfaction	SS18	Harmonious social relationship			
5		EN05	Mix land use Planning			
6		EN06	Land use efficiency			
7		EN07	Housing density			
8		EN18	Compact planning and design			
9	Reduced disputes occurrence	SS08	Reduced occurrence of disputes and litigation			
TOTAL RATING						
Marketing and The Waiting Time						
1	Housing facility marketability	ES13	Formulate supportive housing policies			
2		ES14	Ensure balanced housing market			
3		SS12	Marketing the housing project facility			
4	Time spent waiting for a housing unit	SS13	Construction cost performance of project facility			
5		SS14	Waiting Time before receiving housing unit			
6		SS15	Subsidies provision for housing			
TOTAL RATING						
Housing Life-Cycle Costs						
1	Maintainability of housing (cost of maintenance or retrofitting)	SS03	Maintainability of housing units and facilities			
2		ES15	Cost effectiveness			
3		ES23	Value of housing units after use			
4	Other lifecycle cost of housing Energy and water efficiency (utility bills)	ES04	Reduced Housing Life cycle cost			
5		EN01	Energy efficiency			
6		EN03	Water efficiency			
TOTAL RATING						
Environmental Effectiveness						
1	Environmental friendliness	EN02	Housing environmental performance			
2		EN12	Waste management for housing project			
3		EN19	Recycle and reuse construction material			
TOTAL RATING						
Quality of Housing Performance						
1	Aesthetic view of completed house	SS09	Project Aesthetics			
2	Technical specification of housing facility	SS10	Technical specifications of housing units			
3	Technology transfer	SS11	Application of building technology			
4	Quality performance of housing facility	SS17	Tenure security			
5		SS21	Security			

6	Quality performance of housing facility	SS22	Privacy			
7		SS23	Suitability			
8		SS01	Performance of housing units			
9		SS24	Quality of housing units			
10		SS25	Multi type and size of housing units			
11		SS26	Organizing the human scale			
12		EN08	Disaster resistance			
13		EN09	Adequate living space within small size units			
14		EN10	Housing quality (reliability and durability)			
15		EN11	Effective utilization of resources			
16		EN13	Local design			
17		EN15	Functional and structural Space flexibility			
18		EN16	Building material efficiency			
19		EN17	Environmental design criteria			
TOTAL RATING						

2.6. CONCLUSION

In this chapter, a hybrid research method was utilized to pinpoint key indicators for the performance of sustainable and affordable housing developments. This section reviews various assessment frameworks that pertain to sustainable and affordable housing, with the aim of creating an initial set of indicators for evaluating the performance of housing projects in terms of sustainability and affordability. However, the results showed that there is no existing assessment model for evaluating the various aspects of housing sustainability and affordability in the Palestinian construction industry. After conducting a thorough literature review, relevant key criteria and factors were identified from the literature and established for data collection. Subsequently, a set of indicators for sustainable affordable housing were identified to develop a comprehensive model for assessing the sustainability and affordability performance of housing. The assessment model is a comprehensive evaluation tool that considers economic, social, and environmental goals for affordable housing sustainability.

It is important to note that the sustainable affordable assessment model, which was developed to assess housing sustainability and affordability in Palestine, was based solely on the findings of a literature review. This was due to the lack of specialists and experts in the field of sustainable and affordable housing in Palestine, as well as the scarcity of comprehensive studies on this topic in the region. Consequently, the effectiveness of the model and its representation of the Palestinian society in the results, cannot be fully determined. Therefore, the model remains theoretical, and its validation requires the application of the model to sustainable and affordable case studies in regions similar to Palestine.

CHAPTER 3

RESEARCH METHODOLOGY

3.1. INTRODUCTION

In previous chapters, a literature review was conducted on the assessment tools for measuring housing sustainability and affordability performance, critical success criteria and success factors to sustainable and affordable housing projects, as well as housing conditions in Palestine. Although the study is supported by the gaps in relevant research knowledge revealed by the literature review, selecting the best research methodology is critical to achieving the aim and objectives of the study (Steele, 2000). As a result, the purpose of this chapter is to explain the methodology used to achieve the study's stated aim and objectives. This chapter describes the research study approach, followed by an explanation of the various stages of the research framework used. Finally, data collection and analysis techniques for research were discussed. This chapter explains how to determine the research methodology and how to achieve the research objectives in a logical, systematic, and clear sequence.

3.2. RESEARCH METHODOLOGY

The research methodology is a framework that critical to use a well-defined approach to ensure that the objectives of the research are met. A methodology describes the data sources that were collected, including how and where they were obtained, as well as the method of analysis used to produce reliable and valid results (McCombes, 2022).

3.2.1. Research Approach

The research approach is concerned with the application of theory, and there are two major research approaches which are deductive and inductive (Saunders et al., 2009; Malalgodia et al., 2018). The primary goal of this research is to develop trustworthy knowledge in the form of a framework that explains an objective reality, specifically the issue of unsustainable and unaffordable housing. This study belongs to the category of explanatory research as it seeks to explain a specific phenomenon. This begins with becoming acquainted with the research problem and is followed by highlighting strategies of problem-solving and performance measures (Vaishnavii and Kuechler, 2004). In the same way, identifying the unaffordable and unsustainable housing crisis, as well as problem-solving strategies and performance measures, is based on previously developed theory or knowledge. Hypotheses about Palestine's unaffordable and unsustainable housing situation are developed after evaluating the current state of buildings in terms of sustainability and affordability using a variety of criteria and indicators gathered from previous studies.

The theoretical approach is related to the theories and ideas presented and identified in the field of study to point to the need for affordable and sustainable housing for all members of society. The literature aids in understanding the theoretical basis of the research related to the keywords (sustainable housing, affordability, success factors, success criteria, risk factors, and assessment model).

3.2.2. Research Method

The two most common devices for framing the architectural research outline, according to Groat and Wang (2013), are quantitative versus qualitative. The quantitative approach uses a deductive inquiry process to find cause-and-effect explanations, while the qualitative approach uses an inductive inquiry process to identify multiple critical factors influencing the phenomenon. This study's methodology is based on a comprehensive approach that combines both quantitative and qualitative findings.

- **Qualitative research**

The primary focus of qualitative research is on the comprehensive exploration of contexts and complex situations, which necessitates both a review of the fieldwork and literature. This is for understanding the entire process of affordable and sustainable residential building projects, as well as data collection.

- **Quantitative research**

This study identifies numerical and static data, such as thermal comfort indicators, housing prices relative to income, and building life cycle cost. The analysis of this type of data is central to quantitative research.

Following the collection of data via a survey and the selection of case studies, simulations for two multi-story apartment buildings were carried out. Using Design Builder software (V7.0.2.006), a

3D digital model was created for each case to examine daylight performance and thermal comfort by measuring PPD, PMV, and MRT indicators.

The housing price in relation to income, energy consumption, and building life cycle cost was calculated using the CRAVEzero LCC Web Tool, a method for calculating the total cost of a building over its entire life cycle in accordance with ISO 15686-5:2017 standards.

The models were created using the actual building form as well as fieldwork information on building materials, techniques, and costs. Furthermore, the existing site information (including building orientation, altitude, longitude, latitude, and so on) was derived from the Energy Plus 9.2 website's weather data for the Hebron region for simulation.

3.3. DATA COLLECTION TECHNIQUES

In this study research, data collection was done through extensive literature research, a document review survey, and a field survey using interviews.

3.3.1. Comprehensive Literature Review

A comprehensive literature review was carried out through scientific journals, research papers, and books. It was necessary to have a strong foundation, experience, and knowledge with residential building technologies, techniques, and cases to make them sustainable and affordable. The literature reviews also sought to identify and compare the most commonly used methodologies and data analysis methods in similar studies, as well as to select and justify the most acceptable methods based on availability and suitability to the field of study. The review of literature was divided into two sections as shown in Fig. 4.1, which were discussed in subsequent chapters:

1. An extensive review of housing conditions and problems, as well as assessment tools for measuring housing sustainability and affordability performance, critical success criteria, and success factors for sustainable and affordable housing projects, is provided in Chapter 2.
2. In Chapter 4, case studies were chosen that were built to meet the principles of sustainability for low-income people to benefit from them in terms of design technique, strategies used, risk, and challenges faced in providing sustainable residential buildings at affordable costs.

This study employed a variety of research methods to identify the primary factors influencing housing sustainability and affordability. A comprehensive review of the literature was conducted to generate an initial list of performance indicators for sustainable and affordable housing development. The process of creating an assessment model was divided into three stages:

- Analysis of existing frameworks, tools and literature for assessing sustainable and affordable housing.
- Developing a model for assessing housing performance in terms of sustainability and affordability.
- Validation of this framework through application on sustainable and affordable case studies and evaluation of its effectiveness.

3. Chapter 6 presents the findings of a literature scoping study that investigated the design strategies and issues to be considered that influence each indicator in each category of the assessment model that delivers affordable and sustainable housing in developing country contexts worldwide.

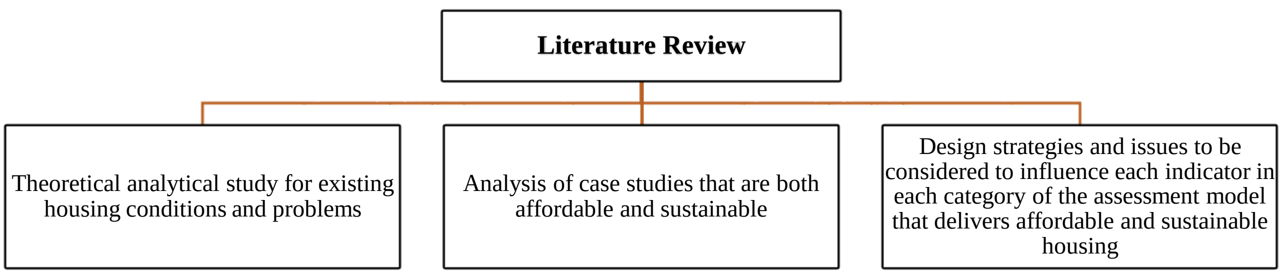


Fig 3. 1: Components of literature review (Researcher, 2023)

3.3.2. Document review survey

This study employs document analysis as a qualitative research technique, which is an organized process for evaluating or reviewing documents -both electronic (Internet-transmitted and computer-based) and printed material- (Bowen, 2009; Corbin and Strauss, 2008). The process entails reviewing documents to analyze them, comprehend their significance, and establish a foundation for the information they provide. This study examined public documents, which are official records from Hebron municipality, the Palestinian Central Bureau of Statistics, and the Palestinian Engineers Association about the housing sector, standard of life, and individual income in Palestine.

3.3.3. A Field Survey in Hebron City- Interviews

Survey research is defined as "the collection of information from a sample of individuals through their responses to questions" (Chieck and Schott, 2011). This type of research enables a wide range of data collection, participant recruitment, and instrumentation methods (Ponito, 2015). Field surveys are one of the most common data collection methods used by researchers. Interviews were used as common methods of field survey in this study, which are essential in obtaining research data from various design institutions, including architects and building users (Lucas, 2016). All of the interviews for this study were unstructured, beginning with a set of questions for each group, followed by a free-flowing discussion.

The goal of the interviews is to learn about the various types of housing units in Hebron City and obtain more details about the most common design and construction methods, materials, and costs for Hebron housing buildings. This is combined with a document review survey to help in the creation of a building information database by conducting a general study of the area. Because there had been very few previous studies or research on architectural styles in Hebron City (Hadid, 2002), interviews were chosen as the most suitable method for this part of the study. The interviews were conducted in three stages between June 2022 and August 2023:

1. The first interviews took place in June 2022. Interviews were conducted with several green architecture experts, some of whom had prior experience with Palestine's housing affordability issues. These interviews were conducted online through Google Meet to learn more about the realities of affordable and sustainable architecture in Palestine, the policies put in place to achieve them, and the challenges involved.
2. The second interview was held in April 2023. Engineering offices, an engineer's association, a municipality, and an urban planning specialist were interviewed. These face-to-face interviews were conducted to investigate the status of residential buildings in Hebron, as well as their classifications and most common types. On the other hand, the stages of the design and implementation of residential buildings in Hebron, as well as the challenges and obstacles they face at each stage.
3. The final interviews were held in June 2023 with the designers, supervision engineers, and building contractors, as well as the owners and residents of the residential buildings chosen as local case studies for this study. These interviews were conducted to evaluate indicators

of sustainability and affordability of these buildings, such as social indicators and some economic and environmental indicators that are hard to measure from a distance.

3.4. SUSTAINABLE AND AFFORDABLE CASE STUDY SELECTION CRITERIA

The study cases were chosen using a set of criteria, the most important of which are:

- Scale: The scale was a key common feature among the projects chosen as case studies, with med-rise residential buildings, whether standalone or within residential complexes. Whereas, case studies that match the required scale can provide more relevant and more useful information.
- The project Type: Case studies with a similar project type can assist in comparing spaces, the resident behavior, building management, and specific facilities that relate to the desired design. The case studies were chosen from residential complexes with one- or two-bedroom apartments built for middle- and low- income households.
- The project Location: As much as possible, the research cases were chosen in parts of the Global South, which are developing countries, and they are also lower-income countries and include Palestinian cities which are similar in terms of economic and social status (Iyioke, 2020).

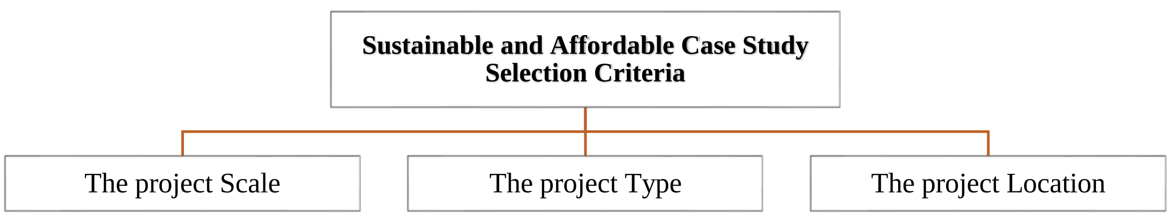


Fig 3. 2: Sustainable and Affordable Case Study Selection Criteria (Researcher, 2023)

3.5. LOCAL CASE STUDIES SELECTION CRITERIA

Many variables were considered when selecting local case studies from the city of Hebron to apply the sustainability and affordability assessment model to these case studies. These characteristics include the building's type and classification, location, construction period, and the type of residents for whom it is built.

A. Selection based on the building type

Based on the Palestinian code's definition of a multi-story building, this study focuses on multi-story residential buildings taller than 20 meters. As previously stated, current architectural developments in the housing market, particularly in Palestine, have shifted to multi-story apartment buildings. This is a result of rising land prices and increased demand for dwellings in densely populated areas (Itma, 2018). According to the Hebron municipality's GIS Department, the findings of housing and establishment surveys in 2021 show that there are approximately 3,252 multi-story buildings out of a total of 21,747 buildings in Hebron (Abu Munshar, 2021).

B. Selection based on the location of the building

According to the Hebron structural plan - Hebron Municipality 2023, the case studies were chosen considering that they are located in zones designated as Classification (B), which include the highest percentage of residential buildings in Hebron city.

C. Selection based on the construction period

The case studies were chosen so that the design and construction stages began and ended within the last five years. This is because, in recent years, there has been a greater awareness of the importance and necessity of architectural design of housing in Palestinian cities, designing the interior space while considering environmental factors, and considering the improvement of the indoor environmental quality of housing. Previously, these buildings were built without any design or engineering supervision. On the other hand, according to the SPCB of Statistics 2023, the cost index for residential building construction rises more each year than the preceding year due to increases in building material prices, pay, and labor cost increases, and so on.

D. Housing conditions

The case studies were chosen to include the most prevalent main characteristics and conditions encountered in residential buildings in West Bank in general, and Hebron in particular, such as type of house, ownership, area, number of rooms, and so on.

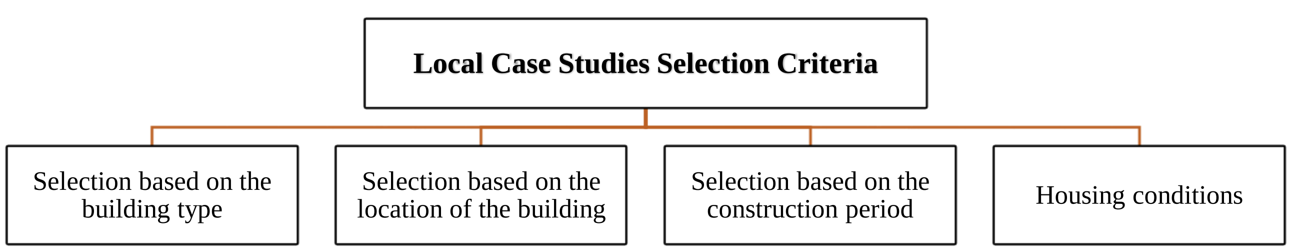


Fig 3. 3: Local Case Studies Selection Criteria (Researcher, 2023)

3.6.DATA ANALYSIS METHODS

3.6.1. Developing an assessment model

By analyzing literature data, a framework was developed to assess the affordability and sustainability of housing performance. This framework enabled the identification of performance indicators based on affordable and sustainable housing characteristics. The assessment model's effectiveness in practical applications was demonstrated through the analysis of sustainable and affordable housing case studies.

3.6.2. Local case studies analysis

The aim of analyzing case studies in this research is to investigate residential buildings in Hebron City in terms of sustainability and affordability, using an assessment model built based on a literature review. The broad gap and the key issues confronting existing residential buildings are highlighted here.

Research is being done to develop these types of structures by applying and analyzing the strategies and ways of working and thinking examined in earlier studies, to create sustainable and affordable residential buildings in Palestine.

The case studies analysis structure includes:

- Provides specific information for the chosen case study.
- Justifications for selecting this case.
- Environmental investigation
- Life Cycle Cost Analysis (LCCA)
- Discussion

3.6.3. Simulation

The Design-Builder software (V7.0.2.006.) was used to evaluate the daylight performance of the case study buildings, as well as thermal comfort indicators such as PPD, PMV, and MRT.

The Housing Price in relation to Income, Energy Consumption, and Building Life Cycle Cost was calculated using the CRAVEzero LCC Web Tool, a method for calculating building life cycle costs in accordance with ISO 15686-5:2017.

In accordance with the actual building data and building materials obtained during the fieldwork, a 3D digital model was created for each case. Furthermore, current site information (such as building orientation, altitude, longitude, latitude, and so on) was derived from the Energy Plus 9.2 website's meteorological data for the Hebron region for simulation. Two multi-story buildings were simulated in order to provide quantitative information for each one, such as daylight factors, thermal comfort indicators, and life cycle cost analysis.

3.6.4. Case studies evaluation using a sustainable and affordable assessment model

The determination of indicator values in the assessment model's evaluation of sustainable and affordable case studies, as well as local case studies, was based on the results of an environmental and economic analysis of the case studies. This analysis was supplemented by interviews with individuals associated with the selected case studies, as well as secondary sources such as government publications and local government reports.

A system of ratings (0: does not meet (X); 1: comes close (Δ); 2: exceed or meet (√)) is used to determine the degree to which each case meets the indicators of each criterion listed in the sustainable and affordable housing assessment model. Rating scales were developed with a focus on clear and well-defined criteria, with periodic evaluations to ensure their relevance and accuracy. When used correctly, these rating scales provide valuable insights, facilitate decision-making, and support continuous improvement efforts in a variety of contexts. The rating scales shown in Table.3.2 were created to provide a consistent and reliable framework for assessment.

Table 3. 1: The Sustainable-Affordable Housing Assessment Model rating scales and scores

Assessment Model For Sustainable- Affordable Housing							
No.	**Indicators**	**Code**	**Sub-indicators / Issues to be considered under each indicator**	**Meet (√) -2 scores**	**Come close (∆)- 1 score**	**Dose not meet (✕)- 0 score**	**Ref.**
Economic Viability and Housing Affordability							
1	Housing price to income	ES01	House Price in relation to income	Price/income ≤ 30%	30% ≤ Price/income ≤ 45%	Price/income ≥ 45%	(OECD, 2021)
2	Rental cost to income	ES02	Rental costs in relation to income	Rental costs /income ≤ 30%	30% ≤ Rental costs /income ≤ 45%	Rental costs /income ≥ 45%	(OECD, 2021)
3	Reduced commuting cost	ES03	Reduced commuting cost	Low reliance on the automobile	Moderate reliance on the automobile	Heavy reliance on the automobile	(Ibem, 2011)
4		ES11	Reduced Transportation costs	Existence of a public transportation network that is suitable for users throughout the neighborhood	Existence of a public transportation network that is not well-suited to the all needs of residents	There is no public transportation network that is suitable for users	(Ibem, 2011)
5		ES19	Availability and access to employment	High—key employment site within 15 min by public transport	Moderate—key employment site within 30 min by public transport	Low—key employment site over 30 min away by public transport	(Mulliner et al., 2013)
7		SS05	Accessibility to public transportation	Distance from house to public transport Station Less than 2 Km	Distance from house to public transport Station 2Km – 5Km	Distance from house to public transport Station More than 5 Km	(Ezennia and Hoskara, 2021)
8		SS06	Accessibility to green public spaces	Green public spaces within 15 min by public transport	Green public spaces within 30 min by public transport	Green public spaces over 30 min away by public transport	(Mulliner et al., 2013)
9	Reduce housing initial cost	ES06	Site preparation costs	Low Site preparation costs	Moderate Site preparation costs	High Site preparation costs	(bigrentz, 2022)
10		ES07	Minimize design standards to lower the costs	Only required design specifications	Typical design specifications	Maximal design specifications	(Nainggolan et al., 2020)
11		ES12	Infrastructures costs	Consider the existing infrastructure and utility access	Little attention to existing infrastructure and access to facilities	Do not consider the existing infrastructure and utility access	(Yvonne, 2018)
12		ES16	Reduced Non-housing costs	Unskilled labour with no training or local skills traditionally available, low-tech tools	Unskilled labour with intensive training (several weeks) or skilled workers	Very advanced skill level or tools required	(Wallbaum et al., 2012)

14		ES21	Financing system	Available funding	-	No funding available	(Wallbaum et al., 2012)
15		ES22	Funding organizations	Adequate funding and provision	-	Insufficient funding and provision	(Saidu and Yeom, 2020)
16		ES05	Running costs for public housing	Low operating costs	Moderate operating costs	High operating costs	(Heffernan and Wilde, 2020)
Household Satisfaction							
1	End user's satisfaction with facilities	SS02	Providing Users' needs and achieve satisfaction on facilities	High level of end-user satisfaction with supplementary facilities	Moderate level of end-user satisfaction with supplementary facilities	Low level of end-user satisfaction with supplementary facilities	(Adabre and Chan, 2020)
2		SS27	Desirability	Housing architectural design in relation to a unique cultural reflection	Housing architectural design in a small relation to a reflection of the unique cultural	Housing architectural design is not based on a unique cultural reflection.	(Ibem, 2011)
3	Functionality of housing facility	EN14	Functional efficiency	Housing facility to meet the evolving needs of households	Housing facilities may be able to meet the changing needs of households.	Housing facility unable to meet household needs	(Mulliner and Maliene, 2011)
4	Community satisfaction	SS16	Equal and balanced distribution of housing units for households	High level of integration and equality	Moderate level of equality and integration	Low level of integration and equality	(Tupenaite et al., 2017)
5		SS20	Safety performance of housing facility (crime rate)	Well above city average	Average	Well below city average	(Mulliner et al., 2013)
6	Social Acceptability	SS19	Social acceptability	High level of satisfaction	Moderate contentment	Low level of satisfaction	(Tupenaite et al., 2017)
The Project Team and Community Satisfaction							
1	Stakeholders' satisfaction	SS04	Achieve project Team satisfaction	High level of satisfaction	Moderate contentment	Low level of satisfaction	(Adabre and Chan, 2020)
2		SS07	Adherence to project schedules	The project is following its planned schedule	The project is not progressing as planned, but it is not running late.	The project is running late.	(Adabre and Chan, 2020)
4	Neighborhoods' satisfaction	SS18	Harmonious social relationship	High level of social mix in housing environment	Moderate level of social mix in housing environment	Low level of social mix in housing environment	(Tupenaite et al., 2017)
5		EN05	Mix land use Planning	Multiple land use functions	Not distinctive land use functions	The same land use functions	(Tupenaite et al., 2017)
6		EN06	Land use efficiency	High efficiency	Moderate efficiency	Low efficiency	(Tupenaite et al., 2017)
7		EN07	Housing density	High density	Moderate density	Low density	(Tupenaite et al., 2017)

8		EN18	Compact planning and design	Compact layout	-	Less compact layout	(Tupenaite et al., 2017)
9	Reduced disputes occurrence	SS08	Reduced occurrence of disputes and litigation	Low disputes and litigation	Moderate disputes and litigation	High disputes and litigation	(Adabre and Chan, 2020)
Marketing and The Waiting Time							
1	Housing facility marketability	ES13	Formulate supportive housing policies	High supportive housing policies	Moderate supportive housing policies	Poor supportive housing policies	(Office of mental health, 2022)
2		ES14	Ensure balanced housing market	A well-balanced housing market	Moderately balanced housing market	Unbalanced housing market	(Mulliner and Maliene, 2011)
3		SS12	Marketing the housing project facility	Economic and market instruments were aligned to provide incentives	-	Incentives could not be provided because economic and market instruments were not aligned	(Singh and Pandey, 2012)
4	Time spent waiting for a housing unit	SS13	Construction cost performance of project facility	Cost-effective construction performance	Moderate performance of Construction cost	Construction cost underperformance	(Ibem, 2011)
5		SS14	Waiting Time before receiving housing unit	Erection of one unit 1–3 days	Erection of one unit < 1.5 weeks	Erection of one unit > 1.5 weeks	Wallbaum et al., 2012)
Housing Life-Cycle Costs							
1	Maintainability of housing (cost of maintenance or retrofitting)	SS03	Maintainability of housing units and facilities	Maintenance costs and interaction costs for corrective and preventive maintenance are rarely intervened with.	Interventions with a medium level of skill and cost	Intervention with advanced skill and a high cost level	(Wallbaum et al., 2012)
2		ES15	Cost effectiveness	Recover the service costs	Recover a part of the service costs.	Service costs are not recovered	(Singh and Pandey, 2012)
3		ES23	Value of housing units after use	Long-lasting materials and a cost-effective design	Moderately long-lasting materials and a low-cost design	Low durability materials and an inefficient design	(Nainggolan et al., 2020)
4	Other lifecycle cost of housing Energy and water efficiency (utility bills)	ES04	Reduced Housing Life cycle cost	Low Housing Life cycle cost	Moderate Housing Life cycle cost	High Housing Life cycle cost	(Nainggolan et al., 2020)
5		EN01	Energy efficiency	High level of Energy-efficient systems and Renewable energy use	Energy systems that are moderately efficient	Energy-inefficient systems Renewable energy does not use	(Tupenaite et al., 2017)
6		EN03	Water efficiency	Water-saving and harvesting systems were used	Water-saving or water-harvesting systems were used	Water-saving and harvesting systems were not used.	(Tupenaite et al., 2017)

Environmental Effectiveness							
1	Environmental friendliness	EN02	Housing environmental performance	Environmentally friendly waste management, materials, and gas emissions	Environmentally friendly in terms of waste management, materials, or gas emissions	Neither waste management nor materials, nor gas emissions, are environmentally friendly.	(Adabre and Chan, 2020)
2		EN12	Waste management for housing project	Reduce and dispose of waste in accordance with best practices.	-	Waste management and facilities were not included	(Mulliner and Maliene, 2011; ODPM, 2005)
3		EN19	Recycle and reuse construction material	High degree of recycling	Medium degree of recycling and demolition effort	Low degree of recycling	(Wallbaum et al., 2012)
Quality of Housing Performance							
1	Aesthetic view of completed house	SS09	Project aesthetics	Significant contribution to urban landscape aesthetics and morphology	Moderate contribution to the aesthetics of urban landscape and morphology	Low contribution to urban landscape aesthetics and morphology	(ibem, 2011)
2	Technical specification of housing facility	SS10	Technical specifications of housing units	Meet technical requirements	-	Fail to meet technical requirements	(bredenoord, 2015)
3	Technology transfer	SS11	Application of building technology	Integrated into the construction process, and reduced effort	Additional processes required, such as wall chasing	Only exposed possible	(Wallbaum et al., 2012)
4	Quality performance of housing facility	SS17	Tenure security	Have legal protection against forced evictions, harassment, and other threats	-	Lack of legal protection against evictions, harassment, and other threats	(Ezennia and Hoskara, 2021)
5		SS21	Security	High levels of safety and Security	Moderate levels of safety and Security	Inadequate safety and Security	(Badyina and Golubchikov, 2012)
6		SS22	Privacy	High levels of Privacy	Moderate levels of Privacy	Lack of privacy	(Tupenaite et al., 2017)
7		SS23	Suitability	High levels of Suitability	Moderate levels of Suitability	Suitability is insufficient	(Ezennia and Hoskara, 2021)
8	Quality performance of housing facility	SS01	Performance of housing units	Meet certain quality requirements	-	Do not meet certain quality requirements	(Badyina and Golubchikov, 2012)
9		SS24	Quality of housing units	Good indoor and outdoor environmental quality	Moderate Quality of indoor and outdoor environment	Poor Quality of indoor and outdoor environment	(Mulliner et al., 2013)
10		SS25	Multi type and size of housing units	Offering a variety of sizes and types	-	Cannot provide a variety of sizes and types	

11		SS26	Organizing the human scale	Consider the Human scale into design	-	Do not take the human scale into account when designing	(Baldwin, 2021)
12		EN08	Disaster resistance	Use the best options to deal with the various possible dangers.	Use options to deal with some potential risks while ignoring others	Don’t consider the various possible dangers when designing	(GFDRR, 2013)
13		EN09	Adequate living space within small size units	Fitting good life into a small space		Bad life in a small space Or large spaces that are not used	
14		EN10	Housing quality (reliability and durability)	Reliability and durability >40 years	Reliability and durability >20 years	Reliability and durability <10 years	(Wallbaum et al., 2012)
15		EN11	Effective utilization of resources	Involve the Active systems for optimal use of renewable energy. And optimal use of materials	Involve either active systems or optimal material use.	Neither active systems nor optimal material use are involved.	(Nainggolan et al., 2020)
16		EN13	Local design	Building materials and techniques available in the country own open market with high potential for large scale use	Building materials and techniques available in the country potential market (not currently commercial)	Building materials and techniques not available on the local market	(Wallbaum et al., 2012)
17		EN15	Functional and structural Space flexibility	High flexibility in case of change of use	Medium modularization or medium flexibility in case of change of use	Low flexibility in case of change of use	(Wallbaum et al., 2012)
18		EN16	Building material efficiency	High efficient renewable and durable materials	Moderate efficient material	Low efficient materials that are not renewable nor durable	(Nainggolan et al., 2020)

3.7.RESEARCH PROCESS

The research process for this study is divided into several phases. **The first phase** involves establishing the research background, the research problem and questions, as well as the research goal and objectives. This preliminary phase of the study was developed through a comprehensive review of the literature and discussions with the academic supervisors.

The second phase The second phase includes an overview of theory (a systematic review and analysis of existing literature) on housing conditions and problems in general around the world, the definition of sustainable and affordable residential buildings (low-cost housing) and their approaches and assessment tools, success criteria and success factors to achieving sustainable and affordable housing as well as the reality of housing in Palestine. Based on this analysis, an assessment model was developed to measure the sustainability and affordability of residential buildings.

A comprehensive explanation of the research methodology is included in **the third phase** of the research study. This includes the research strategies and approach, as well as the research techniques and methods.

To validate the developed assessment model of sustainable and affordable housing, **the fourth phase** includes an analysis of case studies of sustainable and affordable housing from several countries. They were analyzed based on indicators identified from the systematic literature carried out from the critical criteria and success factors of housing sustainability and affordability performance.

The fifth phase involved selecting and analyzing case studies from the Hebron study area in terms of environmental, social, and economic factors. The case studies were evaluated for their sustainability and affordability, as well as the efficacy of applying the sustainability and affordability assessment model developed in previous stages in local housing.

In phase six, the findings from previous stages are used to develop a sustainable and affordable housing design framework.

Finally, Engineering companies was given a framework for designing sustainable and affordable residential buildings, and they worked on redesigning one of the residential buildings based on the design framework of sustainable and affordable housing to evaluate its efficacy as well as its ability to provide a more affordable and more sustainable residential buildings in Palestine.

The research stages, its process, and outcomes at various stages are presented in the research framework for the study in Fig. 3.4 below

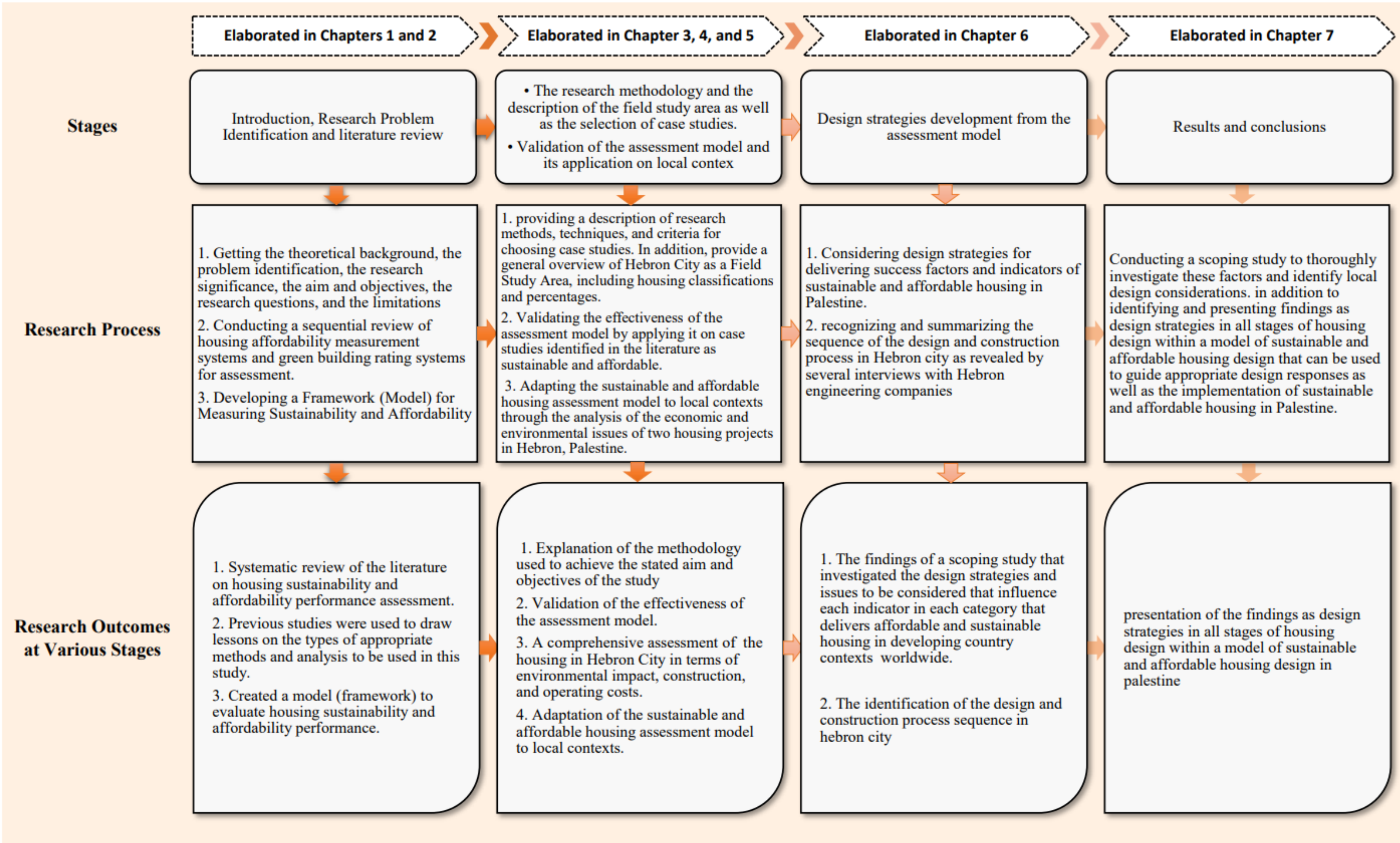


Fig 3. 4: Research Framework for the Study (Researcher, 2023)

CHAPTER 4

ASSESSMENT MODEL VALIDATION BY SUSTAINABLE AND AFFORDABLE CASE STUDIES

4.1. INTRODUCTION

The case study method is widely used in architectural research; there is no doubt that proper case studies inform good design and best practices (Nnaemeka, 2015). Case studies can be valuable as they can be a source of practical information about potential solutions to difficult problems. They are also a great method for teaching by example, learning problem-solving abilities, and developing helpful evaluation procedures (Adewumi et al., 2020).

Different residential buildings constructed to meet the principles of sustainability for low-income people were chosen as case studies for this research. in order to benefit from them in terms of design technique, strategies used, risks, and challenges faced in providing affordable sustainable residential buildings. Furthermore, the developed sustainable and affordable assessment model was validated through the application of case studies that demonstrating current best practices in one or more aspects of affordability and sustainability. The purpose of this evaluation was to validate the efficacy of the assessment model developed for assessing the sustainability and affordability of residential buildings.

4.2. A CASE STUDY OF PALESTINE - SHTAYYA RESIDENTIAL BUILDING

This section presented and discussed a case study in Nablus city in Palestine. The primary data about this sustainable and affordable case study was extracted the primary data from (Shtayyeh, 2018) research and an exclusive interview with the building's owner and designer in June 2022.

4.2.1. Project Overview

The Shtayya Building (Fig.1), chosen as a case study, is located in Nablus, West Bank. It is an environmentally friendly residential structure. According to the project manager, this project is being constructed with two goals in mind: the first is to achieve LEED certification in eight categories: location, transportation, materials, sustainable site, indoor environmental quality, water efficiency, energy atmosphere innovation, and integrative design, and the second is to achieve the lowest possible cost for better marketing.

During the design and construction stages, many strategies were used to achieve the three sustainability pillars, environmental, economic, and socio-cultural aspects in each stage.

Fig. 4. 1: Shtayya Building (SHTAYYA, 2018)

4.2.2. Nablus' Climate Data

Nablus has a Mediterranean climate, with long, hot, arid and clear summer days and cold with mostly clear winter days. The temperature typically ranges from 6°C to 29°C all year, rarely falling below 2°C or rising above 32°C (weatherspark, 2023).

Spring arrives in Nablus around March-April, and the hottest months are July and August, with an average high temperature of 29.6 °C. January is the coldest month, with average temperatures of 6.2 °C. Rain usually falls between October and March, with an annual precipitation rate of 656 mm (weatherspark, 2023).

4.2.3. Project Location and transportation

The design phase began with the selection of the project site (Figure 2), which was chosen in a vital area close to Nablus' city center. The project location meets most of the Location and Transportation credits requirements regarding the public transportation and existing the main services as educational, health, and commercial services around the project.

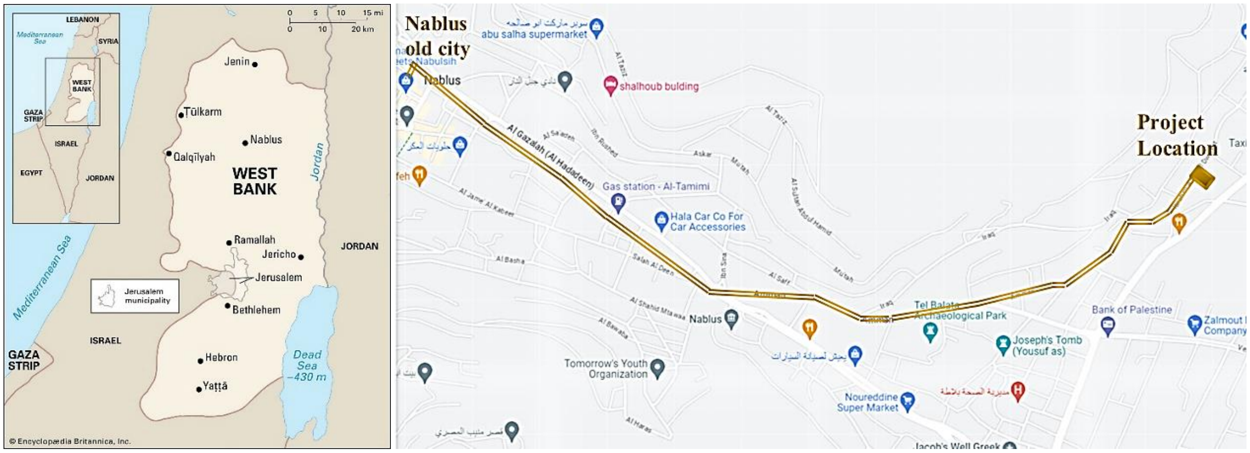


Fig. 4. 2: Shtayya Building's Location (Google Maps, 2023)

4.2.4. The Design of the Project

4.2.4.1. Site planning

The Shtayya residential building has designed to provide environmentally friendly apartments to residents with affordable prices by using passive strategies and green materials.

The distance between the front and side setbacks has been increased to allow the sun to reach all sides of the building. As a result, the distance between the building and its surroundings has grown. A parking area for the bicycles and electric car was designed with all of the required equipment and tool. 35% of the Projects land is Green Areas (there is small gardens for each flat's balconies and one big garden on the building roof for all occupants). And all of these green areas is planted with xeriscaping plants in order to save water consumption.

4.2.4.2. The apartment building criteria

Building design combines the modern and attractive form and the function, considering most of the sustainable requirements integrally without any conflict. In order to achieve the sustainable benefits from our building without adding more costs and to decrease the energy demand, we've designed our project according to the passive design specifications like; Natural Ventilation, Project's envelop insulation, Building Orientation, Natural Lighting, Rain Water Harvesting. Etc. In addition to that we've used the most powerful simulation software to create the required reports and to provide us with the essential information for LEED Design submission (like Revit & Design Builder).

Fig. 4. 3: Site Plan (SHTAYYA, 2018)

Fig. 4. 4: Ground floor plan (SHTAYYA, 2018)

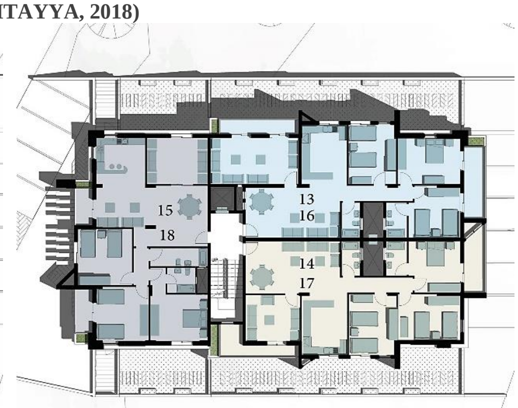


Fig. 4. 5: First floor plan (SHTAYYA, 2018)

4.2.4.3. Energy Efficiency

Energy efficiency in the building is increased by:

1. Reduce the amount of energy a building consumes

Passive techniques were used to reduce The building's energy consumption in lighting, cooling, and heating has been reduced.

The energy used in lighting has been reduced by relying on natural lighting to illuminate all interior spaces during the day and using energy-saving lighting elements to illuminate spaces when natural lighting is not available.

To reduce the energy consumed in heating and cooling the building, thermal insulation in the building envelope was used to reduce heat exchange between the outside and inside of the building, internal channels and holes were designed to improve natural ventilation, and solar chimneys were used to provide passive heating.

2. Utilize renewable energy onsite

The photovoltaic system was used in this building to provide the required electricity power to the public services (elevator, staircase, entrances, etc.).

Fig. 4. 6: photovoltaic panels on the building's roof (SHTAYYA, 2018)

4.2.4.4. Water Efficiency

- **Rainwater harvesting**

The rainwater harvesting tank is located beneath the building at the lowest point on the site. Water is collected from the building's roof via pipes.

Storm-water planters: There were vegetated areas on the site that collected storm water runoff.

These planters collect and filter water through multiple layers of soil and vegetation using bio-retention practices.

- **Gray water treatment**

The KLARMAX wastewater recycling technology has been used. The system operates in a 24-hour cycle, consisting of three phases: ventilation, sedimentation to get a top layer of clean water and the stage of pumping out clean water and resting the system. The extracted clean water can be used directly to irrigate plants and clean outer squares.

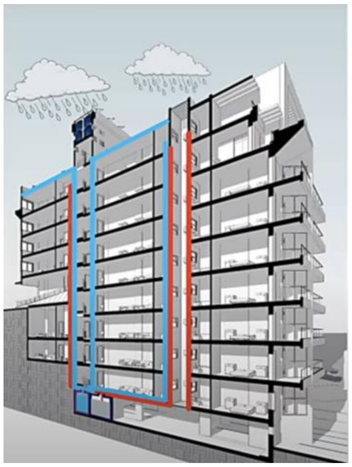


Fig. 4. 7: Rain water collection system (SHTAYYA, 2018)

Fig. 4. 8: Gray water recycling system (SHTAYYA, 2018)

4.2.4.5. Materials and resources

To achieve the lowest cost and energy consumption, eco-friendly materials were chosen. Using ThermoCoat as an external coating instead of stone and the Voided Slab System in the building structure reduced the initial cost of construction while also reducing stress on the building, requiring less reinforcing than a typical building.

- Insulation (ThermoCoat)

ThermoCoat was used as an external coating and insulation material, which has Plaster formed ThermoCoat products (Fig. 4.9), which provide heat, water, and sound insulation. To our world, which is fighting global warming, ThermoCoat Ecologic Insulation Plaster. Provides cool environments in the summer and warm environments in the winter to save up to 50% on cooling and heating costs (Fig. 4.9).

• Waterproof: provides a high level of water repellency on applied surfaces.

• Sound insulation: due to its high sound absorption capacity, it provides comfortable conditions in rooms.

• Fireproof: produces no smoke, soot, or toxic gases.

• Breathability - healthy: provides a comfortable living environment. There are no greenhouse gas emissions.

Fig. 4. 9: ThermoCoat insulation material (SHTAYYA, 2018)

- Voided slab systems (U-Boot Voided Slab System)

It is a lightweight reinforced voided flooring solution that is produced from recycled polypropylene that allows large-span floors to be easily passed without beams (Fig. 4.10), creates a space in the floor, and provides cost savings of up to 25% from concrete and iron in construction cost (Ghalimath et al., 2019).

Fig. 4. 10: U-Boot Voided Slab System (SHTAYYA, 2018)

- Building materials such as iron and cement were supplied from the factories closest to the project site, to reduce the CO2 emissions which resulted from the transportation process. The remains of the materials used in the project, such as wood and iron, were recycled and reused during the construction phase to reduce the project's waste.

4.2.4.6. Indoor environmental Quality

The conditions inside the building are most simply described as indoor environmental quality (IEQ). It encompasses not only air quality, but also access to views and daylight, occupant control over thermal comfort and lighting, and pleasant acoustics. It may also include functional aspects of space, such as if the layout allows for easy access to people and tools when needed, as well as if there is enough space for occupants. Building operators and managers can improve building occupant satisfaction by considering all aspects of IEQ as opposed to just air quality or temperature (Kamaruzzaman et al., 2019).

- **Improve indoor air quality**

The movement of air is mainly caused due to pressure and temperature differences. therefore, the interior ducts and holes were designed to enhance natural cross-ventilation as shown in Fig. 4.11. Smoking is not permitted within the building or in its immediate surroundings. To be able to smoke, the smoker must move 7.5 meters away from the building's entrances in order to ensure that smoke does not affect the indoor air quality (Fig. 4.12).

Fig. 4. 11: Air cross-ventilation through the building (SHTAYYA, 2018)

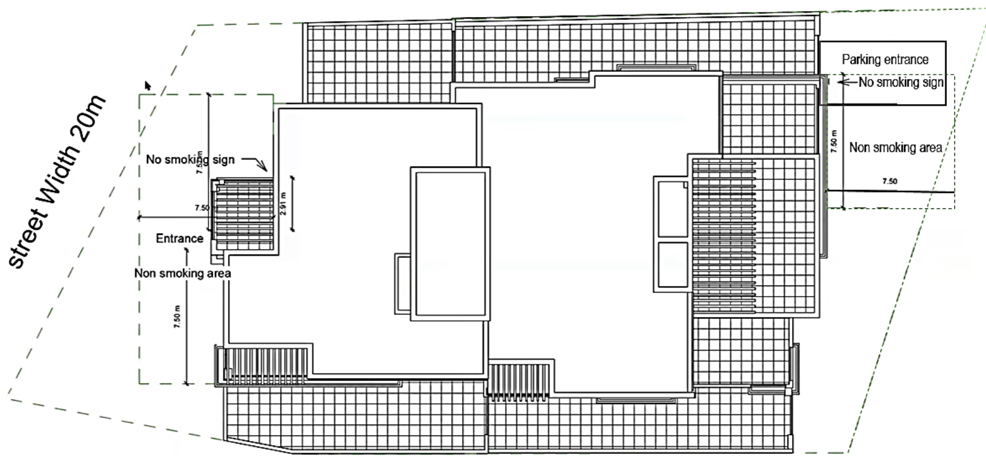


Fig. 4. 12: site plan with no smoking areas (SHTAYYA, 2018)

- **Improve indoor lighting quality**

To achieve the best indoor environmental quality, the best orientation for the building and its inner spaces was chosen using Revit and Design-Builder software.

Green lighting design matches the quantity and quality of light to the function of a space. Lighting sections for various spaces or functions were on separate controls in this building, allowing users to decide how much light they required. Task lighting has been installed where necessary, and ambient lighting has been reduced elsewhere. Occupancy sensors that turn lights off and on as needed have been used to reduce energy consumption while having little impact on building occupants.

The amount of daylighting was increased while glare and unwanted heat gain were reduced. The use of daylight in a building is thought to benefit building occupants by reducing the demand for artificial lighting. The distance between the front and side setbacks has been increased to allow sunlight to reach all sides of the building. As a consequence, the building's distance from its surroundings has increased.

- **Improve indoor thermal quality**

Sun blocks were designed based on an analysis of sun angles to provide appropriate daylight while keeping the temperature of the interior spaces under control. In the summer, south-facing windows with appropriate overhangs provide indirect light, and in the winter, both heat and light are provided (Fig. 4.13). And passive heating was provided in the winter via a solar chimney that shown in Fig. 4.14.

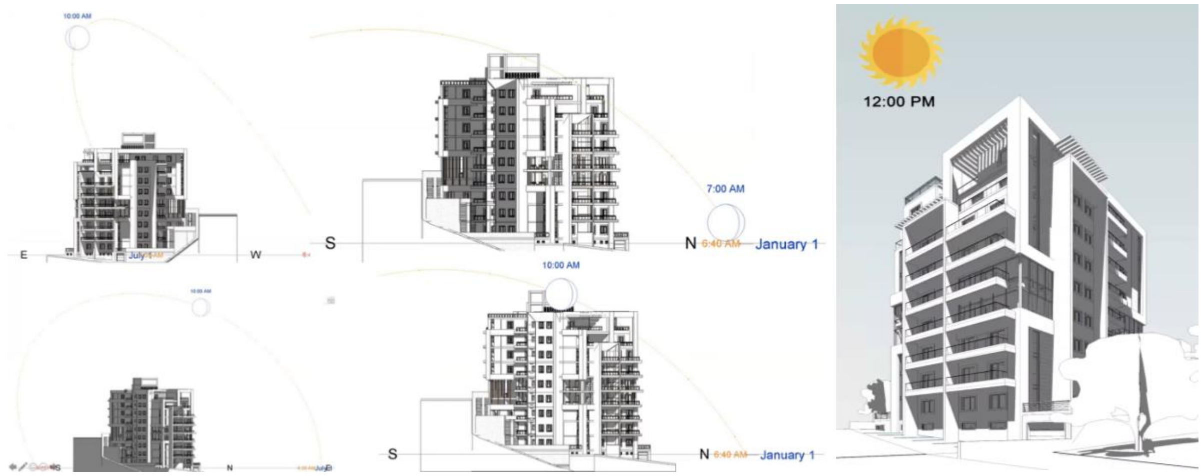


Fig. 4. 13: analysis of sun angles (SHTAYYA, 2018)

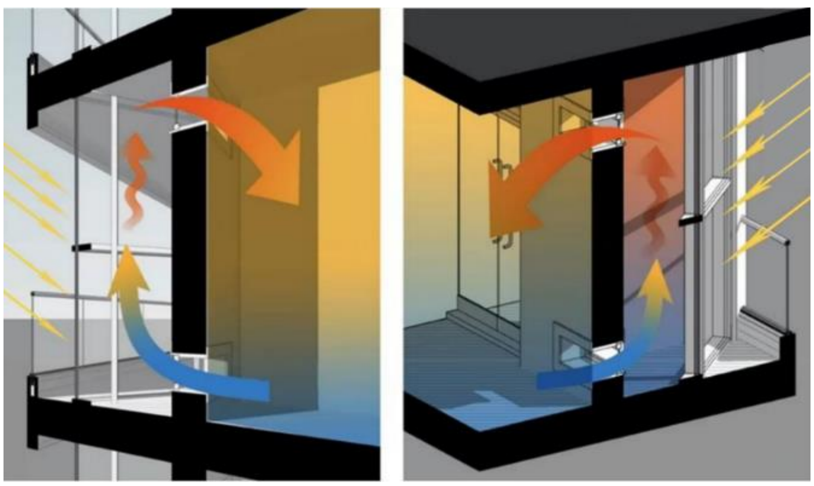


Fig. 4. 14: solar chimney (SHTAYYA, 2018)

A typical double-glazed window with high-solar gain low-E glass and argon gas fill was used (Fig. 4.15). These windows were designed to reduce heat loss while allowing solar gain.

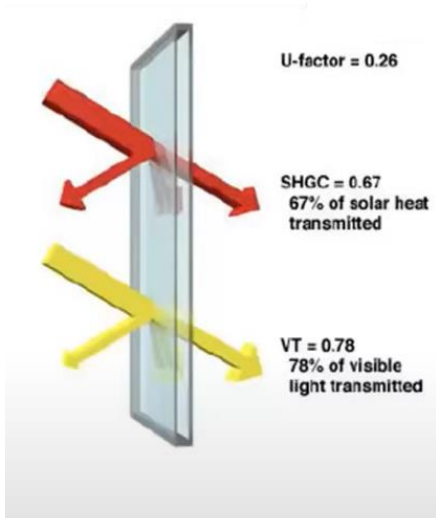


Fig. 4. 15: double-glazed window with high-solar gain (SHTAYYA, 2018)

4.2.5. Cost Estimation

There is insufficient information about the actual initial cost of the building's construction. The building supervision team explained that the exterior wall used in the building saves approximately 60% more than traditional external walls, as shown in Table 4.1. This cost, however, does not include the remaining materials and construction work in the project, as well as any additional systems that have been added. According to the owner, the minimum price for the apartment without finishing is 340 dollars per square mete (SHTAYYA, 2020).

Table 4. 1: comparative between Palestinian Stone-Wall and Thermocoat-Wall (SHTAYYA, 2020)

Palestinian Stone-Wall		Thermocoat-Wall	
Wall Layers	**Cost (USD/m²)**	**Wall Layers**	**Cost (USD/m²)**
Internal plaster	6.40	Internal plaster	6.40
Hollow block	8.30	Thermocoat Block	19.40
Construction workers fee (for blocks)	3.30	Construction workers fee	3.30
Insulation material (mineral wool)	2.80	--	--
Concrete layer	5.50	--	--
Stone layer	33.20	--	--
Construction workers fee (for stone)	38.80	--	--
Filling	5.50	--	--
Total	**103.80**	**Total**	**29.1**

4.2.6. Life Cycle Analysis

The life cycle energy analysis of the building was carried out using Revit-Software. The life cycle energy cost in one year, as shown in the table 4.2 and graphs in Fig. 4.16, was $148,527 USD (Ibtehal, 2017).

Table 4. 2: Life Cycle Energy Use/Cost of Shtayya building (SHTAYYA, 2020)

Life Cycle Energy Use/Cost	
Life Cycle Electricity Use	9,635,529 KWh
Life Cycle Fuel Use	37,180,621 MJ
Life Cycle Energy Cost	148,527 USDs

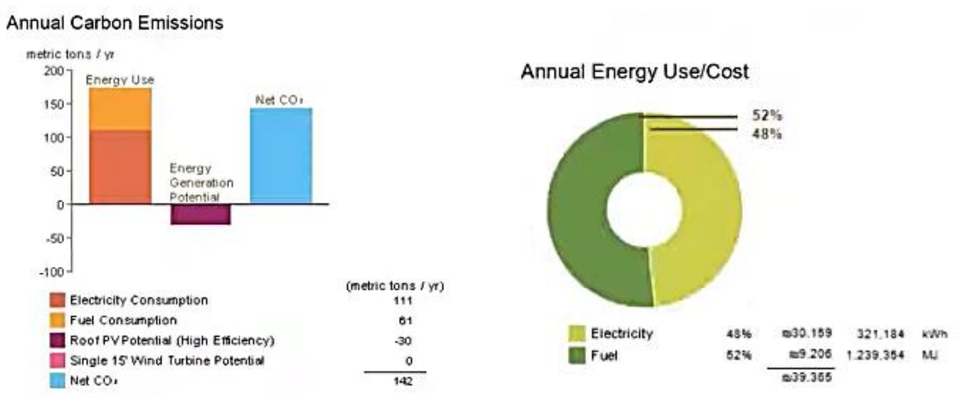


Fig. 4. 16: Annual carbon emissions and energy use for shtayyah building (SHTAYYA, 2020)

4.3. A CASE STUDY OF JORDAN - ABU ALANDA RESIDENTIAL BUILDING

4.3.1. Project overview

In 2010, the United States Agency for International Development-The Instituting Water Demand Management in Jordan (USAID-IDARA) hosted a low-income housing initiative in Jordan's highlands. The purpose was to create an efficient design of water and energy housing, which will assist in lowering the operating costs of low-income housing in Jordan. This project is located in Amman's Abu-Alanda district and features a typical four-story apartment building, which is a popular housing style in Jordanian cities and is employed in large-scale housing complexes, particularly in the low-income sector (CSBE, 2010). The project proposed a solar water heater system, an energy-efficient design that relies on the optimal orientation to maximize natural light entering the rooms, electricity counters, wind catchers for cross ventilation, and using overhangs. Furthermore, the design advocated for the use of near-zero volatile organic compounds (VOC) paintings, local materials, double-glazed windows, and thermal insulation. In addition to water counters, it proposed the use of water harvesting and grey water systems (Ali and Alzu'bi, 2019). This section presented and discussed this project using the primary data extracted from (Saymeh and Abuhassan, 2010; Ali and Alzu'bi, 2019).

4.3.2. Project location and transportation

The chosen location is part of a Housing and Urban Development Corporation (HUDC) low-income housing development in the Abu Alanda neighborhood of Amman's southeastern region. Abu Alanda is situated at 31.53° north latitude and 35.58° east longitude.

HUDC has prepared a plan for the Abu Alanda low-income housing development, which includes identifying low-income residential plots. Three phases have been established within the area. The location for this project was chosen as Phase 3 of the Abu Alanda development (CSBE, 2010).

The road layout and plot division have been designed, as have the green spaces. The project was carried out in an eight-plot block on the Phase III site (plot numbers 574 - 667).

4.3.3. Amman climatic data

Amman has a Mediterranean climate, with long, hot, arid, and clear summer days and cold, mostly clear winter days. Throughout the year, temperatures typically range from 3.3°C to 31.7°C, with temperatures rarely falling below -6°C or rising above 43°C (Amman Climate, 2023). The annual rainfall ranges from 500 mm in the northwest to 150 mm in the southeast. The annual rainfall in the site area ranges from 250 to 300 mm. The predominant wind direction is west (CSBE, 2010).

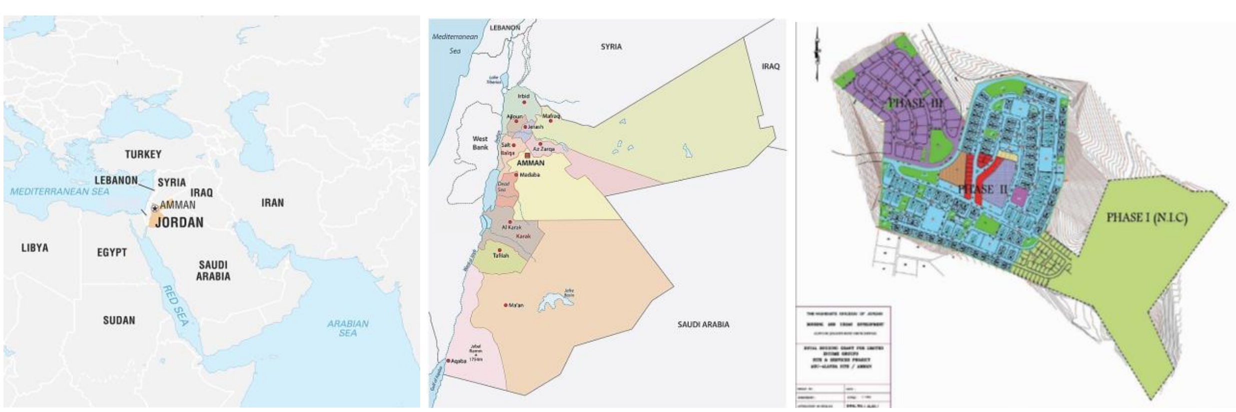


Fig. 4. 17: Project Location (CSBE, 2010)

4.3.4. The design of the project

4.3.4.1.Site planning

The site was divided into two parts. The park connects Zones 1 and 2. The main concept was a continuous pedestrian path that connected courtyards. Each residential unit reflects onto a courtyard, creating an introverted environment in which neighbors can meet and interact.

The central pedestrian path in the first section is linear because the land runs north-south. The path in Part 2 is zigzagged to keep the buildings oriented north-south. The design also provided more space for the masses on the southern façades by transforming the buildings (Fig. 4.18).

Fig. 4. 18: site plan (Saymeh and Abuhassan, 2010)

4.3.4.2.The apartment building criteria

- The car entrance to the parking level has a three-and-a-half-meter side setback.
- Sunk-in gardens were added to the apartments on levels 1 and 2; they first allow sunlight into the rooms while also providing a pleasant landscaping experience for the residents. Second, they provide privacy and security by separating these apartments from the common courtyard (Fig. 4.19).
- There are two entrances, one from the lower street, which serves 12 apartments, and the other from the upper street, which serves the remaining 9 apartments.
- Residents in residential complexes may customize the courtyard to their liking. Some may use it as a play area for children, while others may prefer landscaping to give their apartment complex a distinct identity.

- The stepped arrangement of the buildings creates terraces at various levels. As shown in Figure 4.20, this allows the apartments to shade each other and the courtyard. Furthermore, the building's various levels assist in reducing heat loss from the Solar Thermal System.

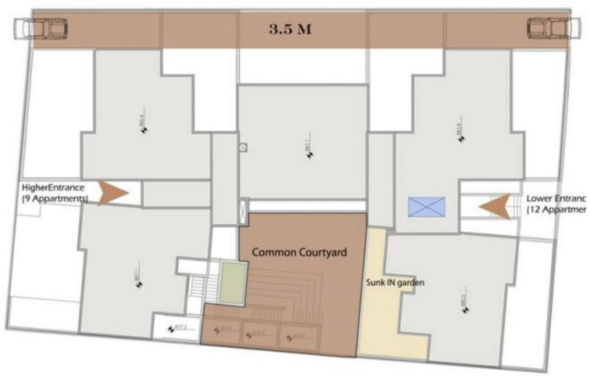


Fig. 4. 19: Conceptual plan showing the proposed setback, the entrances and the courtyard (Saymeh and Abuhassan, 2010)

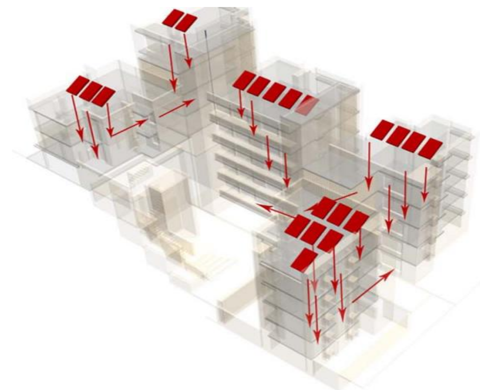


Fig. 4. 20: stepping of masses reduces the heat loss of the solar system (Saymeh and Abuhassan, 2010)

4.3.4.3.Energy Efficiency

Passive indigenous responses to the environment are utilized to achieve energy efficiency, which include the following measures:

- The design of the apartments is aimed at maximizing the amount of natural daylight that enters the rooms. To this end, 70% of the living rooms and kitchens face the southern sun, ensuring maximum solar gain in winter.
- Vertical windows are used in the western and eastern windows to prevent heat gain from a low-angle sun (Fig.4.21).
- Overhangs on the southern-facing windows prevent summer solar heating.
- The Courtyard balcony features wet straw, which cools the air as it passes through and enters the lower apartment through a screened unit.
- Collestra Façades are used in the western and eastern stairwell elevations to reduce heat gain caused by the sun's low solar angle.
- Wind is also taken into consideration to ensure proper ventilation and cooling within the apartments. wind catchers are positioned to catch western prevailing winds and pump air into areas with less air movement.

Fig. 4. 21: vertical windows

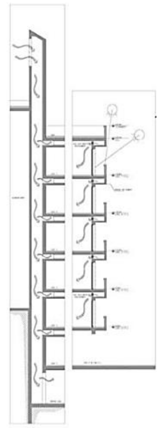


Fig. 4. 22: Wind catchers (Saymeh and Abuhassan, 2010)

Fig. 4. 23: Collestra Façades

The initial degree of energy conservation is dependent on the people themselves. As a result, the project recommends installing water and electricity counters in the apartments. These residents can estimate their energy consumption. Psychologically, it helps in raising people's awareness of the importance of energy conservation.

4.3.4.4.Water Efficiency

- **Rainwater harvesting**

The rainwater harvesting tank has been positioned below the designated park, at the lowest point on the site. Water is collected by means of pipes from the terraces of eight plots. The accumulated water is intended for the irrigation of the garden situated within the park. (Fig.4.24).

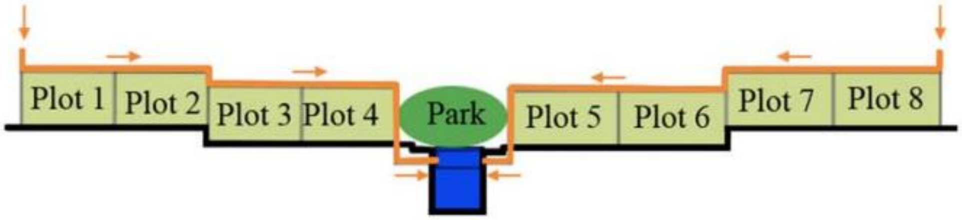


Fig. 4. 24: Rainwater harvesting tank below the park (Saymeh and Abuhassan, 2010)

- **Gray water treatment**

The water that has been utilized in bathtubs, washing machines, floor drains, sinks, and showers will be gathered in a basement tank with a capacity of 5 cubic meters. Subsequently, this collected water will undergo a filtration process through a Gray Water filter. The initial stage of this filtration process entails the use of a stainless steel screen mesh to filter out hair and other solid materials.

The water then proceeds to pass through multiple layers of wood, sand, stone courses, and cement. The filtered water will then be directed to a second tank that will pump it to an upper tank. This upper tank will be connected to 22 tanks, 21 of which are designated for the residents' use for toilet flushing and cleaning purposes via specialized pipes, while one tank is reserved for watering plants in the common courtyard using drip irrigation to keep the gray water out of the children's reach. All the tanks have valves for disposing of the water when required (Fig.4.25).

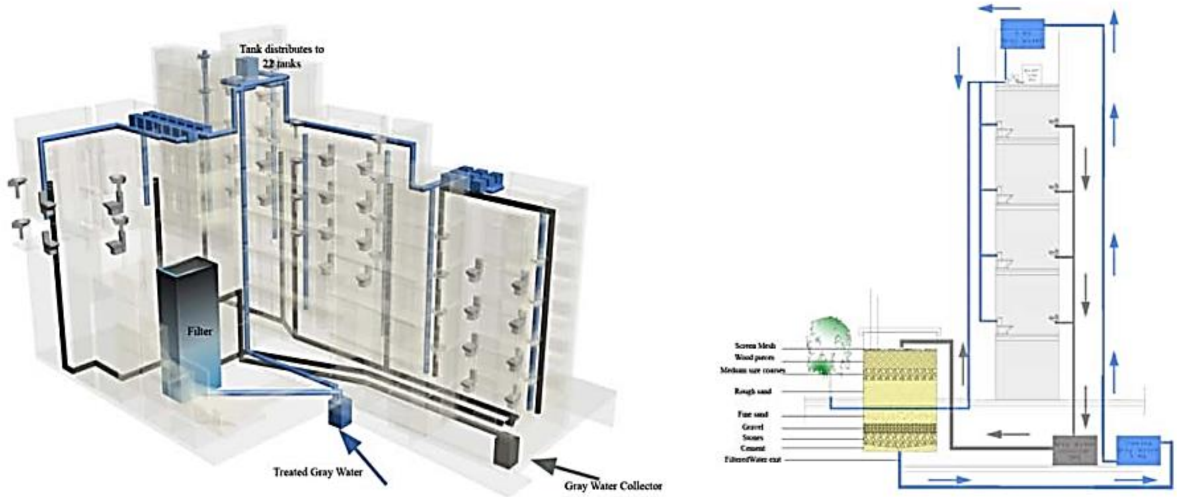


Fig. 4. 25: The process of Gray Water Filtering (Saymeh and Abuhassan, 2010)

4.3.4.5.Materials and resources

The materials used in the construction of this project are environmentally friendly, and they are as follows:

- The buildings are built with locally sourced concrete, which is made up of local cement, aggregates, and reinforcement. Concrete is used in construction to create structures that are durable and long-lasting throughout their entire life cycle. Furthermore, due to its ability to absorb and retain heat, concrete construction saves energy. Concrete production is tailored to each project, resulting in less waste. Additionally, once the building has served its purpose, it can be recycled and crushed.
- Ceramic tiles, specifically local ceramic tiles for services and porcelain floor tiles, are used in the project's construction. Ceramic tiles are manufactured using natural raw and clay materials sourced locally.

- The building structures are painted with high-quality pure acrylic emulsion paint. Pure acrylic is nearly free of volatile organic compounds (VOCs), non-toxic, and biodegradable.
- The doors and double-glazed frames of the building's windows are made of aluminum. Aluminum is a strong, lightweight, and recyclable material that is ideal for construction. Furthermore, recycling aluminum uses only 5% of the energy used in the original production process and produces minimal emissions.

  - **Insulation**

The building is insulated to reduce the potential of thermal bridging. Thermal insulation is used on both the ceilings and parking roofs. To offer the external walls a low thermal resistance and U-value, 5 cm of expanded polystyrene is employed (Fig.4.26). Double-glazed windows also used to decrease future costs.

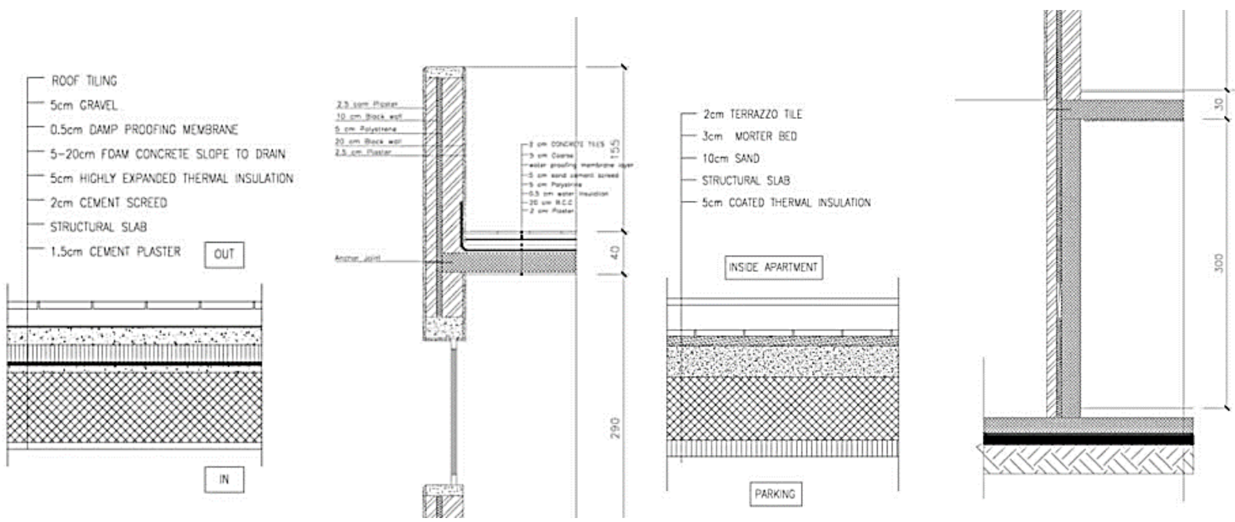


Fig. 4. 26:Thermal Insulation (Saymeh and Abuhassan, 2010)

4.3.4.6.Indoor environmental Quality

- Improve indoor air quality

The apartments on the upper streets are situated on columns to avoid obstructing the airflow into the courtyard. The air will flow over a bamboo plantation. The Bamboo's structure functions as a grill, allowing air to pass through it. In the summer, it will be sprinkled to keep its surface moist. The bamboo cools the air that goes through it. The air then becomes heavy and descends to chill the courtyard (Fig.4.27).

- Improve indoor lighting quality

The apartments' rooms are designed to let in as much natural light as possible during the day. In particular, 70% of the apartments' living rooms and kitchens face the southern sun, which helps to maximize the sun's energy during the winter season.

- Improve indoor thermal quality

The Trombe-Michel wall is a type of wall that has vents near both the floor and the ceiling. The top vents allow heated air to enter the room, pulling cooler air from the bottom up with it. As a result, the temperature of the cavity air and the outside surface of the wall are reduced, resulting in less heat loss (as shown in Figure 4.28).

There is a central heating system in place, which is a two-pipe system. This means that each radiator has a hot feed from the boiler as well as a separate cold feed, allowing the user to turn off any radiator and set each radiator to a different temperature. When the temperature in the house drops by 5 degrees, the boiler typically heats the radiators every 40 minutes. If the temperature in any room drops too quickly for any reason, the radiator's thermostat will open, reducing the pressure on the boiler. The boiler will then turn on, sending hot water to the open radiator but not heating the rest of the system until it is needed. Each radiator has a thermostat, and the radiators used have back fins that limit heat loss into the walls, resulting in cost savings.

Fig. 4. 27: Bamboo Plant in cooling the courtyard (Saymeh and Abuhassan, 2010)

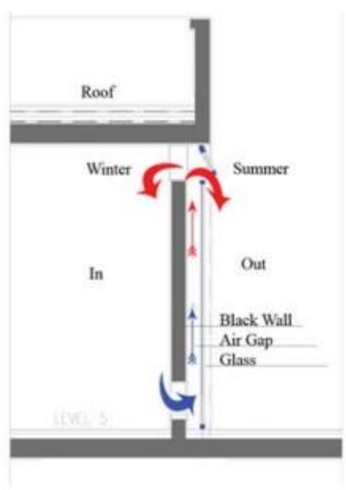


Fig. 4. 28: Trombe-Wall Mechanism (Saymeh and Abuhassan, 2010)

4.3.5. Cost Estimation

The initial cost of the building was estimated to be 868,526.8 USD as shown in Table 4.3, which included the building's substructure and superstructure, finishing, facades, landscaping and external works, roof works, mechanical and electrical works.

4.3.6. Life Cycle Analysis

LCCA = Initial cost + Replacement cost - Residential value + 20 (total operating and repair costs)
Initial cost =868,526.80 USD

The cost of replacement is equal to The cost of replacing any system that is not expected to last the entire time period is zero.

Residual value is any remaining value that the resident can recover at the end of the twenty-year period = 1,408,500 USD

Total cost of operation and repair (28+14+14) *12* 20*21=282,240 USDs as follows:

- 21 is the number of apartments
- 20 is the requested time for the analysis
- 28 USD electricity bill per apartment
- 14 USD is the monthly maintenance cost
- 14 USD is the monthly water bill per apartment

LCCA= 868,526.80 +0 - 1,408,500 + 282,240 LCCA= -257,733 USD

Table 4. 3: the quantity and cost calculation for the building's initial cost (Saymeh and Abuhassan, 2010)

Item No.	Description	Unit	Quantity	Unit Price (USD)	Total Price (USD)
1	**Substructure**				**221,060**
1.1	Excavation & Earth Works	m^3	3,800	4.20	15,960
1.2	Backfilling	m^3	200	4.20	840
1.3	Plain Concrete	m^3	100	97.30	9,730
1.4	Reinforced Concrete	m^3	1,210	141.00	170,610
1.5	Bitumen Waterproofing	m^2	2600	9.20	23,920
2	**Superstructure**				**183,255**
2.1	Reinforced Concrete	m^3	700	141.00	98,700
2.2	Concrete Masonry Unit				67,755
2.2.1	150mm thick, for partitions between apartments & outer walls	m^2	3,750	11.30	42,375
2.2.2	100mm thick, for inner partitions & outer walls	m^2	1,800	14.10	25,380
2.3	Thermal Insulation	m^2	3,000	5.60	16,800
3	**Finishing**				**232,260.5**
3.1	Internal Plastering	m^2	7,000	8.50	59,500
3.2	Ceramic Tiles	m^2	1,650	22.55	37,207.5
3.3	Terrazzo Tiles	m^2	1,530	14.10	21,573
3.4	Aluminum Works	m^2	400	136.70	54,680
3.5	Wooden Doors	m^2	250	100.00	25,000
3.6	Paint	m^2	7,000	4.90	34,300
4	**Façades**				**31,566**
4.1	Plastering	m^2	1,800	8.50	15,300
4.2	Paint	m^2	1,800	7.00	12,600
4.3	Metal Works	m^2	52	70.50	3,666
5	**Roof Works**	m^2	**600**	**42.30**	**25,380**
6	**External Works & Landscaping**				**10,709.7**
6.1	Paving	m^2	600	15.50	9,300
6.2	Agricultural Soil & Plantation	L.S.	1	1,409.70	1,409.7
7	**Mechanical Works**				**96,207.3**
7.1	Thermosiphon System	Apt.	21	2,481.00	52,101
7.2	Solar auxiliary system	Apt.	21	570.90	11,988.9
7.3	Bathrooms Fixtures	Apt.	21	380.60	7,992.6
7.4	Gray water Filtration System	Apt.	21	408.80	8,584.8
7.5	Networks	Apt.	21	740.00	15,540
8	**Electrical Works**				**68,088.3**
8.1	Power Fixtures	Apt.	21	1,452.00	30,492
8.2	Lighting Fixtures	Apt.	21	507.50	10,657.5
8.3	Low-Current systems Fixtures	Apt.	21	352.40	7,400.4
8.4	Conduits, Cabling & Wiring	Apt.	21	930.40	19,538.4
Total					**868,526.8**

4.4. A CASE STUDY OF KENYA- NAIROBI'S ZIMA HOMES HOUSING PROJECT

4.4.1. Project Overview

The Zima Homes project connects affordable, climate-smart homes with innovative housing finance models, making them available to a common target audience of families in the bottom 40% of the income pyramid. The Zima Affordable Homes Project is a housing development on a 2022-square-meter parcel of land on Nairobi's Gitaru Road in Wangige.

Zima Homes plans to construct 137 housing units, including 16 studios, 81 one-bedrooms, and 40 two-bedrooms. The 137 units will provide housing for an estimated 338 people across a three-stage development plan. The average price of these homes was USD $23,000, with the cheapest units priced at USD $14,000. It also offers rental services starting at USD $90 per month (Cities Investment Portal., 2022).

4.4.2. Project Location

Zima Homes is ideally located to reduce residents' daily commuting time while allowing them to live in a peaceful environment. The site is adjacent to the new Western Bypass and is located in the rapidly growing neighborhood of Wangige in Nairobi, Kenya's capital city. It is centrally located and well-connected to business and shopping centers (zimahomes, 2022).

Nairobi is located in Kenya's south-central highlands, in East Africa, at an elevation of approximately 1,680 meters. It is 480 kilometers northwest of Mombasa, Kenya's main port on the Indian Ocean (Lotha, 2023).

Fig. 4. 29: Kenya location (Britannica, 2023)

Fig. 4. 30: Nairobi city location (CDC, 2023)

Fig. 4. 31: Project location (zimahomes, 2022)

4.4.3. Nairobi's Climate Data

Nairobi has a subtropical highland climate (Cwb) according to the Köppen climate classification. Evenings can be cool at 1,795 meters above sea level, especially in June and July, when temperatures can drop to 5 degrees Celsius. From December to March, the sun shines the brightest, and daytime temperatures average in the high twenties Celsius. The average maximum temperature during this time period is 28 °C (United Nations, 2007).

There are rainy seasons, but rainfall can be moderate. The cloudiest period of the year is immediately following the first rainy season, when conditions are typically overcast with drizzle until September. Seasonal differences are minimal in Nairobi due to its proximity to the equator. The seasons are classified as wet and dry. For the same reason, sunrise and sunset times vary little throughout the year (Gaisma, 2023).

4.4.4. The Design of the Project

The primary goal of the project is to highlight innovation in sustainable design principles that incorporate alternative building materials and technologies. To accomplish this, we created modular layouts that prioritize easy-to-build, replicable designs. Our intelligent design principles optimize material use and waste while adhering to strict low-carbon design and environmental performance targets. In addition, we use inclusive and community design approaches to ensure that our project meets the needs of all community members.

4.4.4.1.Site planning

The project site is located along Gitaru Road in the Kibiku-Ngababa area, about 1.3 kilometers from Wangige Town in Kiambu County.

The proposed development includes 143 housing units of varying sizes. The apartments will be located in three four-story blocks on a 2022-square-meter plot of land. The unit density was determined by a combination of factors, including the adherence to affordability requirements, the creation of a comfortable and dignified environment, the requirement to comply with zoning regulations, and the best use of available land. A modular layout with a 3m X 3m grid was chosen as it allowed for flexibility in unit sizes and functions.

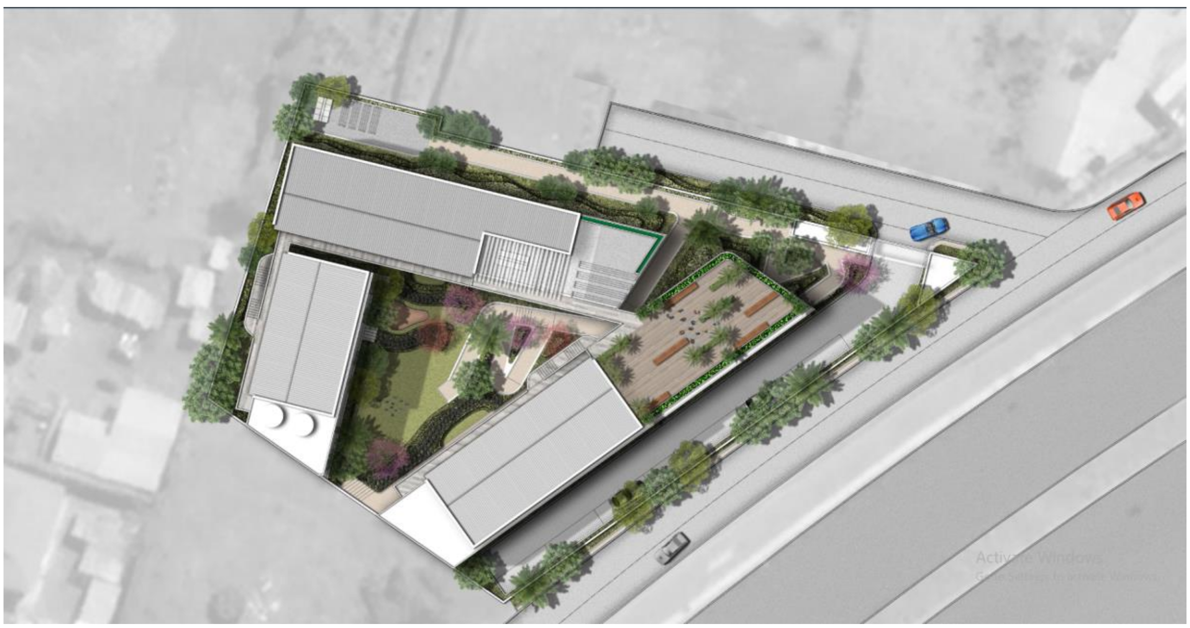


Fig. 4. 32: Site plan of Zima Homes (zimahomes, 2022)

4.4.4.2.The apartment building criteria

The Zima Homes Project will provide 137 affordable housing units over three phases, providing housing for 338 people. There will be three types of units built in three four-story blocks of apartments: 16 studios, 81 one-bedroom units, and 40 two-bedroom units. Block C has 25 units, including 6 studios, 13 one-bedroom apartments, one two-bedroom apartment, and five two-bedroom duplexes. Block B has 53 units, including 7 studios, 28 one-bedroom apartments, 3 one-bedroom duplexes, 6 two-bedroom apartments, and 9 two-bedroom duplexes. Block A has 59 units, including three studios, 37 one-bedroom apartments, eight two-bedroom apartments, and eleven two-bedroom duplexes. These homes were designed to be IFC EDGE certified (zimahomes, 2022) -EDGE " (Excellence in Design for Greater Efficiencies) is an international green building certification system focused on making buildings more resource-efficient" (EDGE, 2023).

4.4.4.3.Energy Efficiency

It is estimated that the power demand for buildings will be 260 KVA, assuming a single-phase supply to each 4KVA unit. The existing grid electricity supply network in the area will provide the power. The presence of occupants in the houses will increase the demand for grid energy. This is due to the extensive use of household electronics, as well as the need for increased electricity to supply these electronics.(ESIA, 2021).

The Zima homes are EDGE Certified, with energy savings ranging from 23% to 33% (Buildx Studio, 2020). Solar energy technologies for lighting, water pumping, and water heating are among the project designs. Energy-saving measures in building designs have become an important aspect of modern architecture. Installing properly sized windows that allow maximum natural light entry while maintaining a warm internal environment is one of these measures. Energy consumption is monitored throughout the life of a project by installing and reading energy consumption meters. As a result, any increase in demand is expected to have negligible or minor consequences (ESIA, 2021).

4.4.4.4.Water Efficiency

The total water demand for the project, assuming full occupancy by families, is estimated to be 35m3/day. The water source is an on-site borehole that was drilled and outfitted during the housing development's construction phase. A hydrogeological survey on the site revealed a moderate groundwater potential, with a borehole drilled on the site capable of producing more than 6m3/hr of water. The borehole is at least 250 meters below ground level (ESIA, 2021).

The Zima homes are EDGE Certified with water savings of 29% (Buildx Studio, 2020). Rainwater-harvesting facilities for use in cleaning and irrigation of lawns, as well as the use of high-efficiency water fixtures, are sustainable features related to increasing water efficiency in buildings. High-efficiency water fixtures include Efficient Water, Water-efficient Faucets in Bathrooms, Water-efficient Faucets in Kitchen, and Closet Water-efficient Showerheads (ESIA, 2021).

4.4.4.5.Materials and resources

The cost of construction materials accounts for the majority of the investment required to construct a building. An examination of the material's cost, social acceptance, and embodied energy are important factors in determining its suitability for Zima Homes. These factors must be carefully considered to ensure the selection of appropriate materials. The following criteria were used to select materials:

- Local labor buildability: whether or not the average local construction worker has experience or skill with the material.
- Price: the market price of the material
- Building Code Acceptance: Whether the material is approved for use in the current Kenyan building code.
- Embodied energy: the amount of energy expended in the production of the material.
- Build time: The speed with which the material can be used to construct a structure.

In recent years, there has been a lot of talk about using sustainable materials in construction. While some materials, such as rammed earth, are innovative and environmentally friendly, they are labor and overall expense intensive. Compressed Stabilized Earth Blocks (CSEBs) are a more cost-effective and environmentally friendly alternative. These blocks have a low embodied energy and cost, are highly scalable, and have already been approved by building codes. Stone, on the other hand, is a viable material because of its ease of implementation and low cost, but it has a high embodied energy due to transportation and quarrying. As a result, the use of CSEBs can be a practical and long-term solution for construction projects that want to reduce their environmental impact while keeping costs low (ESIA, 2021).

The main chosen materials were masonry stones for load-bearing and external walls, and concrete panels for non-load bearing internal walls. There were also many prefabricated materials, most of which were sourced locally. This includes prefabricated wall panels as well as beam-and-block floor (Alderton, 2022). Prefabricated materials are more sustainable than traditional materials because they are built in less time and have their quality checked at the factory (Harris, 2023).

4.4.4.6. Indoor environmental Quality

- Improve indoor lighting quality

The Zima Homes Project was created to promote user dignity and health by focusing on key environmental comfort factors. Each home includes balconies, wide hallways that can be used as shared communal areas, and a conscious effort to maximize natural lighting (Alderton, 2022). Windows were properly sized to let in as much natural light as possible, and solar energy technologies were used to enhance lighting (Harris, 2023).

- Improve indoor thermal quality

Through passive design, the project ensures thermal comfort. People inside the space do not need to use air conditioning or turn on the lights because the building's key features include cross-ventilation and large windows with sun-blocking shades (Alderton, 2022).

4.4.5. Life cycle analysis

The project's total construction cost is estimated to be 1757000 USD. The cost of key project elements is summarized in Table 4.4 below.

Table 4. 4: ZIMA Homes Elemental Construction Cost Evaluation Summary, 2021

Proposed Construction of ZIMA Homes Elemental Construction Cost Evaluation Summary June 2021			
	Total cost (USD)	**Rate per m²**	**% of construction cost**
Block A	567,300	203	43%
Block B	440,830	190	33%
Block C	226,322	218	17%
Common Services	98,678		7%
Cost of Building Works	**1,333,130**	**204**	**100%**
Add 5% preliminaries (Electricity, Water, Security, insurances, permits, health and safety…etc)	66,656	--	--
Vat (16%)	223,966	32	--
Add 10% contingency (To be expended on authority of the client)	133,313	--	--
Total Construction Cost	**1,757,068**		
Average Cost Per m²	**236**		

4.5. SUSTAINABILITY AND AFFORDABILITY ASSESSMENT

The assessment model has been tested in recent housing development projects that incorporate the most recent sustainability and affordability best practices. The study examined three case studies of sustainable and affordable housing, each claiming to have such characteristics. The inclusion of case studies that prioritized sustainability over affordability, or vice versa, proved beneficial as it broadened the scope of the assessment model.

The three case studies were evaluated according to the sustainability and affordability assessment model developed in the second chapter of the study. These case studies have been designed as sustainable and affordable residential buildings in the cities of Nablus, Amman, and Nairobi. The purpose of this evaluation was to determine the efficacy of the assessment model developed for assessing residential buildings in terms of sustainability and affordability.

Table 4.6 summarizes the evaluation of all sustainable affordable housing case studies based on the assessment model. A rating scheme (0: does not meet (X); 1: some way to meet (Δ); 2: exceeds or meets (√)) is used to determine the degree to which each individual case meets the indicators of the criteria listed in Table 4.5.

The categorization was developed as a result of an analysis using an assessment model with 70 sub-indicators. Economic, social, and environmental indicators were given equal weighting. The case study of Abu Alanda, the medium to high density housing in Amman, Jordan, is the one that stands out. This sustainable-affordable-housing-case-study meets 87% of the affordability and sustainability criteria, according to the case study's weighted summary score through the assessment model. And the other two sustainable-affordable-housing-case-studies from Nairobi and Nablus, which scored nearly in the evaluation and also reflect, respectively, 85% and 79% of the affordability and sustainability criteria identified. After interpreting the case studies evaluation findings, it is necessary to note that the developed sustainability and affordability housing assessment model has the following limitations:

- The model incorporates various intricate indicators, and evaluating them based on three options may not entirely represent every aspect of each measure.
- the even distribution of economic, social, and environmental components as well as the equal weighting of each indicator may not be suitable, as it may lead to a greater emphasis on economic sustainability with a focus on affordable housing.

Despite the aforementioned limitations regarding weighting and summary score, it is still possible to use the sustainable affordable assessment model and provide some general inferences. The weighted summary ratings revealed which of the case studies best reflected the defined features of affordable and sustainable housing in a context where the environmental, economic, and social aspects of housing were all given equal weight. The assessment methodology was eventually deemed broad enough to include the majority of the case studies' affordable and sustainable components. The environmental and economic sustainability indicators were determined to be the most robust with metrics and performance benchmarks. The social sustainability indicators, on the other hand, were found adequate for qualitative analysis but need further improvement in terms of metrics.

Table 4. 5: evaluation of Sustainable and Affordable case studies through the Assessment Model

Assessment Model For Sustainable- Affordable Housing						
No.	**Criteria**	**code**	**Sub-indicators** / Issues to be considered under each indicator	**Nablus**	**Amman**	**Nairobi**
			Economic Viability and Housing Affordability			
1	Housing price to income	ES01	House Price in relation to income	Δ	√	√
2	Rental cost to income	ES02	Rental costs in relation to income	Δ	√	√
3	Reduced commuting cost	ES03	Reduced commuting cost	√	√	√
4		ES11	Reduced Transportation costs	√	√	√
5		ES19	Availability and access to employment	√	√	√
6		ES20	Availability of housing accommodation	√	√	√
7		SS05	Accessibility to public transportation	√	√	√
8		SS06	Accessibility to green public spaces	√	√	√
9	Reduce housing initial cost	ES06	Site preparations costs	√	√	√
10		ES07	Minimize design standards to lower the costs	X	Δ	X
11		ES12	Infrastructures costs	X	√	√
12		ES16	Reduced Non-housing costs	Δ	X	X
13		ES17	Providing human resources for housing development	√	√	√
14		ES21	Financing system	√	√	√
15		ES22	Funding organizations	X	√	√
16		ES05	Running costs for public housing	X	X	√
			TOTAL RATING	21	27	28
			Household Satisfaction			
1	End user's satisfaction on facilities	SS02	Providing Users needs and achieve satisfaction on facilities	√	√	√
2		SS27	Desirability	√	√	X
3	Functionality of housing facility	EN14	Functional efficiency	√	√	√
4	Community satisfaction	SS16	Equal and balanced distribution of housing units for households	√	√	√

5		SS20	Safety performance of housing facility (crime rate)	√	√	√
6	Social Acceptability	SS19	Social acceptability	√	√	X
		TOTAL RATING		12	12	8
The Project Team and Community Satisfaction						
1	Stakeholders' satisfaction	SS04	Achieve project Team satisfaction	√	√	√
2		SS07	Adherence to project schedules	√	√	√
3		EN04	Selection of housing projects location	√	√	√
4	neighborhoods' satisfaction	SS18	Harmonious social relationship	X	√	√
5		EN05	Mix land use Planning	√	X	√
6		EN06	Land use efficiency	√	√	√
7		EN07	Housing density	√	√	√
8		EN18	Compact planning and design	√	√	√
9	Reduced disputes occurrence	SS08	Reduced occurrence of disputes and litigation	√	√	√
		TOTAL RATING		16	16	18
Marketing and The Waiting Time						
1	Housing facility marketability	ES13	Formulate supportive housing policies	X	√	√
2		ES14	Ensure balanced housing market	X	√	X
3		SS12	Marketing the housing project facility	√	√	√
4	Time spent waiting for a housing unit	SS13	Construction cost performance of project facility	√	√	√
5		SS14	Waiting Time before receiving housing unit	√	√	√
6		SS15	Subsidies provision for housing	√	√	√
		TOTAL RATING		8	12	10
Housing Life-Cycle Costs						
1	Maintainability of housing (cost of maintenance or retrofitting)	SS03	maintainability of housing units and facilities	√	√	√
2		ES15	Cost effectiveness	√	√	√
3		ES23	Value of housing units after use	√	√	√
4	Other lifecycle cost of housing	ES04	Reduced Housing Life cycle cost	√	√	√
5	Energy and water efficiency (utility bills)	EN01	Energy efficiency	√	√	√
6		EN03	water efficiency	√	√	√
		TOTAL RATING		12	12	12
Environmental Effectiveness						
1	Environmental friendliness	EN02	Housing environmental performance	√	√	√
2		EN12	Waste management for housing project	√	√	√
3		EN19	Recycle and reuse construction material	√	√	√
		TOTAL RATING		6	6	6
Quality of Housing Performance						
1	Aesthetic view of completed house	SS09	Project Aesthetics	√	√	√
2	Technical specification of housing facility	SS10	Technical specifications of housing units	√	√	√
3	Technology transfer	SS11	Application of building technology	√	√	√
4		SS17	Tenure security	√	√	√
5		SS21	Security	√	√	√
6		SS22	Privacy	√	√	√

7		SS23	Suitability	√	√	X
8	Quality performance of housing facility	SS01	Performance of housing units	√	√	√
9		SS24	Quality of housing units	√	√	√
10		SS25	Multi type and size of housing units	√	√	√
11		SS26	Organizing the human scale	√	√	√
12		EN08	Disaster resistance	√	√	√
13		EN09	Adequate living space within small size units	X	X	√
14		EN10	Housing quality (reliability and durability)	√	√	√
15		EN11	Effective utilization of resources	√	√	√
16		EN13	Local design	√	√	√
17		EN15	Functional and structural Space flexibility	X	Δ	√
18		EN16	Building material efficiency	√	√	√
19		EN17	Environmental design criteria	√	√	√
	TOTAL RATING			34	34	36
	TOTAL			**109**	**120**	**118**

4.6. CONCLUSION

Three affordable sustainable housing projects were selected and analyzed as case studies for this study in order to benefit from them in terms of design technique, strategies used, risks, and challenges encountered in providing sustainable and affordable housing. Following that, using the sustainable and affordable assessment model developed in Chapter 2, the case studies were evaluated in terms of sustainability and affordability. The purpose of this evaluation was to validate the accuracy of the assessment model in assessing both the sustainability and affordability of housing.

The assessment model, despite some limitations with respect to weighting and summary scores, has been found to be comprehensive enough to encompass the majority of the sustainable and affordable features of the sustainable and affordable case studies.

CHAPTER 5

ASSESSMENT MODEL APPLICATION ON LOCAL CASE STUDIES

5.1. INTRODUCTION

Adapting building assessment systems to specific local contexts is a significant and impactful field that can be effectively employed in the development of buildings (Gou and Lau, 2014). Even though the indicators of the assessment model developed in the second chapter were intended to take into account the coordination of the ecological, social, and economic environments, as well as affordability, it also needs to be based on specific criteria and indicators that are dependent on local requirements within a country, to guide construction and design processes.

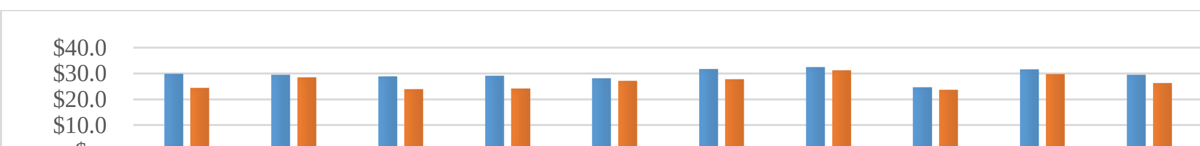
To bridge this gap, this chapter examined the economic and environmental issues of two housing projects in Hebron, Palestine, and used the sustainable affordable assessment model for evaluating their sustainability and affordability, to identify existing issues and problems. Introducing and applying global assessment systems to local buildings, on the other hand, has the potential to reveal the underlying constraints of local practices and propel sustainable and affordable building design forward. The physical and operational characteristics of the building were obtained from the owners through a review of "as built" drawings and other relevant documents. Personal interviews with architects and housing decision-makers as well as field surveys provided additional information. The information gathered contained the household monthly incomes, the initial costs of existing housing units, water and energy consumption data, air conditioning (HVAC) systems, ventilation, heating, fenestration, openings, and wall and roof assembly. This aided in the development of the base case model near the actual building. The DesignBuilder simulation program was used to analyze the energy consumption patterns, lighting, and thermal comfort factors of these housing projects. The LCCA Calculator was used to calculate the life cycle cost.

Based on the previous analysis, the sustainable and affordable housing assessment model was adjusted and customized to the local Palestinian contexts, resulting in the development of a new sustainable and affordable housing assessment model in Palestine.

5.1.1. Palestinians' living conditions in the West Bank

A variety of factors influence Palestinians' living conditions in the West Bank, including the ongoing Israeli-Palestinian conflict, political insecurity, and economic challenges. It is important to note that living conditions in the West Bank vary greatly, with some areas facing far greater challenges than others. The situation is delicate and complicated, and efforts to improve living conditions frequently involve political, diplomatic, and humanitarian considerations.

According to the Palestinian Central Bureau of Statistics (PCBS), in mid-2022, it was estimated that the population of Palestine is 5.35 million, with 3.19 million people living in the West Bank and 2.17 million in the Gaza Strip. Palestine's population is young: In mid-2022, 38% of the total population was under the age of 15. In 2021, the labor force participation rate for people aged 15 and up in Palestine was 43.4%: 68.9% for men and 17.2% for women, and the revised unemployment rate was 26.4%. The majority of workers (72.2%) in Palestine were waged employees. Concerning living standards, Poverty is a multifaceted phenomenon that has both financial (economic well-being) and non-financial (social well-being) aspects. In Palestine, where the poverty rate reached 29.2% in 2017 (13.9% in the West Bank and 53.0% in the Gaza Strip), the multidimensional poverty rate reached 24.0% in the same year (10.6% in the West Bank and 44.7% in the Gaza Strip), and the adjusted poverty rate was 4.3% in the West Bank and 19.4% in the Gaza Strip (PCBS, 2022; PCBS and ESCWA, 2020). The chart in Fig. 5.1 displays the average daily wage in dollars for wage workers in the West Bank governorates aged 15 and older in 2020.



	Jenin	Tubas	Tulkarm	Nablus	Qalqiliya	Salfit	Ramallah	Jecicho	Bethlehem	Hebron
Males	$29.8	$29.6	$28.9	$29.1	$28.1	$31.7	$32.4	$24.7	$31.6	$29.5
Females	$24.5	$28.6	$24.0	$24.2	$27.2	$27.7	$31.2	$23.6	$29.7	$26.3

Fig. 5. 1: Average Daily Wage in Dollars for Wage Employees Aged 15 Years and Above in the West Bank (PCBS, 2020)

As a result of the Israeli occupation, the Palestinian consumer in the West Bank faces to an uncertain political situation, which has an impact on the general economic condition in Palestine in terms of trade restrictions, commodity pricing, and employment opportunities. The Palestinian consumer's livelihood is extremely vulnerable, especially in the case of a change. Palestinian consumption trends have changed dramatically over the years and are expected to change further as a result of the globalized world in which Palestinians now live, which has created new needs and provided consumers with a wide range of options (ARIJ, 2015). In 2017, the monthly average per capita expenditure in the West Bank was 310.75 USD. The percentage of per capita expenditure on food groups to total per capita expenditure was 30%, followed by 16% on transportation, 14% on Imputed rent value of the dwelling, and 8 % on housing as shown in Fig. 5.2. Fig. 5.3 represents the increase in average monthly household expenditure and consumption on housing, imputed rent value of the dwelling, and transportation and communications in the West Bank from 1996 to 2017. The complicated political situation, as well as the failure to reach solutions that would allow Palestinians to control all of the West Bank's lands, have greatly increased land prices as well as the costs of building construction and transportation (Weinthal and Sowers, 2019). Rentals have also increased, with slightly more than 10% of Palestinian households renting. This corresponds with an increase in large-scale housing developments, primarily in the Ramallah-Bethlehem area, where more than 20% of households rent (Habitat III, 2014).

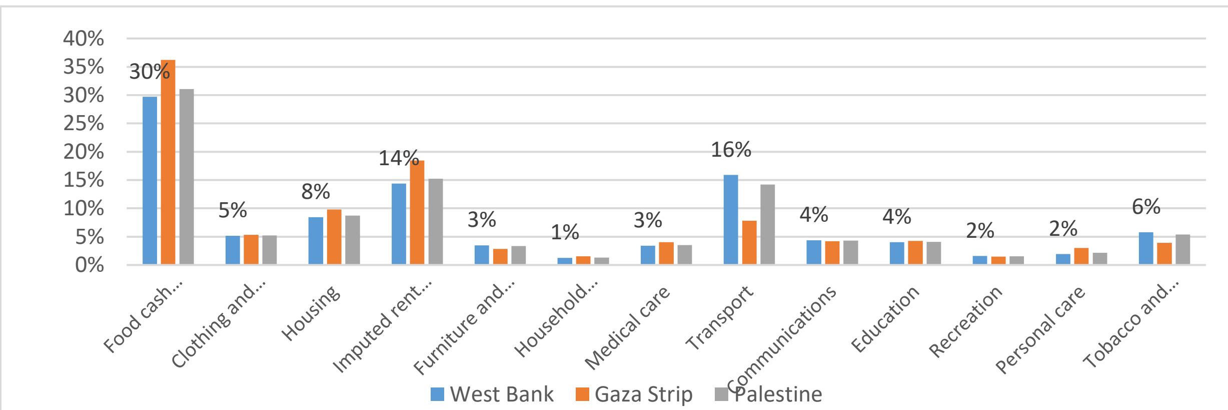
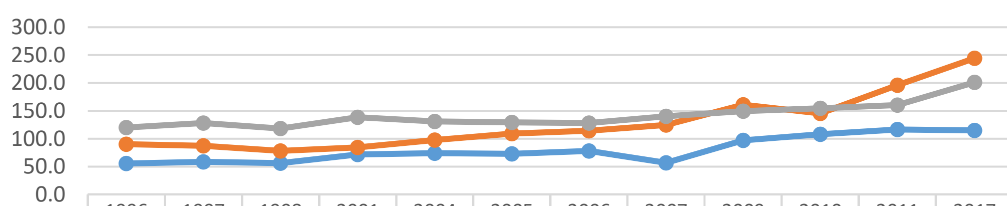


Fig. 5. 2: Percentage Monthly Household Expenditure and Consumption in Palestine by Commodities and Services Groups and Region, (PCBS,2017)



year	1996	1997	1998	2001	2004	2005	2006	2007	2009	2010	2011	2017
Housing	55.4	58.5	56.1	71.8	74.2	72.9	77.8	56.8	97.1	108.1	116.5	115.1
Transport	89.8	87.1	78.1	84.6	97.6	109.3	114.2	124.9	160.7	145.2	196.1	244.2
dwelling rent value	120.1	128.3	118.2	138.2	131.0	129.2	128.2	140.2	149.3	154.8	160.6	201.1

Housing Transport dwelling rent value

Fig. 5. 3: Average Monthly Household Expenditure and Consumption in United States Dollars (USD) in Palestine by Commodities and services Groups, (1996-2017) (PCBS, 2017)

5.1.2. Housing sector in the West Bank

After the Palestinian National Authority (PNA) establishment in 1994, it gained control of roughly 40% of the land designated as zones A and B (The World Bank, 2008). As a result, land lots are becoming scarce and expensive (Hantash and Salah, 2009). This had an impact on the construction process; Palestinian cities experienced significant and rapid residential development to address local housing shortages. The high demand for dense housing, the rise in land prices, and Palestine's rapid population growth all played important roles in the development of urban form (Abdelhamid, 2006), and caused chaos in architectural style development and planning (Badawy, 2012).

According to the PCBS 2022 census, Palestine had a total of 701,937 physical dwelling units in the year it was conducted. As the current housing typology, high-rise, and free-standing apartment buildings have displaced traditional low-rise courtyard houses. The number of levels in multi-story buildings is increasing, not just due to limited land and financial constraints, additionally due to the significance of extended family in local culture (Qądi et al., 2018). Furthermore, outdoor spaces in this housing are mostly limited to small balconies, verandas, and yards, abandoning the traditional courtyard concept and its previous socio-environmental role (Hussein et al., 2010).

Residential buildings in Palestinian cities are typically clustered and located in neighborhoods. These buildings are made up of a variety of separate or semi-connected apartment units connected by a stairway (Obaid, 2013). Apartment buildings are the dominant housing typology in current urban housing. It's similar to boxes with some openings but with less regard for environmental needs. Due to the high prices of land lots within cities, designers are now raising apartment buildings vertically - more than four floors - on the same land. These types of buildings are global prototypes that can be found in other countries, but in varying sizes and shapes (Wells et al., 2020). According to Fig. 5.4, apartment buildings will account for 54% of residential households in Palestine in 2022, 53% in the West Bank, and 65.6% in the Gaza Strip. And the majority of Palestinian household apartment units had three or four bedrooms (35% and 30%, respectively), followed by two bedrooms (16%) and more than five bedrooms (15%).

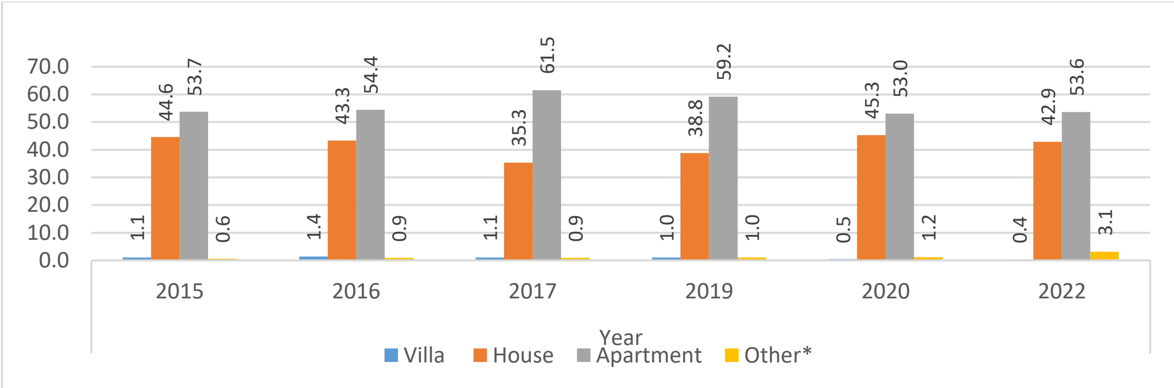


Fig. 5. 4: Percentage Distribution of Households in the West Bank by Type of Housing Unit, 2015-2022 (PCBS, 2022)

In Palestine, residents own 85% of the housing units (Monna et al., 2020). the ownership of a house is essential for Arab societies, who prefer owning their houses regardless of the associated social and economic pressures (Habitat III, 2014). Owner-occupied housing has generally been prevalent in Palestine, accounting for 81% of all housing in 2022, 87.3% in the West Bank, and 69.8% in Gaza as shown in Fig. 5.5 (Itma and Wasim, 2023). A large percentage of households in both rural and urban areas construct their own houses. people generally turn to self-funding their houses due to a lack of acceptable financing programs to satisfy their requirements in the housing market, a lack of programs to finance affordable housing for individuals with limited income, and high interest rates on housing loans (Khawaja et al., 2021).

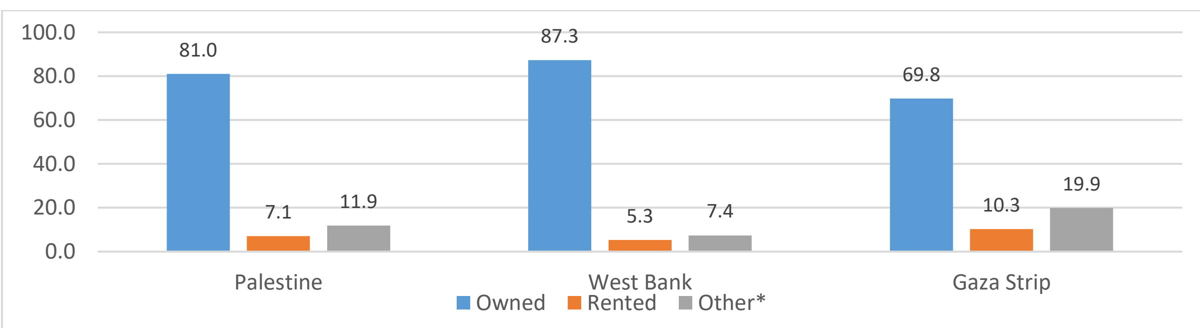


Fig. 5. 5: Percentage Distribution of Households in Palestine by Region and Tenure of Housing Unit (PCBS, 2022)

Concrete bricks, concrete, and natural stone are currently used in all fields of construction. Furthermore, few dwelling utilize thermal insulating layers that are uncommon in Palestinian houses (Said and Alsamamra, 2019). Fig. 5.6 present Building Licenses Issued in the West Bank from 2016 to 2022 based on the Construction Material Used for External Walls.

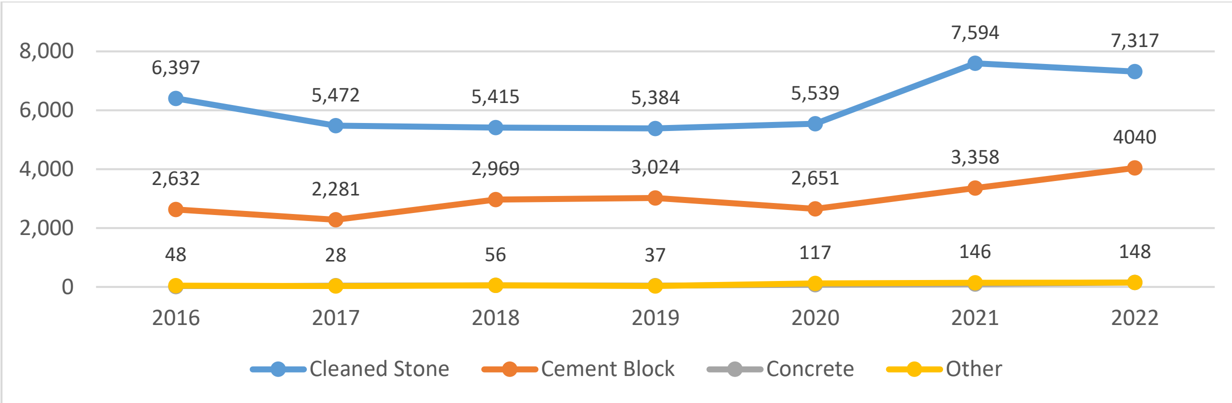


Fig. 5. 6: Building Licenses Issued in the West Bank by Construction Material of External Wall, 2016- 2022 (PCBS, 2022)

According to PCBS data represented in Fig. 5.7, spending on new building construction increased to approximately 913 million US dollars in 2013 (711.5 million in the West Bank and 201.6 in the Gaza Strip). Furthermore, spending on building maintenance and capital renovations went up marginally year on year, totaling more than 650 million US dollars (Fanack, 2020). The Construction Cost Index (CCI) for residential buildings in the West Bank reached 120.55 in May 2023, representing a 20.55% increase over the base year of 2013 as shown in Fig. 5.8. At the major group level, raw material prices increased by 4.7%, while equipment rental prices decreased by 1.5%. At the same time, labor costs and wages jumped by 40%, as illustrated in Fig. 5.9.

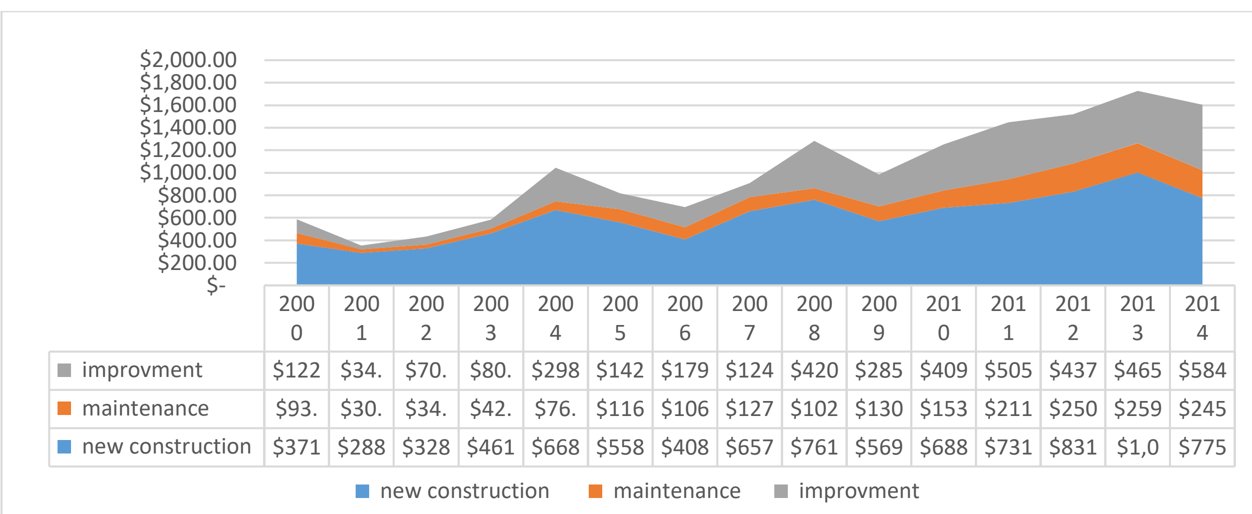


Fig. 5. 7: Value in million USD of expenditure on new construction and additions, current maintenance, capital additions repairs, and improvement on buildings in The West Bank for the years 1997-2013 (PCBS, 2014)

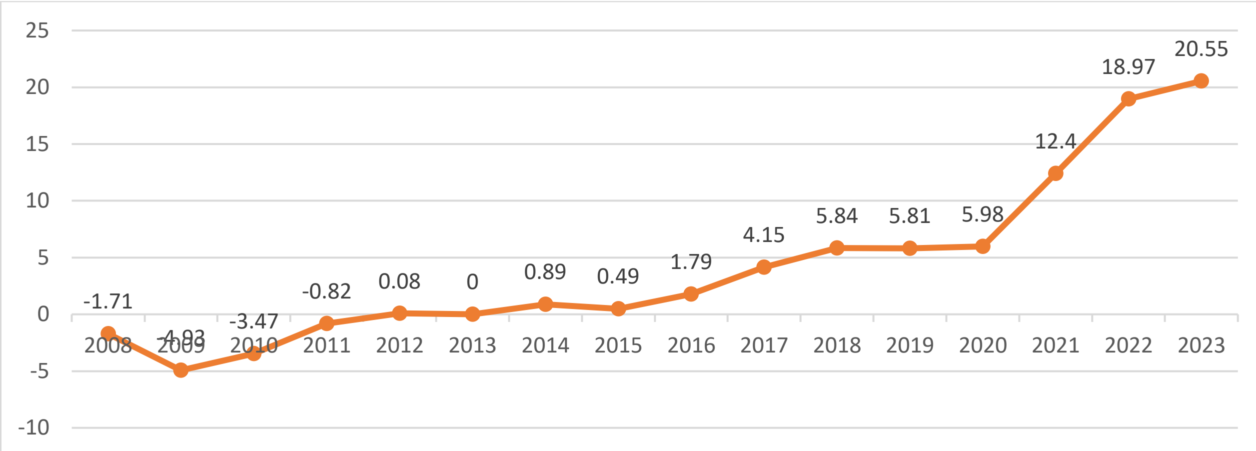
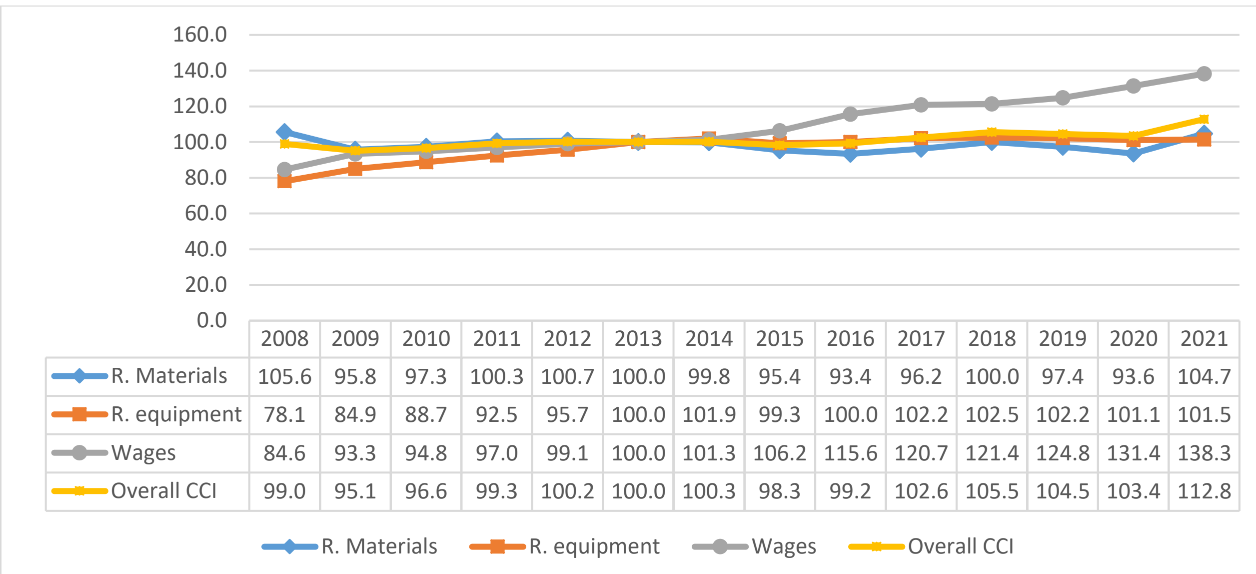


Fig. 5. 8: % Change of Construction Cost Index of Residential Building 2008-2022 (PCBS, 2022)



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
R. Materials	105.6	95.8	97.3	100.3	100.7	100.0	99.8	95.4	93.4	96.2	100.0	97.4	93.6	104.7
R. equipment	78.1	84.9	88.7	92.5	95.7	100.0	101.9	99.3	100.0	102.2	102.5	102.2	101.1	101.5
Wages	84.6	93.3	94.8	97.0	99.1	100.0	101.3	106.2	115.6	120.7	121.4	124.8	131.4	138.3
Overall CCI	99.0	95.1	96.6	99.3	100.2	100.0	100.3	98.3	99.2	102.6	105.5	104.5	103.4	112.8

Fig. 5. 9: Construction Cost Indices for Residential Buildings by Major Groups in the West Bank for 2009 - 2022 (PCBS, 2022)

Energy security is one of Palestine's key challenges today, and it is regarded as a critical impediment to achieving sustainable political and economic independence. The energy sector situation in Palestine differs significantly from that of other Middle Eastern countries for a variety of reasons, including a lack of natural resources, unstable political conditions, a financial crisis, and a high population density. Moreover, Palestine is dependent upon other countries for 100% of its fossil fuel imports and 89% of its electricity imports. Furthermore, the rapid growth of the Palestinian population, rising living standards, and rapid industrialization have resulted in massive energy demand in recent years. The total energy consumption per inhabitant in Palestine is the lowest in the region (7900 KWh/inhabitant) and costs more than anywhere else in the Middle East countries (Juaidi et al., 2016). The Annual Electricity Consumption Per Capita in 2017 was 1138.3

KWh per Capita. Palestinian households spend about 10% of their income on energy (Albisher and Alsamamra, 2019). Fig. 1.14 presented the percentage of Households that Used Energy by Region and Energy Type in 2015.

In contrast to the limited availability of traditional energy sources on Palestinian territory, there are abundant natural resources, such as wind, biomass, and solar energies, for the production of nontraditional energy (Abu Hamed et al., 2012). With its high potential, solar energy has the potential to contribute significantly to the future Palestinian energy supply. Palestine has approximately 3,000 hours of sunlight per year and an average solar radiation of 5.4 kWh/m (Yamin, 2023). Solar energy has the potential to account for 13% of total energy consumption in the Palestinian Territories (Juaidi et al., 2016). Over half of all Palestinian households use solar energy heaters, though only 3% rely on it as their primary source (PCBS, 2015). Fig. 1.15 presents the Percentage Distribution of Households by Availability and usage of Solar Heater in 2015. Due to the high costs associated with such systems, photovoltaic and solar thermal systems have yet to gain traction in Palestine (Yamin, 2023).

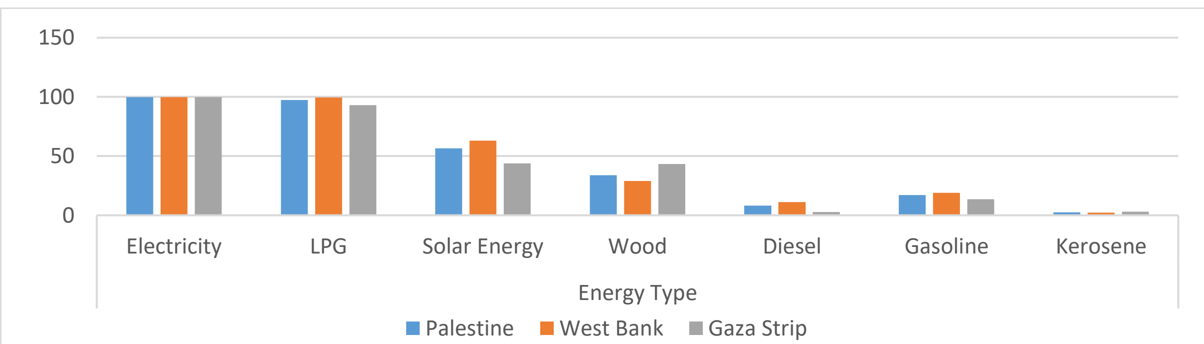


Fig. 5. 10: percentage of Households that Used Energy by Region and Energy Type (PCBS, 2015)

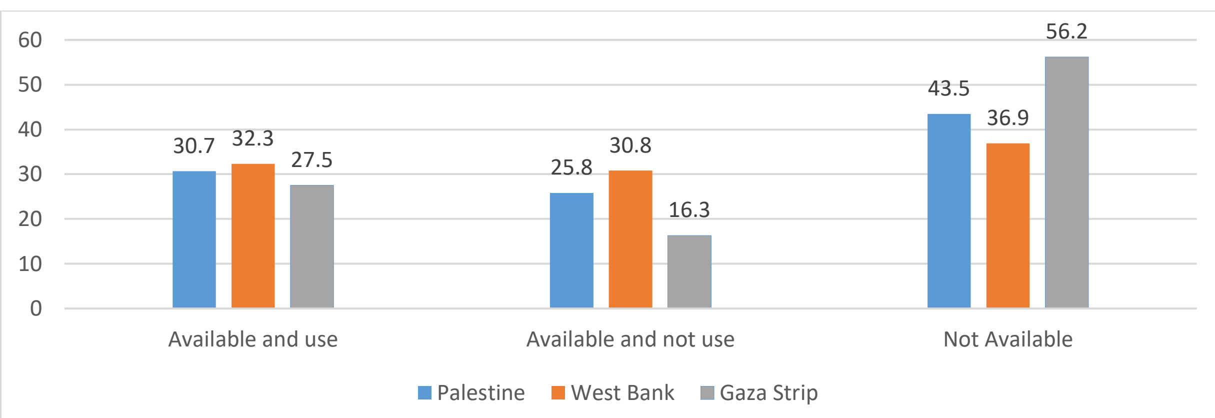


Fig. 5. 11: Percentage Distribution of Households by Availability and usage of Solar Heaters (PCBS, 2015)

5.2. CASE STUDY AREA: HEBRON

Hebron is the capital of the Hebron Governorate, which is located in the southern part of the West Bank. It is bounded to the east by Bani Na'im, to the north by Halhoul, to the west by Taffuh, and to the south by Yatta (ARIJ, 2009).

With an area of 997 km2 and a population of 808,000 people, Hebron is the largest Governorate in the West Bank. Accounting for nearly 25% of the West Bank's population. Hebron city is the governorate's largest city (200,000 people, about one-third of whom are refugees) and the the second largest in the West Bank. It is largely considered as the industrial and commercial powerhouse of the Palestinian economy.

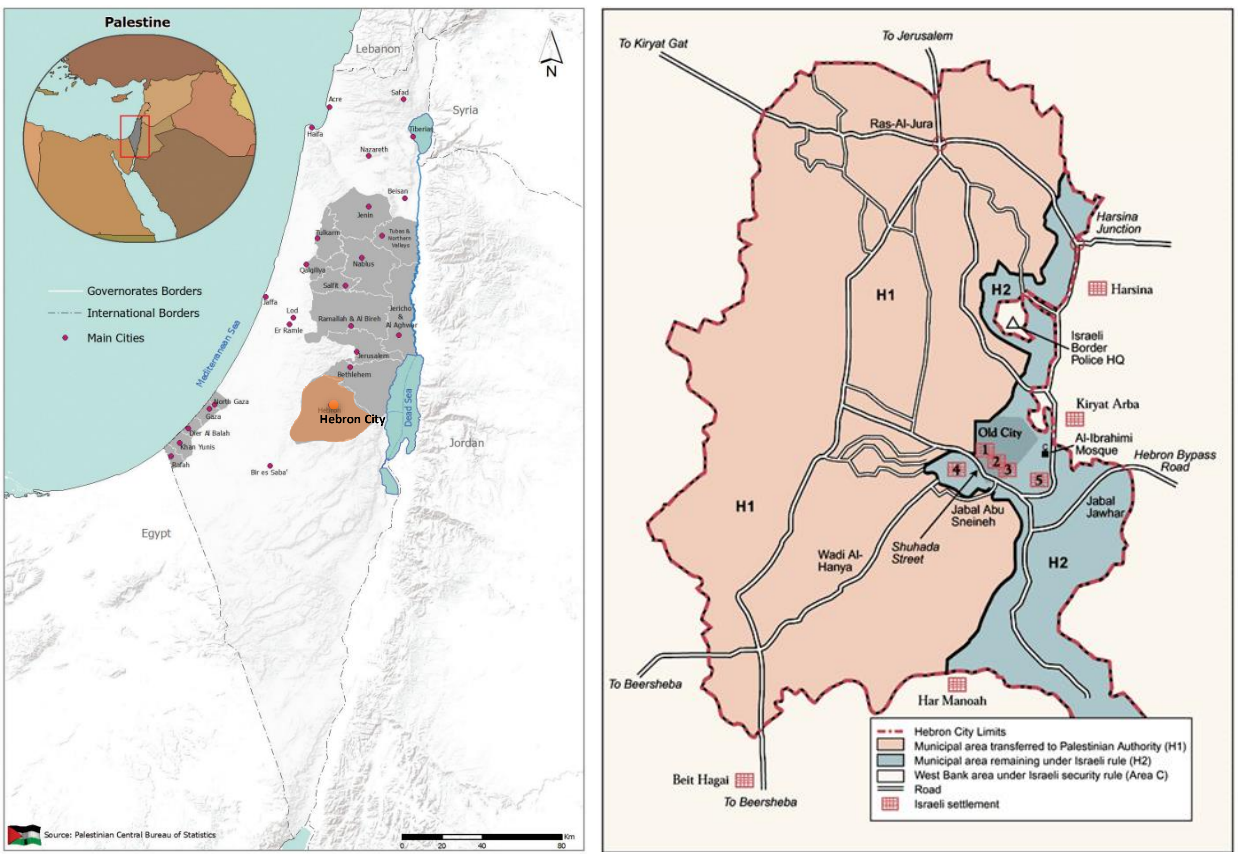


Fig. 5. 12: Hebron city location

The Hebron Governorate has the West Bank's highest poverty rate. More than 32% of its residents live below the national poverty line, which is significantly higher than the West Bank's overall poverty rate of 18.3%. In 2015, men represented the majority of Hebron's labor force, with women accounting for only 17.8%. Furthermore, women comprise a small proportion of waged workers in Hebron, accounting for only 14.6%, with 60% earning less than the minimum wage. The average monthly wage for these women is NIS 805 per month, which is the lowest in the West Bank (PCBS, 2017).

5.2.1. CLIMATE DATA

Hebron City is located in a highland setting at an elevation of 888 m above sea level, with an average annual rainfall of 370 mm, an average annual temperature of 16 °C, and an average annual humidity of 61% (ARIIJ, 2009).

Hebron has a Mediterranean climate, with long, hot, clear, and arid summer days and cold, mostly clear winter months. Throughout the year, the temperature typically ranges from 3°C to 29°C, with temperatures rarely falling below 0°C or rising above 33°C. The warm season lasts 4.4 months, from May 23 to October 5, with an average daily high temperature exceeding 25.5°C. The cool season lasts 3.1 months, from December 5 to March 8, with an average daily high temperature of less than 14.5°C. The coldest month is January, with an average low of 3°C. From October 28 to April 5, the rainy season lasts 5.2 months, with a typical 31-day rainfall of at least 1.5 cm. The perceived humidity varies with the season in Hebron. The muggier season lasts 2.4 months, from July 9 to September 21, and the comfort level is oppressive or terrible at least 4% of the time. August 17 is the muggiest day of the year, having muggy conditions 16% of the time.

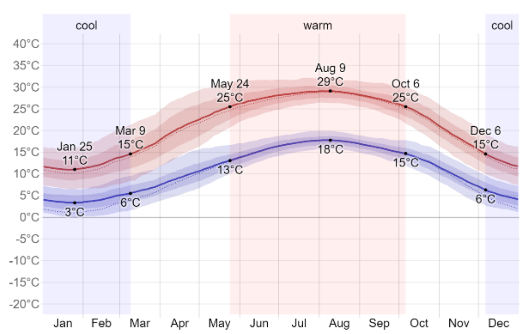


Fig. 5. 13: The daily average high (red line) and low (blue line) temperature in Hebron (Weather Spark, 2020)

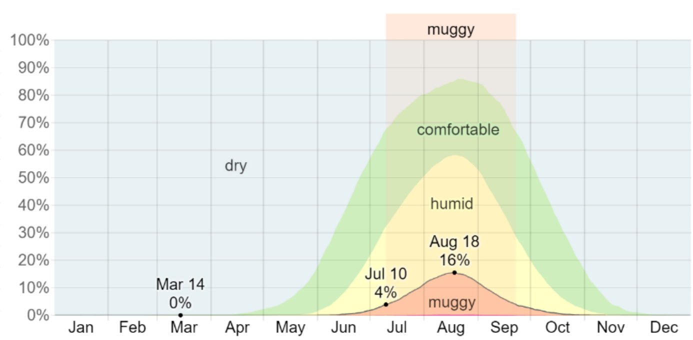


Fig. 5. 14: The percentage of time spent at various humidity comfort levels (Weather Spark, 2020)

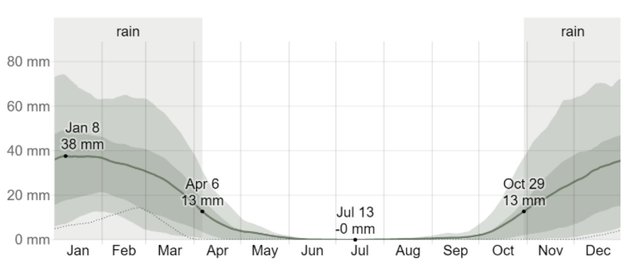


Fig. 5. 15: The average rainfall in Hebron (Weather Spark, 2020)

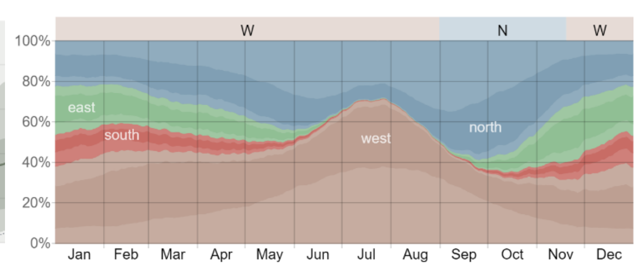


Fig. 5. 16: The percentage of hours from the wind direction in Hebron

The mean hourly wind speed in Hebron varies just slightly throughout the year. From May 10 to September 25, the windier season lasts 4.5 months, with average wind speeds of more than 11.5 kilometers per hour. The calmer season lasts 7.5 months, from September 25 to May 10. December 18 is the calmest day of the year, with an average hourly wind speed of 10 kilometers per hour (Weather Spark, 2020).

5.2.2. HOUSING SECTOR IN HEBRON CITY

Apartments accounted for 26,665 of the 39,614 inhabited housing units in Hebron City in 2017, which represented 67.3% of the inhabited housing units (PCBS, 2017).

The building's design frequently follows the planning and organizational laws of the lands into Patterns A, B, and C. The Ministry of Local Government provides these regulations to determine the proportion of the building and the number of floors (Thawaba, 2019). Such regulations are intended to restrict building density in accordance with regional planning aims. The Palestinian Ministry of Local Government established guidelines for residential buildings in cities and neighborhoods, such as the number of floors, rebounds, materials, and so on. As a result, residential buildings in Palestinian cities are classified as follows (MOLG, 2011):

- High-rise residential buildings: In Hebron, high-rise high-density housing is typically made up of several independent apartment buildings and is widespread throughout the city. These structures are built on sorted land plots of at least 2000 m2 in size, with a construction rate of 36% of the permitted land area. Each structure is composed of a central staircase surrounded by 2-4 apartments.
- Villa: A villa is a standalone building constructed to accommodate one household. It comprises two suites connected by internal staircases on single, double, or triple floors. One suite is for sleeping areas, while the other is for reception and includes a kitchen and other related services. Villas are typically built on well-planned land with a minimum area of 700 m2 and a construction percentage of 30% of the land area. The villa is usually surrounded by a garden, which is enclosed by a boarding wall or fence, regardless of its size. Furthermore, villas frequently include a covered parking area.
- High-Rise Type A: multi-family apartment complexes' residential buildings. These structures have 5-7 floors, each with two to four apartments. They are built on sorted land

plots ranging in size from 1000 to 2000 m2, with a maximum construction rate of 40% of the land area allowed.

- Building type, A, B, and C: These are residential buildings for extended families, with 5 floors and one or two apartments on each floor. The specifications for each classification are determined by the location of the building, the nearby streets, and the uses and classification of the surrounding lands. The typical area of the selected land pieces is around 500-1000 m2, depending on classification, and the allowable percentage area of the building with types A, B, and C is around 36%, 42%, and 48%, respectively.
- Building type D: Type D housing differs from types A, B, and C in that construction is permitted in areas less than 500 square meters and as small as 300 square meters, and the permitted construction percentage becomes higher to 52%.
- Agricultural housing: After receiving initial approval from the competent committee and preliminary approval from the Supreme Planning Council, agricultural housing areas can be used to establish vegetable farms, cooperative housing society projects, and investment projects for housing, public service buildings, hotels, parks, and gas stations.

Some architectural and structural characteristics are shared by all of the buildings mentioned (Elawi, 2019):

- The majority of these structures are designed in rectangular or square shapes.
- The structure includes one or more vertical accessibility units (staircases), an elevator, and skylights. Each floor contains one to four apartments.
- Typically, parking is located in the ground floor or basement, with apartments for housing located on the upper floors (Mouna et al., 2020).
- The roof is a concrete slab with an 80 cm high parapet that is normally flat.
- solar water heating units and Water tanks are situated on the stairwell roof.
- most existing residential building envelopes are not thermally insulated (Monna et al., 2021). The window frames are made of aluminum and it has either single or dual glazing. There is no standardization of the openings "windows and doors." In general, window widths typically range from 1.00 to 1.50 m, while window heights typically range from 1.25 to 1.50 m (Maraqa, 2020). Traditional materials such as stone, hollow concrete blocks, concrete, and plaster are used to build the walls.

According to the findings of the housing and establishments surveys in 2020, Hebron has approximately 21,747 structures, 51.0% of which are residential buildings and 32.0% are mixed-function buildings (Abu Munshar, 2021). Type-B housing, as shown in Table 3.1 below, accounts for the city's second-highest percentage after agricultural housing (Hebron municipality, ٢٠٢٣).

Table 5. 1: Housing Classification in Hebron (Hebron municipality, 2023)

Classification	Area in dunum	Percentage %
A-class housing	5352.53	9.6%
B-class housing	18161.11	23.5%
C-class housing	5160.37	10.3%
D-class housing	5012.26	11.7%
Villa housing	3485.37	6.9%
agricultural housing	19665.89	36.8%

As a reference group, housing engineering and architecture companies were interviewed in a 2021 study to identify the most significant features of existing housing in Hebron City. It was found that multi-story residential buildings in Hebron City can be classified as follows:

1. Apartment buildings

There are two types of apartment buildings: investment residential buildings and extended family residential buildings. The most prevalent type of residential building in Hebron is the extended family residential building, which has one, two, or three apartments on the same floor. The most popular type, however, is two units on each floor. In contrast, the most frequent style in "investment residential buildings" consists of four apartments on each story.

The apartments shared side walls with the adjacent apartment and frequently had just one or two outside walls. The number of floors above the street line in large investment residential complexes can exceed eight, with three or four basements.

2. Mixed-use building

In Hebron, mixed-use buildings are relatively common; they typically consist of business "shops" on the lower levels "ground floor" and housing on the upper floors, with each floor containing one, two, three, or four flats, as in the preceding kind (Abu Munshar, 2021).

5.3.CASE STUDY 1: Farsh-Alhawa Case Study

The first case study is a residential building in Farsh-alhawa, northwest of Hebron. It was constructed between 2020 and 2022. On three sides, the building is surrounded by residential buildings: north, east, and west. The building's long axis is to the west and east. See the Fig 5.17.

5.3.1. Location and accessibility

Fig. 5. 17: Location and Accessibility to Farsh-alhawa Case Study

5.3.2. General Description of the Project

The building is designed in the L-shape, and it has 10 stories and a roof, two of which are below the main street level and include two apartments, while the remaining floors contain three apartments on each floor, and the roof contains two apartments and Terraces. The apartments' areas range from 158 to 176 square meters. Each apartment consists of three or four bedrooms, one of which is a master bedroom, as well as a living room, a kitchen, a guest room, three bathrooms, and one or two balconies.

Fig. 5. 18: Farsh-alhawa Case Study (researcher, 2023)

5.3.3. Physical analysis

The building orientation, plan view, floor geometry, natural ventilation, opening system and overhangs, and wall and roof systems were all considered in the physical analysis. This data was derived from survey interviews, physical site analysis, archived data, and simulations performed with various software tools.

a. Building layout and orientation.

The floor geometry of this housing project was L-shaped. The building consists of ten floors and a roof, two of which are below the main street level and contain two apartments, while the remaining floors contain three apartments on each floor, and the roof has two apartments and Terraces.

The total floor area is approximately 568 m2. The sizes of the flats range from 158 to 176 square meters. They have six to seven rooms, three or four bedrooms (one of which is a master bedroom), a living room, a kitchen, a guest room, three bathrooms, and one or two balconies.

The building's total height is 27 m above the street level, and the height of the wall between two slabs is 2.75 m. The long axis orientation of the building ranging was East–West, and the entrance was eastern-oriented.

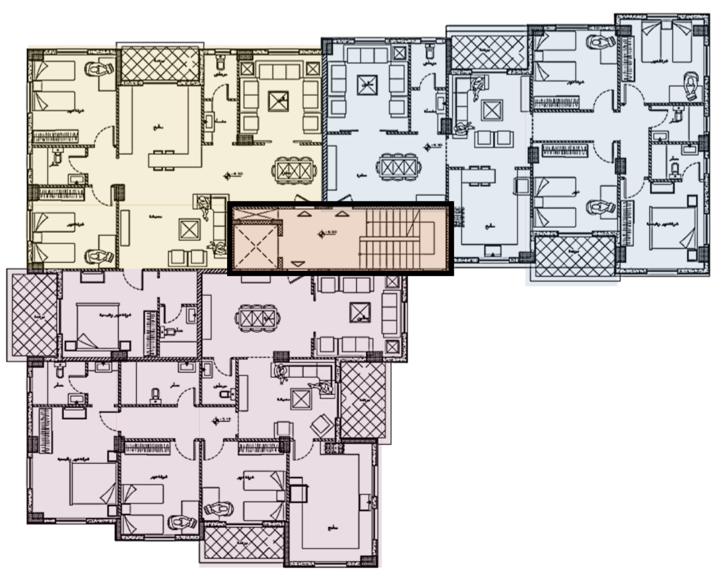


Fig. 5. 19: Repeated floor plan for residential apartments- Farsh-alhawa

b. Wall and roof systems.

Natural stone, concrete, and hollow blocks were the primary building materials used. Thermal insulation is not contained in the walls nor roofs. All windows are double air-filled glass windows with sliding panes and aluminum frames. There were no shading devices used. Almost all of the windows are distributed across the four facades, with window-to-wall ratios ranging from 9 to 17%. The flats' inner doors are all made of wood, while the exterior doors are all made of aluminum.

5.3.4. Reasons for selecting the case

The case was chosen for the following reasons:

- This case examined an investment residential building with three apartments. The three apartments are arranged around a single staircase with an elevator.
- The case study was chosen because they are in Classification (B) zones, which have the highest percentage of residential buildings in Hebron city.
- When selecting the case study, the highest percentages of residential conditions for most residents of the West Bank in general and Hebron city, in particular, were taken into account, as statistics show that 65% of Hebron residents live in apartments, and 50% own three-bedroom apartments.

5.3.5. Simulation

The variation of the built environment is a complex process influenced by numerous factors. Some of these factors include outdoor weather conditions, heating for various indoor heat sources, and outdoor and indoor ventilation. As a result, computer simulation methods must be utilized for predicting the conditions of the built environment. Natural lighting and thermal comfort simulations have been conducted on several floors of each case study to analyze the environmental conditions. To evaluate some indicators and issues in the previously developed sustainability and affordability assessment model for these case studies, it was necessary to carry out some simulations to help evaluate lighting conditions and thermal comfort better and more accurately than using observational methods, manual measurements, and so on. The DesignBuilder Software was used to forecast the daylight factor of the apartments' indoor spaces, changes in indoor temperature and humidity over time. It was also used for estimating human thermal comfort, which is influenced by four major environmental factors: indoor air temperature, radiant temperature, relative humidity, and air velocity (Chow, 2022). The input data included local climate data, building construction records, occupancy, internal load, lighting and HVAC component data, equipment data, and so on.

a. Lighting analysis

The incorporation of light into a building is a critical component of creating space. The psychological and physiological effects of daylighting on building occupants are several; however, if special care is not taken in daylighting design, it can have a negative impact on the indoor environmental quality of that space (i.e. overheating and glare) (Kaląimathy et al., 2023). The daylight factor (DF) is one of the main methods for predicting daylight (Galąsiu and Reinhąrt, 2008). Daylight factor (DF) is defined as "a daylight availability metric that expresses as a percentage the amount of daylight available inside a room (on a work plane) compared to the amount of unobstructed daylight available outside under overcast sky conditions" (Hopkinsón, 1963). The greater the DF, the greater the amount of light in the room. Rooms with a DF of 2% or higher are considered daylight-lit, but electric lighting may still be required to perform visual tasks. When the average DF is 5% or higher, a room appears to be well-lit by daylight, and electric lighting is unlikely to be used during the day (CIBSE, 2007).

Utilizing a simulated model with an overcast sky that adheres to CIE standards, DesignBuilder software was used to simulate daylight on three different floors at various levels. Because of the change in flooring, it becomes essential to analyze daylight performance based on the building floor levels; as a result, the daylight factor of the ground, third, and last floor levels was determined the simulation results are displayed in Fig.5. 20-22, and show that the third floor was considered to be the best situation in this instance, with the ground floor assessed to be the worst. However, the percentage of naturally lit areas on the three floors did not exceed 40% in the best case.

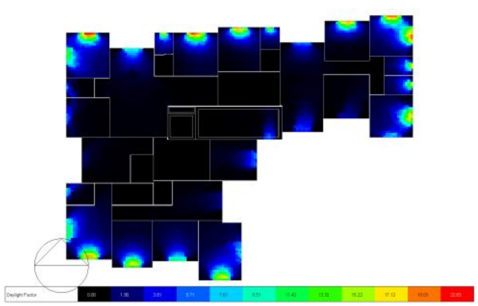


Fig. 5. 20: Daylight simulation results of the ground floor

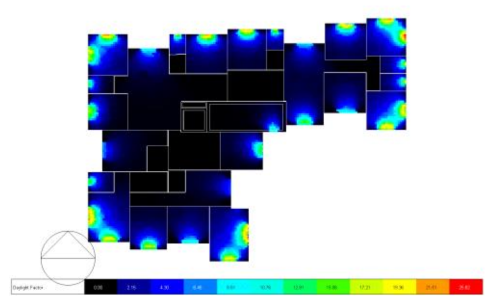


Fig. 5. 21: daylight simulation result of the third floor

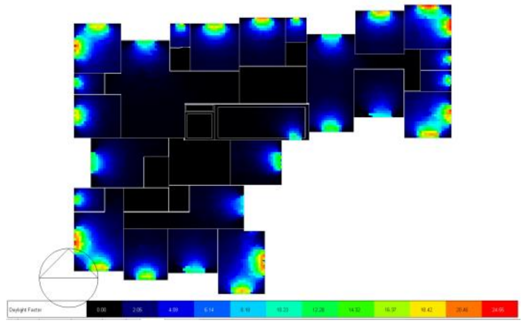


Fig. 5. 22: Daylight simulation result of the last floor - Farsh-alhawa

b. Thermal comfort analysis

The following environmental parameters are measured: ‘air temperature’, ‘mean radiant temperature’, ‘air velocity’, and ‘air humidity’. After these variables were estimated or measured, the predicted mean vote (PMV) and predicted percentage dissatisfied (PPD) indexes were calculated to predict the thermal sensation for the entire body. PMV index measures thermal comfort and ranges from ±3 to 0, with zero being the best thermal comfort. According to ISO 7730, PMV should be kept between ranges of ±0.5 for a good standard of comfort (ISÓ, 2006). The PPD index estimates the number of occupants in a space who would be dissatisfied with the thermal conditions. To ensure thermal comfort, all occupied areas in a space should be kept below 20% PPD, according to known standards (ASHRÁE, 2020; ISÓ, 2006)

For a year, the first, third, and ninth floors were simulated. To determine the actual situation of natural ventilation and temperature, the building is naturally ventilated and does not use any kind of cooling or heating devices during simulation. Fig 5.23 shows the operating temperature for each floor, which was very close. On all three floors, the results for temperature, humidity, and thermal comfort were comparable. As a result, the remaining results for the third floor were displayed because it was in an intermediate state between the first and last floors. Appendix 2 contains the simulation results for the remaining floors. Fig 5.24 shows the comfort data of the third-floor level, which includes air temperature, outside dry bulb temperature, radiant temperature, and operative temperature. According to the data, the lowest outside dry bulb temperature is 7.34°C in February and the highest is 23.08°C in August. Furthermore, the lowest operative temperature is 12.83°C on the ground floor and 18.9°C on the third and ninth floors in January, both of which are well below the recommended thermal comfort temperature range of 17°C to 25°C. In August, the highest operative temperature is 28.66°C on the ground floor and 29.76°C on the third and ninth floors, both of which are above the thermal comfort zone.

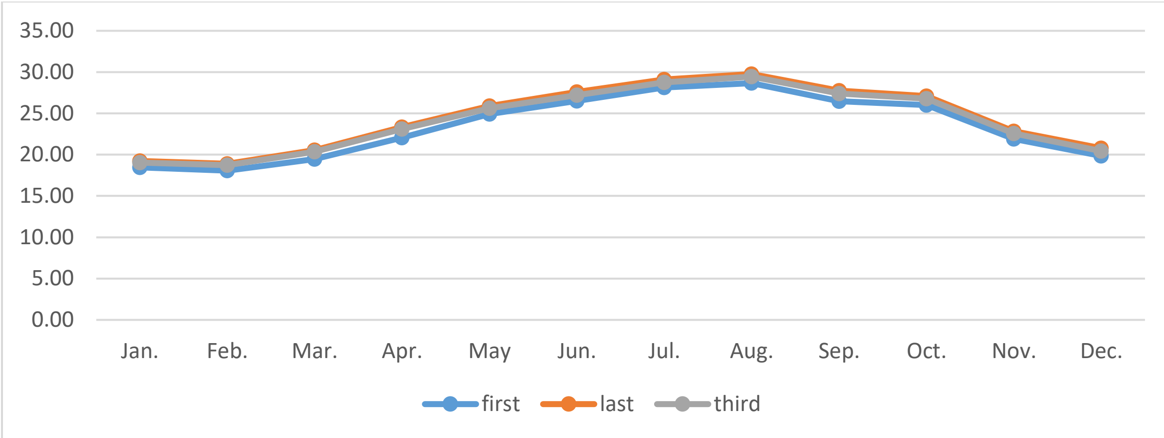


Fig. 5. 23: Annual operational temperature in degrees Celsius on the three levels of floors - Farsh-alhawa

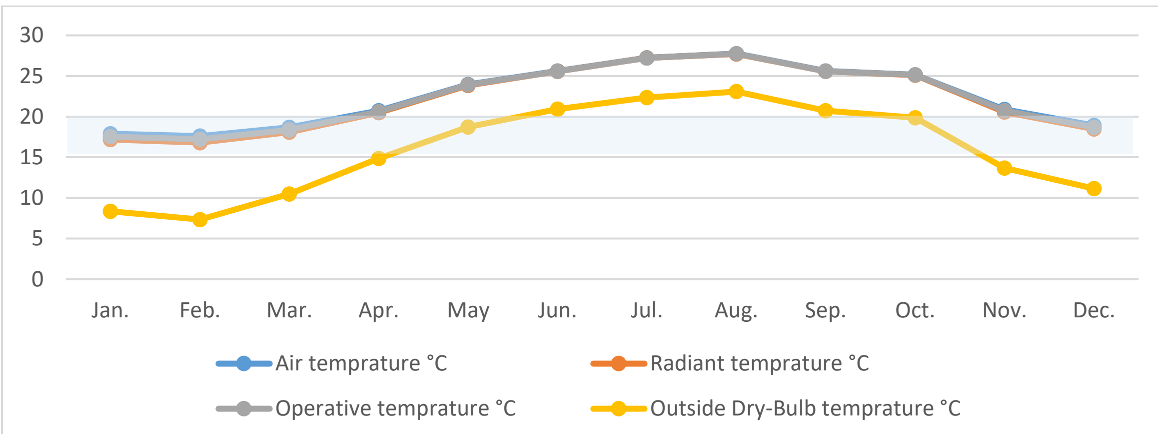


Fig. 5. 24: Annual temperature measurements on the third floor- Farsh Alhawa

The maximum relative humidity is 62% in December and the lowest is 51% in May respectively (Fig. 5.25). In all cases, the humidity level remains within the acceptable range of 60-65% in winter and 50-55% in summer (Weather Spark, 2020).

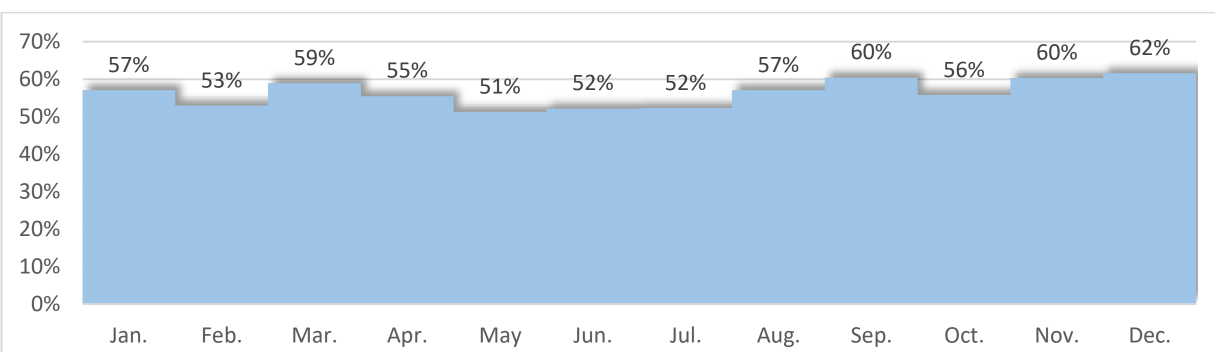


Fig. 5. 25: Annual Relative Humidity % on the third floor – Farsh alhawa

On a monthly basis, the month of January had the most discomfort hours (691.14 hours), while the month of May had the least discomfort hours (286.88 hours), as shown in Fig. 5.26. This result could be attributed to the low temperatures recorded in January and the comfortable temperatures in May. According to the results of the discomfort hours, occupants were uncomfortable for 6405.39 hours of the year. This equates to 73% discomfort versus 27% comfort hours over the entire simulation period.

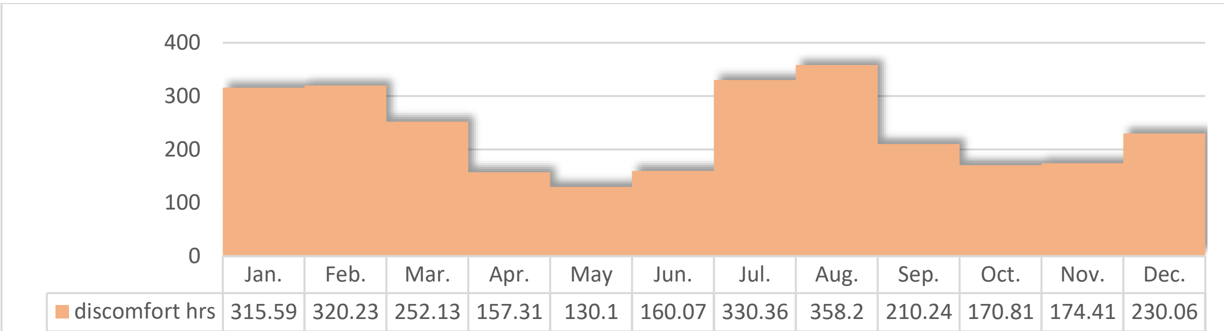


Fig. 5. 26: Annual discomfort hours on the third floor – Farsh alhawa

Fanger (PMV) thermal comfort predictive models based on predicted thermal comfort sensation votes on a seven-point thermal comfort scale are depicted in Fig.5.27. According to the chart, only the months of April to June and October fall within the acceptable PMV range of -0.5 to +0.5 in the Fanger's thermal sensation. Furthermore, the months of January to March, July to September, November, and December are all within the PMV range of dissatisfaction on the thermal sensation scale, which ranges from +0.54 to +1.09. Because of the heat discomfort associated with July to September values, cooling is required to return the building to acceptable comfort levels. Heat discomfort associated with January to March, November, and December values necessitates the use of heating to return the building to acceptable comfort levels.

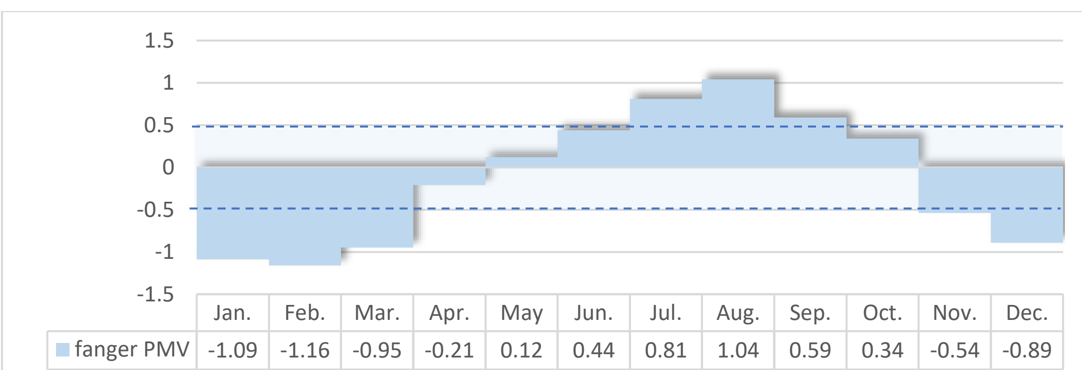


Fig. 5. 27: Fanger PMV – Farsh alhawa

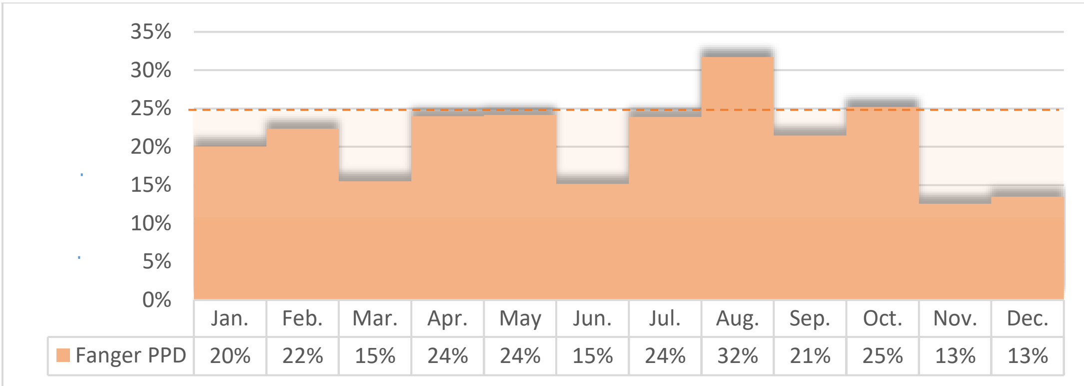


Fig. 5. 28: Fanger PPD – Farsh alhawa

The internal gains in the building are shown in Fig. 5.29. The greatest gains were discovered to be from solar and general lighting. July has the greatest solar gain, followed by June. These are also the months with the highest temperatures, resulting in high latent loads due to solar gains.

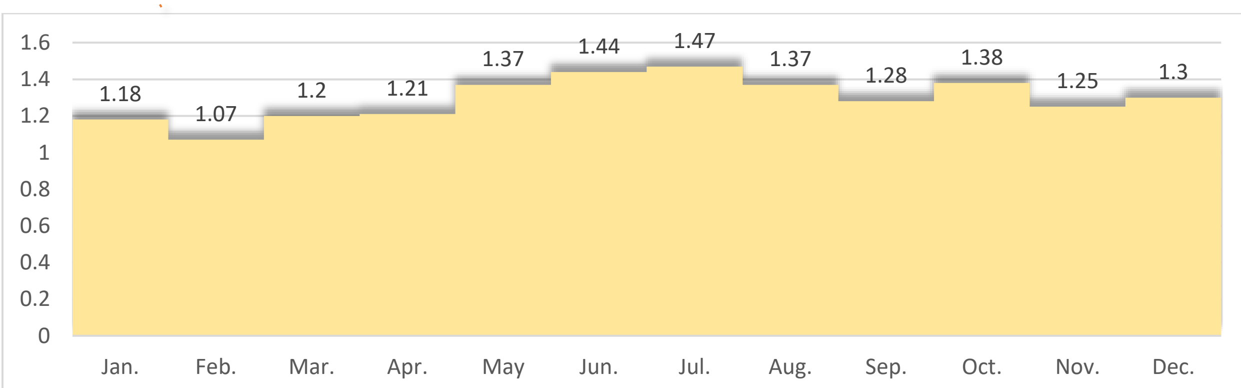


Fig. 5. 29: Solar Gains from Exterior windows MWh – Farsh alhawa

5.3.6. Life Cycle Cost Analysis (LCCA)

The LCCA was used to calculate the total lifecycle costs of a building from cradle to grave. LCCA steps include preconstruction and construction costs, as well as maintenance, replacement, and operational costs. The CRAVEZERO Life Cycle Cost Tool was used to perform the LCCA. The data collection structure within the tool is based on the LCCA structure introduced by Standard ISO 15686:2017 (Buildings and constructed assets - Part 5: Life-cycle costing). The LCCA tool is made up of Project information, Whole Life Cost, Construction Cost, Maintenance Calculation, Results, and Charts.

5.3.6.1.Project information

The first input contains general information about the building under assessment, as well as the boundary conditions required for the LCC calculation, as well as data about surfaces and volumes. Following that, data from the reference area and energy calculation were provided, and in this section, economic boundary conditions were collected. This enables the estimation of actualized maintenance and energy costs over the life of the building. The calculation takes into account the average annual price increase, fuel prices, and the interest rate. Finally, operational costs were calculated using data on energy production in (kWh) and consumption (kWh/m2).

5.3.6.2.Whole Life Cost (WLC)

The WLC is built with non-construction costs, costs associated with the building design process, construction costs, and estimated Operation and maintenance costs.

- Non-construction costs include:
  - Land costs (and the amount that can be built).
  - Finance costs: costs associated with interest or money costs (in the case of a bank loan).
  - Price: the land’s unitary price.
  - User support costs: this includes all costs for support activities during the organization phase (such as general administration, information technology and helpdesk services, and issues property management).
  - Planning fees: fees and taxes that must be paid to obtain permissions and complete administrative tasks.

  o Enabling costs: the cost of site preparation.
- The design costs were provided in the second section of the WLC, which was divided into preliminary, definitive, and executive design.
- Construction costs: This section includes a full breakdown of construction costs, a brief description of the single layer and the related area, the cost of materials, labor costs, and other costs.

5.3.6.3.Results

The LCC calculation was carried out, and the results are summarized in Table 2 by non-construction cost, design cost, whole life costs, construction cost, and operation and maintenance cost.

Table 5. 2: The LCC calculation for the Farsh Alhawa case study

BUILDING CONSTRUCTION STAGE	COSTS (USD)	UNITARY PRICE USDS/ M²
Non-construction cost	**33,204.60**	**207.53**
Design cost	**1,144.00**	**7.15**
Preliminary design	**228.80**	**1.43**
Definitive design	**686.40**	**4.29**
Executive design	**228.80**	**1.43**
Building site management	**1,144.00**	**7.15**
3) LIFE-CYCLE COST	**67,715.01**	**423.22**
Investment cost	**37,566.10**	**234.79**
Operation and maintenance cost	**30,148.91**	**188.43**
Land and enabling costs	**30,916.60**	**193.23**
Cost of land	**28,600.00**	**178.75**
Enabling costs	**1,144.00**	**7.15**
Planning fees	**1,172.60**	**7.33**
Construction cost	**35,278.10**	**220.49**
Building elements	**34,320.00**	**214.50**
Building services / RES/others	**958.10**	**5.99**
Operation and maintenance cost	**30,148.91**	**188.43**
Maintenance	**30,148.91**	**188.43**
Building envelope cost	**34,320.00**	**214.50**
WHOLE LCC	**100919.6**	**630.7**

5.4.CASE STUDY 2 – Ein Sara Case Study

5.4.1. General information

The second case study is a residential building in Ein-Sara, the heart of Hebron. It was constructed between 2019 and 2020. The building is surrounded by residential buildings on two sides: south and east. The building's long axis is to the north and south. See the Fig. 5.30.

5.4.2. Location and accessibility

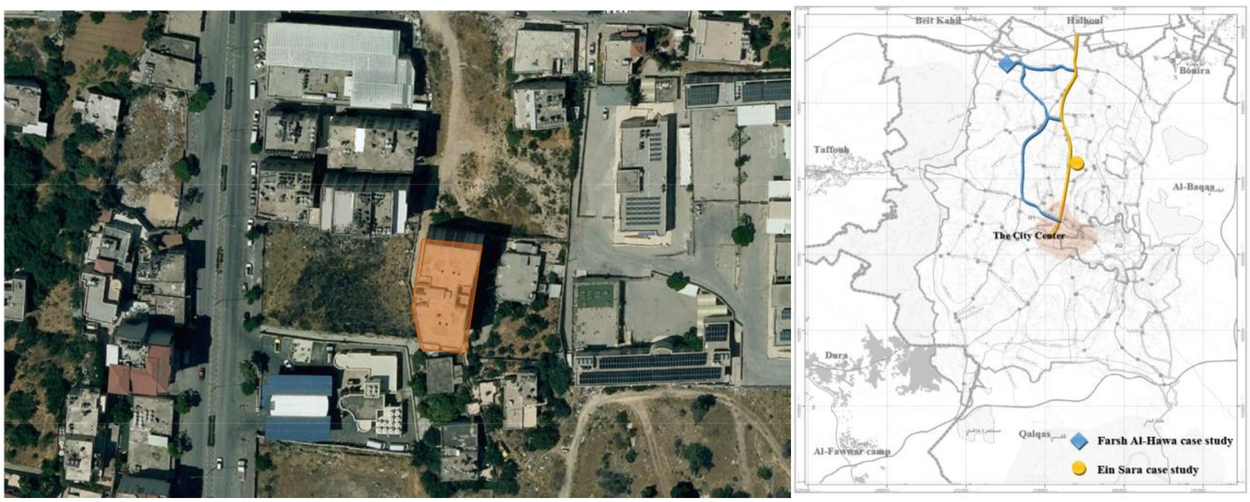


Fig. 5. 30: Location and accessibility for Ein Sara Case study

5.4.3. General Description of the Project

The building is designed in a rectangle shape, and it has 10 stories, one of which is below the main street level and include two water wells, while the remaining floors contain four apartments on each floor. The apartments' areas range from 150 to 164 square meters. Each apartment consists of three bedrooms, one of which is a master bedroom, as well as a living room, a kitchen, a guest room, three bathrooms, and two balconies.

Fig. 5. 31: Ein Sara Case study (researcher, 2023)

5.4.4. Physical analysis

The physical information of this case study was derived from survey interviews, physical site analysis, archived data, and simulations performed with various software tools.

a. Building layout and orientation.

The floor geometry of this housing project was rectangle. The building consists of ten floors. While the remaining floors contain four apartments on each floor.

The total floor area is approximately 623 m2. The sizes of the four flats was 150, 153, 156 and 164 square meters, each one has six rooms. The building's total height is 30 m, and the height of the wall between two slabs is 2.75 m. The long axis orientation of the building was North-South, and the entrance is western oriented.

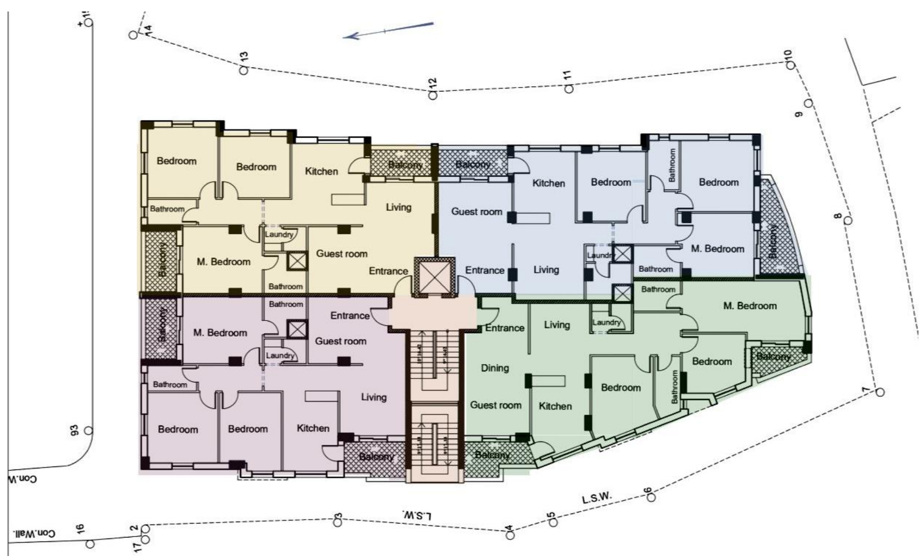


Fig. 5. 32: Repeated floor plan for residential apartments- Ein-Sara

b. Wall and roof systems.

Natural stone, concrete, and hollow blocks were the primary building materials used. Thermal insulation is not contained in the walls nor roofs. All windows are air-filled double glass windows with sliding panes and aluminum frames. There were no shading devices used. Almost all of the windows are distributed across the four facades, with window-to-wall ratios ranging from 8 to 17.2%. The flats' inner doors are all made of wood, while the exterior doors are all made of aluminum.

5.4.5. Reason for selecting the case

The case was chosen for the following reasons:

- This case examined an investment residential building with four apartments. The four apartments are arranged around a single staircase with an elevator.

- The case study was chosen because they are in Classification (B) zones, which have the highest percentage of residential buildings in Hebron city.
- When selecting the case study, the highest percentages of residential conditions for most residents of the West Bank in general and Hebron city in particular were taken into account, as statistics show that 65% of Hebron residents live in apartments, and 50% own three-bedroom apartments.

5.4.6. Simulation

The DesignBuilder Software was used to forecast the daylight factor of the apartments' indoor spaces, changes in indoor temperature and humidity over time. It was also used for estimating human thermal comfort, which is influenced by four major environmental factors: indoor air temperature, radiant temperature, relative humidity, and air velocity (Chow, 2022). The input data included local climate data, building construction records, occupancy, internal load, lighting and HVAC component data, equipment data, and so on.

a. Lighting analysis

Utilizing a simulated model with an overcast sky that adheres to CIE standards, DesignBuilder software was used to simulate daylight on three different floors at various levels. Daylight performance was analyzed by determined the daylight factor of the third floor level. The simulation results are displayed in Fig. 5.20, and show that the percentage of naturally lit areas in the floor area did not exceed 20%.

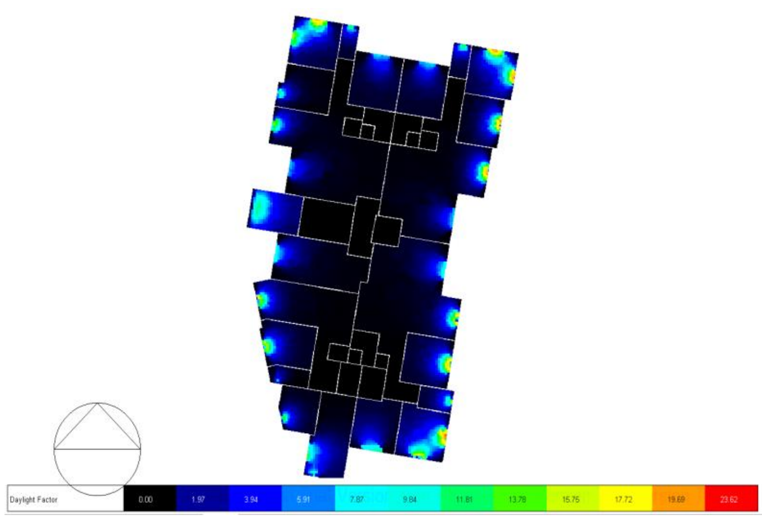


Fig. 5. 33: daylight simulation result of the third floor - Ein-Sara

b. Thermal comfort analysis

The following environmental parameters are measured: 'air temperature', 'mean radiant temperature', 'air velocity', and 'air humidity'. After these variables were estimated or measured, the PMV and PPD indexes were calculated to predict the thermal sensation for the entire body.

To determine the actual situation of natural ventilation and temperature, the building is naturally ventilated and does not use any kind of heating or cooling devices during simulation. The annual comfort data for the third-floor level are shown in Fig. 5.34, which comprises air temperature, outside dry bulb temperature, radiant temperature, and operating temperature. The lowest outside dry bulb temperature is 7.34°C in February and the highest is 23.08°C in August. Furthermore, the lowest operative temperature in February is 19.11°C on the third floor, which is well within the recommended thermal comfort temperature range of 17°C to 25°C. The highest operative temperature in August is 30.81°C, which is above the thermal comfort zone. The maximum relative humidity is 72.94% in December and the lowest is 43.13% in May (Fig. 5.35).

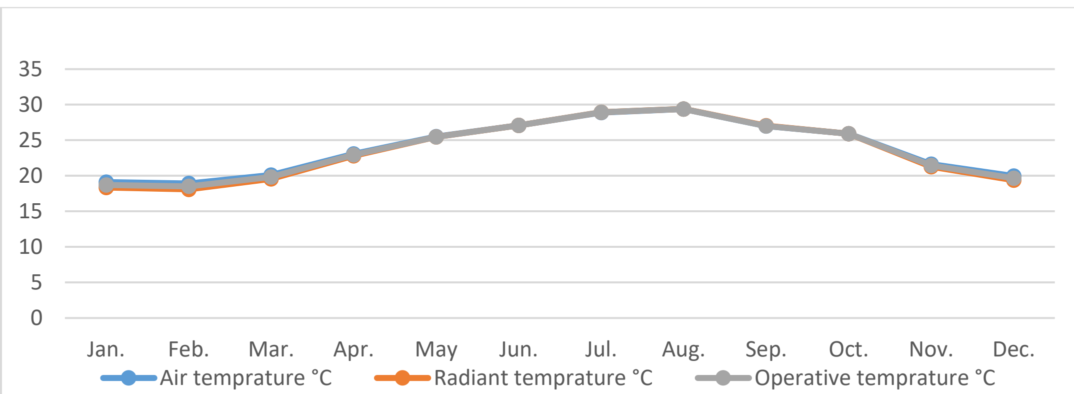


Fig. 5. 34: Annual temperature measurements on the third floor - Ein-Sara

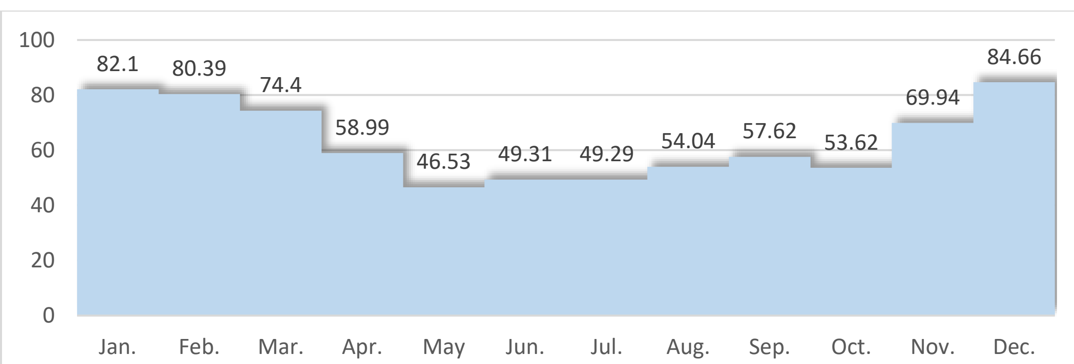


Fig. 5. 35: Relative Humidity % - Ein-Sara

As shown in Fig. 5.36, the month of August had the highest number of discomfort hours (392.31 hours) and the month of April had the lowest number of discomfort hours (159.79 hours). This result could be attributed to the high temperatures recorded in August and the comfortable temperatures recorded in April. According to the results of discomfort hours, occupants were uncomfortable for 3082.27 hours during the year. This equates to 35% discomfort versus 65% comfort hours over the entire simulation period.

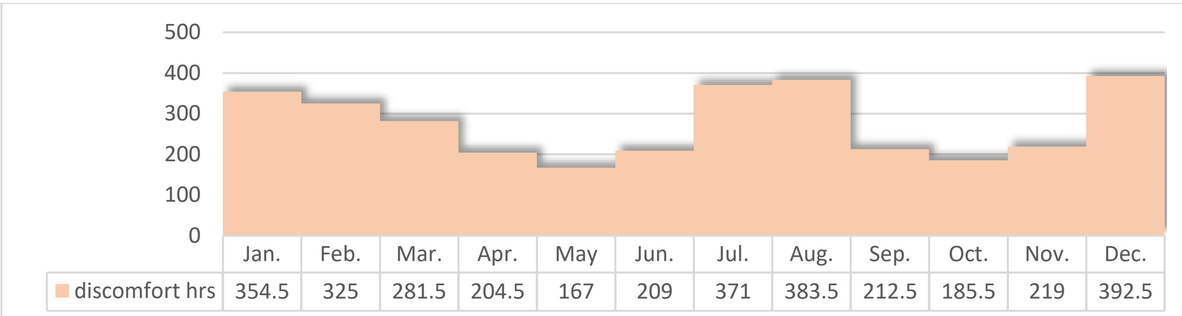


Fig. 5. 36: discomfort hours - Ein-Sara

Based on the seven-point thermal comfort scale, Fig. 5.37 shows predicted thermal comfort sensation votes based Fanger (PMV) thermal comfort predictive models. Only the months of April, May, and November are within the acceptable PMV range of -0.5 to +0.5 in the Fanger's thermal sensation. Furthermore, the months of January to March, September, June to October, and December fall within the PMV range of dissatisfaction on the thermal sensation scale, which ranges from -0.66 to +1.48. Because of the heat discomfort associated with June to October values, cooling is required to return the building to acceptable comfort levels. While the lower temperatures and discomfort associated with January to March and December values necessitates the use of heating to return the building to acceptable comfort levels.

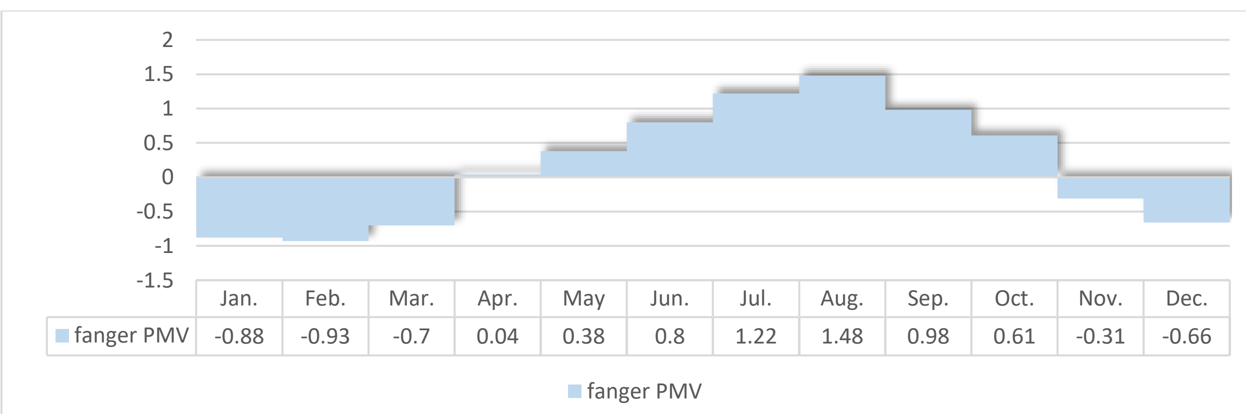


Fig. 5. 37: Fanger PMV - Ein-Sara

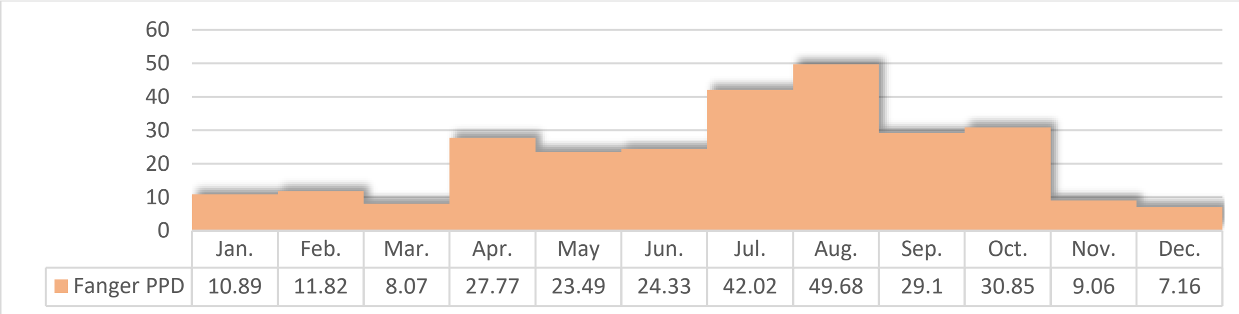


Fig. 5. 38: Fanger PPD - Ein-Sara

The internal gains in the building are shown in Fig. 5.39. The greatest gains have been found to be from solar and general lighting. July has the greatest solar gain, followed by August. These are also the months with the highest temperatures, resulting in high latent loads due to solar gains.

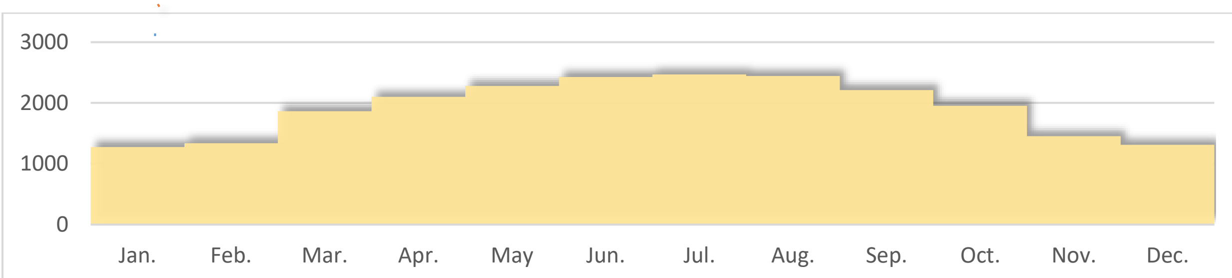


Fig. 5. 39: Solar Gains from Exterior windows - Ein-Sara

5.4.7. Life Cycle Cost Analysis (LCCA)

The LCCA was used to calculate the total lifecycle costs of a building from cradle to grave. LCCA steps include preconstruction and construction costs, as well as maintenance, replacement, and operational costs. The CRAVEZERO Life Cycle Cost Tool was used to perform the LCCA. The data collection structure within the tool is based on the LCCA structure introduced by Standard ISO 15686:2017 (Buildings and constructed assets - Part 5: Life-cycle costing). The LCCA tool is composed of Project information, Whole Life Cost, Construction costs, Maintenance Calculations, Results, and Charts.

5.4.7.1.Project information

The first input contains general information about the building under assessment, as well as the boundary conditions required for the LCC calculation, as well as data about surfaces and volumes. Following that, data from the reference area and energy calculation were provided, and in this section, economic boundary conditions were collected. This enables the estimation of actualized maintenance and energy costs over the life of the building. The calculation takes into account the average annual price increase, fuel prices, and the interest rate. Finally, operational costs were calculated using data on energy production in (kWh) and consumption (kWh/m2).

5.4.7.2.Whole Life Cost (WLC)

The WLC is built with non-construction costs, costs associated with the building design process, construction costs, and estimated Operation and maintenance costs.

5.4.7.3.Results

The LCC calculation was carried out, and the results are summarized in Table 5.2 by non-construction cost, design cost, whole life costs, construction cost, and operation and maintenance cost.

Table 5. 3: The LCC calculation for Ein Sara case study

BUILDING CONSTRUCTION STAGE	Cost (USD)	Unitary price USD/ m^2
Non-construction cost	47,418.80	307.91
Design cost	1,101.10	7.15
Preliminary design	220.22	1.43
Definitive design	660.66	4.29
Executive design	220.22	1.43
Building site management	1,101.10	7.15
LIFE-CYCLE COST	65,286.08	423.94
Investment cost	36,193.30	235.02
maintenance cost (1 year)	29,092.78	188.91
Land and enabling costs	45,216.60	293.61
Cost of land	42,900.00	278.57
Enabling costs	1,144.00	7.43
Planning fees	1,172.60	7.61
Construction cost	33,991.10	220.72
Building elements	33,033.00	214.50
Building services / RES / others	958.10	6.22
Operation and maintenance cost	29,092.78	188.91
Maintenance	29,092.78	188.91
WHOLE LCC	**112,704.88**	**731.85**

5.5.ASSESSMENT MODEL APPLICATION ON THE CASE STUDIES

Following the analysis of local case studies, a sustainability and affordability assessment was carried out in order to identify the main indicators that residential apartments in the city of Hebron lack in order to be sustainable and affordable, as well as discovering indicators that cannot be applied in Palestine due to political, economic, social, or other factors.

The environmental and cost analyses conducted in this chapter for both cases were used to evaluate the economic and environmental aspects of these buildings in order to apply the assessment model to the case studies. In terms of social aspects, as well as some immeasurable economic and environmental indicators, the data was obtained through a semi structured interviews with apartment owners, residents, designer engineers, supervisors, and some construction workers for these residential buildings. This allowed to record the respondent’s behavior based on particular end goals in order to assess the overall quality of living conditions and how the house was used. Social aspects, as well as some economic and environmental factors were assessed based on their responses to a series of questions. A system of ratings (0: does not meet (X); 1: comes close (Δ); 2: exceed or meet (√)) is used to determine the degree to which each case meets the indicators of the criteria listed in Table 5.4.

The examples below show how criteria are evaluated. The average house price to income ratios (ES01) indicator was evaluated by equating average house price to income ratios. A ratio is calculated by dividing the house's purchase price by the annual household income. The geographic information systems (GIS) maps given by the local authority (Hebron City Council) was used to help determine ease of access to facilities and services for each case study area for indicators 2–8 of affordability category (ES03, ES11, ES19, ES20, SS05, and SS06).

Indicator 5 of the household satisfaction category, which is the safety performance of housing facilities or crime rates (SS20), was evaluated using crime statistics from the Palestinian Central Bureau of Statistics (PCBS), which provide economic and social data for all housing wards in Hebron. The crime rate (Reported Criminal Offenses) in Hebron Governorate was compared to other West Bank Governorates. Following Jenin Governorate, Hebron Governorate has the highest crime rate in the West Bank in 2020 (PCBS, 2020), followed by Ramallah and Al-Bireh Governorates. These crimes include assault on people and property, as well as harm, threats, and theft.

According to the experts interviewed, the lack of affordable housing in Hebron City is largely due to overpopulation, which results in high occupancy rates and building density. Furthermore, the city's large population causes it hard to find affordable housing, which is exacerbated by poor planning and maintenance of existing buildings. A well-designed maintenance policy is critical for building durability, as neglecting maintenance for an extended period results in costly rehabilitation and renovation costs. Buildings that become unusable and are abandoned in some cases deplete the existing housing supply. Interviewees who owned houses cited challenges with purchasing land for construction, high building materials and labor costs, a lack of insurance policies to share risks, access to credit facilities, and a lack of financing as major barriers to affording, building, and owning a house. Many interviewees blamed their housing problems on the government's inability to provide basic infrastructure, economic collapse, poor housing policy implementation, and corruption. Respondents suggested addressing this by providing basic infrastructure, using sustainable local building materials, and improving affordable housing design provision.

No.	Criteria	code	**Sub-indicators** / Issues to be considered under each indicator	Case 1	Case 2	Indicator Applicability In Hebron
Economic Viability and Housing Affordability						
1	Housing price to income	ES01	House Price in relation to income	X	X	Applicable
2	Rental cost to income	ES02	Rental costs in relation to income	X	X	Applicable
3	Reduced commuting cost	ES03	Reduced commuting cost	√	√	Applicable
4		ES11	Reduced Transportation costs	√	√	Applicable
5		ES19	Availability and access to employment	√	√	Applicable
6		ES20	Availability of housing accommodation	√	√	Applicable
7		SS05	Accessibility to public transportation	√	√	Applicable
8		SS06	Accessibility to green public spaces	X	X	Applicable
9	Reduce housing initial cost	ES06	Site preparations costs	X	X	Applicable
10		ES07	Minimize design standards to lower the costs	X	X	Applicable
11		ES12	Infrastructures costs	X	X	Applicable
12		ES16	Reduced Non-housing costs	X	X	Applicable
13		ES17	Providing human resources for housing development	√	√	Applicable
14		ES21	Financing system	X	X	Applicable
15		ES22	Funding organizations	X	X	Not Applicable
16		ES05	Running costs for public housing	X	X	Not Applicable
TOTAL RATING				12	12	
Household Satisfaction						
1	End user's satisfaction on facilities	SS02	Providing Users needs and achieve satisfaction on facilities	X	X	Applicable
2		SS27	Desirability	√	√	Applicable
3	Functionality of housing facility	EN14	Functional efficiency	√	√	Applicable
4	Community satisfaction	SS16	Equal and balanced distribution of housing units for households	√	√	Applicable
5		SS20	Safety performance of housing facility (crime rate)	X	√	Applicable
6	Social Acceptability	SS19	Social acceptability	√	√	Applicable
TOTAL RATING				8	10	
The Project Team and Community Satisfaction						
1	Stakeholders' satisfaction	SS04	Achieve project Team satisfaction	√	√	Applicable
2		SS07	Adherence to project schedules	√	√	Applicable

3		EN04	Selection of housing projects location	√	√	Applicable
4	neighborhoods' satisfaction	SS18	Harmonious social relationship	√	√	Applicable
5		EN05	Mix land use Planning	X	√	Applicable
6		EN06	Land use efficiency	X	X	Applicable
7		EN07	Housing density	√	√	Applicable
8		EN18	Compact planning and design	√	√	Applicable
9	Reduced disputes occurrence	SS08	Reduced occurrence of disputes and litigation	X	X	Applicable
TOTAL RATING				12	14	
Marketing and The Waiting Time						
1	Housing facility marketability	ES13	Formulate supportive housing policies	X	X	Not Applicable
2		ES14	Ensure balanced housing market	X	X	Not Applicable
3		SS12	Marketing the housing project facility	X	X	Applicable
4	Time spent waiting for a housing unit	SS13	Construction cost performance of project facility	X	X	Applicable
5		SS14	Waiting Time before receiving housing unit	√	√	Applicable
6		SS15	Subsidies provision for housing	√	√	Applicable
TOTAL RATING				4	4	
Housing Life-Cycle Costs						
1	Maintainability of housing (cost of maintenance or retrofitting)	SS03	maintainability of housing units and facilities	√	√	Applicable
2		ES15	Cost-effectiveness	X	X	Applicable
3		ES23	Value of housing units after use	√	√	Applicable
4	Other lifecycle cost of housing Energy and water efficiency (utility bills)	ES04	Reduced Housing Life cycle cost	X	X	Applicable
5		EN01	Energy efficiency	X	X	Applicable
6		EN03	water efficiency	X	X	Applicable
TOTAL RATING				4	4	
Environmental Effectiveness						
1	Environmental friendliness	EN02	Housing environmental performance	X	X	Applicable
2		EN12	Waste management for housing project	X	X	Applicable
3		EN19	Recycle and reuse construction material	X	X	Applicable
TOTAL RATING				0	0	
Quality of Housing Performance						
1	Aesthetic view of the completed house	SS09	Project Aesthetics	√	√	Applicable
2	Technical specification of housing facility	SS10	Technical specifications of housing units	X	X	Applicable
3	Technology transfer	SS11	Application of building technology	X	X	Applicable
4		SS17	Tenure security	√	√	Applicable
5		SS21	Security	√	√	Applicable
6		SS22	Privacy	√	√	Applicable
7		SS23	Suitability	√	√	Applicable

8	Quality performance of housing facility	SS01	Performance of housing units	√	√	Applicable
9		SS24	Quality of housing units	√	√	Applicable
10		SS25	Multi-type and size housing units	√	√	Applicable
11		SS26	Organizing the human scale	√	√	Applicable
12		EN08	Disaster resistance	X	X	Applicable
13		EN09	Adequate living space within small size units	X	X	Applicable
14		EN10	Housing quality (reliability and durability)	√	√	Applicable
15		EN11	Effective utilization of resources	X	X	Applicable
16		EN13	Local design	√	√	Applicable
17		EN15	Functional and structural Space flexibility	√	√	Applicable
18		EN16	Building material efficiency	X	X	Applicable
19		EN17	Environmental design criteria	X	X	Applicable
TOTAL RATING				24	24	
TOTAL RATING				60	64	

5.6. CONCLUSION

Even though the indicators of the assessment model developed in the second chapter were designed to take into account the coordination of the ecological, social, and economic environments, as well as affordability, it also needs to be based on specific criteria and indicators that are dependent on local needs within a country of Palestine to guide construction and design processes. The sustainable affordable assessment model was used to evaluate the sustainability and affordability of two housing projects in Hebron, Palestine, to identify existing issues and problems. Introducing and applying global assessment systems to local buildings, on the other hand, could reveal the underlying constraints of local practices and propel sustainable and affordable building design forward.

The sustainable and affordable housing assessment model was adjusted and customized to the local Palestinian contexts based on the previous analysis. It was created to focus on aspects of contemporary housing situation that need to be addressed in order to achieve more sustainable and affordable housing. Some indicators that cannot be met in Palestine due to the country's political and economic situation, as well as the obstacles it creates, have also been removed. As a result, a sustainable and affordable housing assessment model is currently being developed in Palestine.

CHAPTER 6

DESIGN STRATEGIES DEVELOPMENT FROM THE ASSESSMENT MODEL

6.1. INTRODUCTION

Much research on sustainable and affordable housing has been conducted, with much of it focusing on housing policy, financing models, planning regulations, land supply, infrastructure funding, and taxation. Despite the fact that design is one of many factors influencing these critical issues, little is known about its role in providing sustainable and affordable housing (Itma, 2019).

The relationship between design quality and construction product quality has been highlighted. According to the findings of a 2003 study, the problems of defective designs are complex and deep-rooted, influenced by numerous factors acting on the individual designer, company, construction industry, global, and national levels (Anidi and Minuto, 2003). Poor project performance is attributed to deficiencies in the design documents (Sui Pheng and Ke-Wei, 1996). Inadequate design time is also the major factor influencing design document quality (Chow and Ng, 2007). It should be noted that design constructability also occurred as a problem due to a lack of construction knowledge on the designer's side and should be addressed (Hamzah et al., 2011).

Affordability and sustainability are heavily influenced by design. This chapter discusses design strategies for delivering success factors and indicators of affordable and sustainable housing in Palestine. While several rules and regulations highlight the growing need for affordable and sustainable housing, there are no practical instances of how this might be achieved in Palestine. This study presented both consumers and developers with a new viable housing design framework. The study demonstrates to government, residents, and eventually home buyers the role that architectural design can play in achieving environmentally and socially sustainable and affordable goals, as well as providing both enriched and inspiring urban form.

In order to achieve a balance between sustainability and affordability in housing, an integrated design approach that identifies goals and establishes sustainability standards is required. The life-cycle cost analysis should also be performed (Subramanian, 2005). According to Tabrizi and Sanguinetti (2015), the established list of design principles is essential for achieving multiple sustainability outcomes. Although incorporating sustainable design elements has benefits as well as drawbacks, many experts believe it raises the initial cost. Such costs have to be thoroughly understood and justified in order to be considered reasonable for affordable housing (Ali and Alzu'bi, 2017).

6.2.DESIGN STRATEGIES FOR MEETING SPECIFIC INDICATOR REQUIREMENTS

Improvements to traditional construction methods, rationalized affordability analysis, and integrated system-based, consultant input housing approaches might provide the most effective combination of sustainability and affordability (Wallbaum et al., 2012). The developed sustainable and affordable housing framework, on the other hand, adheres to flexible design principles as well as affordable, social, and environmental design principles (Ali and Alzu'bi, 2017). It is possible to achieve a balance between sustainability and affordability in housing by establishing achievable sustainability standards, identifying targets, using an integrated design approach, and paying close attention to life-cycle cost analysis (Subramanian, 2005). As a result, in order to have sustainable and affordable housing, a set of design principles that deliver multiple sustainability outcomes should be adapted (Tabrizi and Sanguinetti, 2015).

Table 6.1 presents the findings of a literature scoping study that investigated the design strategies and issues to be considered that influence each indicator in each category of the assessment model that delivers affordable and sustainable housing in developing country contexts worldwide.

The impact of housing on the environment and climate change, as well as the environmental impact of housing itself, all contribute to the environmental sustainability of housing (Badyina and Golubchikov, 2012). Housing is a critical instrument for tackling local and global environmental issues such as public health, CO2 emissions, material efficiency, water, energy, and trash recycling and manufacturing (UN-Habitat, 2012). As a result, a variety of complementary methods for better environmental sustainability in housing should be put in place. Window-to-wall ratio (WWR), building envelope, building orientation, usage of overhangs to shade windows, and window coating selection are among these strategies. Furthermore, solar energy has the potential to significantly decrease energy demand (Randolph and Masters, 2008). Multiple studies have been conducted to investigate the significance of sustainability principles in attaining affordable housing. Mulliner et al. (2013), for example, employed the complicated proportional assessment approach of multi-criteria decision-making to evaluate the affordability of housing locations in a sustainable way. They discovered that, rather than focusing on financial factors, these criteria have a significant impact on the affordability of housing locations (Ali and Alzu'bi, 2017).

Efficient and sustainable housing is critical for the global future. Studies have proven that it is critical to employ locally available, durable, and cost-effective building materials, as well as traditional and vernacular techniques that are compatible with the traditional use of these local materials. It not only contributes to protecting the environment, but it also reduces construction costs, making affordable housing options available to all. Furthermore, incorporating renewable energy sources into residential buildings such as solar panels and wind turbines can significantly reduce fuel energy consumption in lighting, heating, and cooling homes. Innovative materials and technologies that protect, conserve, and reduce energy consumption should also be promoted. It is critical to create adaptive buildings that effectively respond to environmental forces and factors.

Furthermore, eco-friendly designs that address all aspects of life, such as smart development initiatives, are critical for setting the foundations for future development. Participation of the community in the design and implementation of housing proposals is critical to ensuring that they meet the housing needs of the target population.

The government should create housing development monitoring procedures that include all community stakeholders and the construction industry. Allowable land use laws must be established to significantly increase the availability of affordable housing. To ensure proper performance, accurate planning and policy formulation regarding the location, structure, and nature of affordable housing is required. Furthermore, the government must implement policies aimed at maintaining high health standards in housing, as well as manage and maintain existing residential facilities. Close supervision of housing construction is additionally necessary to ensure that standard building materials and techniques have been employed. Finally, resource and growth management activities must be carried out in a comprehensive, system-based, sustainable, and affordable approach.

Table 6. 1: The summary of each indicator's design strategies for producing affordable and sustainable housing in Palestine.

	Design Strategies Development from the Assessment Model			
No.	**Indicators**	**Code**	**Sub-indicators/** Issues to be considered under each indicator	**Design strategies** that can be Establish for meeting specific indicator requirements
	Economic Viability and Housing Affordability			
1	Housing price to income	ES01	House Price in relation to income	'Housing price affordability; mortgage interest rates' (Adabre and Chan, 2020; Mulliner and Maliene, 2011)
2	Rental cost to income	ES02	Rental costs in relation to income	'Rental cost affordability (advance rent charges)' (Adabre and Chan, 2020
3	Reduced commuting cost	ES03	Reduced commuting cost	'Access to library facilities; access to the city center; access to educational institutions or facilities; access to public transportation facilities; access to employment opportunities; access to open green public space; access to leisure facilities; access to childcare facilities; access to health care services; access to shops' (Adabre and Chan, 2020; Mulliner and Maliene, 2011) 'Access to places of worship, workplaces, recreational and sporting facilities, and social infrastructure' (Ibem, 2011).
4		ES11	Reduced Transportation costs	'transport facilities, pedestrian, roadways and bikeways (Bakar et al., 2011) locational suitability to reduce reliance on the car' (Ibem, 2011)
5		ES19	Availability and access to employment	'Access to places of work (Ibem, 2011) The availability of employment opportunities' (Mulliner and Maliene, 2011)
6		ES20	Availability of housing accommodation	'A building or component of a building that is used as the sleeping quarters of its occupants'.
7		SS05	Accessibility to public transportation	'Transportation accessibility' (Bakar et al., 2011) 'traffic planning, fuel quality, road infrastructure, and affordable mass and Good quality transportation system' (Singh and Pandey, 2012)
8		SS06	Accessibility to green public spaces	'encourage community cohesion, green public spaces to interact and relax' (Mulliner and Maliene, 2011)
9	Reduce housing initial cost	ES06	Site preparations costs	'Reduce the costs of the multistep building process of all the pre-construction work you conduct on a site, which includes site surveys, demolition, earthmoving, drainage, clearing land, leveling, and grading' (bigrentz, 2022)
10		ES07	Minimize design standards to lower the costs	'Get rid of redundant spaces, spaces that serve the same purpose, consider multi-purpose spaces and functions so that you can eliminate entire rooms of space, dead spaces in the plan that can be usable areas for other purposes, Reduce the need for a lot of storage.' 'Simplify footprint and layout as much possible. Avoid a lot of ins and outs in your perimeter walls. Try to avoid a lot of curved and angled walls, arches, and

				complex roof lines. Try to keep consistent floor levels instead of having small level changes. Centrally locate or group mechanical, electrical, and plumbing systems together. Reduce square footage where possible.’
11		ES12	Infrastructures costs	‘Consider existing infrastructure and utility access. Locating a housing near the street is optimal and cost-effective for utility and driveway access, if using private utilities, consider their location in relation to your home. (septic systems, well water, gas tank, etc.) The farther away they are the more expensive the site work will’ (Yvonne, 2018).
12		ES16	Reduced Non-housing costs	‘Consider site features (grading, topography, soil conditions, vegetation, etc.)’ (Yvonne, 2018)
13		ES17	Providing human resources for housing development	
14		ES21	Financing system	‘Access to funding/finance available only’ (Heffernan and Wilde, 2020)
15		~~**ES22**~~	~~**Funding organizations**~~	‘Adequate funding and provision’ (Oyebanji et al., 2017)
16		~~**ES05**~~	~~**Running costs for public housing**~~	‘Access to lower running costs’ (Heffernan and Wilde, 2020)
Household Satisfaction				
1	End user’s satisfaction on facilities	SS02	Providing Users needs and achieve satisfaction on facilities	‘End user’s satisfaction level on supplementary facilities such as waste management facilities, adequate drainage systems, community attachment and community living space; open, green public space; leisure facilities; childcare facilities; transportation facilities; recreation facilities; healthcare facilities; educational facilities; and shopping facilities’ (Adabre and Chan, 2020; Mulliner and Maliene, 2011)
2		SS27	Desirability	‘Housing architectural design in relation to a reflection of the unique cultural and historical characteristics, natural way of life, and residents' cultural values’ (Ibem, 2011)
3	Functionality of housing facility	EN14	Functional efficiency	‘Size of room or house; housing floor plan; positioning of different rooms; adequacy of ancillary areas (kitchen design, bathroom), privacy availability in room; ability of housing facility to meet the evolving needs of household’ (Adabre and Chan, 2020; Mulliner and Maliene, 2011)
4	Community satisfaction	SS16	Equal and balanced distribution of housing units for households	‘Social fairness, equality and integration, Sense of community, Community participation.’ (Nainggolan et al., 2020)
5		SS20	Safety performance of housing facility (crime rate)	‘Safe indoor and outdoor environment; number of crimes (burglary and robbery cases) recorded in housing facilities’ (Adabre and Chan, 2020; Mulliner and Maliene, 2011) ‘Incorporating techniques such as Crime Prevention Through Community Design, which includes: Maximizing the visibility of people, parking areas, and building entrances and creating great pedestrian spaces with ‘eyes on

				the street' through permeable building facades, Providing adequate nighttime lighting, Creating well defined property edges through landscaping, pavement and sidewalk design, signage and open fences, Creating transition zones from public to private space through the use of features such as large front porches, entryways, etc.' (MWCOG,2014)
6	Social Acceptability	SS19	Social acceptability	'Poverty alleviation, Protection of human well-being, Promotion of employment opportunities' (Nainggolan et al., 2020) 'Ability to produce a tailored design, increased satisfaction, greater input into specification and materials' (Heffernan and Wilde, 2020)
The Project Team and Community Satisfaction				
1	Stakeholders' satisfaction	SS04	Achieve project Team satisfaction	'cost, quality, safety and environment, and time' (Nzekwe-Excel, 2010)
2		SS07	Adherence to project schedules	'The measure for indicating how well the project is following its planned schedule' (Lipke, 2008)
3		EN04	Selection of housing projects location	'Good location for housing projects'
4	Neighborhoods' satisfaction	SS18	Harmonious social relationship	'Community cohesion; compatibility between housing design and neighboring housing facilities; neighborhoods reputation; neighborhoods satisfaction; reduced number of crimes (robbery and murder) recorded within the neighborhoods; impact of housing facility on price of neighboring housing facilities; impact of housing facility on neighboring community' (Adabre and Chan, 2020; Mulliner and Maliene, 2011), 'level of social mix in housing environment'
5		EN05	Mix land use Planning	'the process of planning and building in regards to different land use functions, in a degree of density with regards to building height and placement, and public transit and walkability options/ Adequate accessibility to social amenities; social infrastructure and mixed usage' (Nainggolan et al., 2020)
6		EN06	Land use efficiency	Small amounts of artificial area are used by many inhabitants
7		EN07	Housing density	'When possible, support greater density and reduce the burden on the developer to provide additional active living elements.'
8		EN18	Compact planning and design	'using the least amount of land for development and supporting infrastructure that is reasonable under the circumstances; Compact and efficient layout' (Nainggolan et al., 2020)
9	Reduced disputes occurrence	SS08	Reduced occurrence of disputes and litigation	'Cohesion among households and neighbors in the community; sense of community' (Adabre and Chan, 2020; Mulliner and Maliene, 2011)
Marketing and The Waiting Time				
1	Housing facility marketability	~~ES13~~	~~Formulate supportive housing policies~~	'Ensure that resident options in choosing preferred long term or permanent housing are enhanced' (Office of mental health, 2022)

2		~~ES14~~	~~Ensure balanced housing market~~	'a sufficient range of affordable housing within a balanced housing market' (Mulliner and Maliene, 2011)
3		SS12	Marketing the housing project facility	'economic and market instruments need to be aligned to provide incentives' (Singh and Pandey, 2012)
4	Time spent waiting for a housing unit	SS13	Construction cost performance of project facility	'Recover the costs of services by proper functioning and maintenance, adaptability of housing units for future needs' (Ibem, 2011)
5		SS14	Waiting Time before receiving housing unit	'the period of time in which a building construction is waiting for further processing.'
6		SS15	Subsidies provision for housing	'Direct payment provided to renters to cover some of the cost of rent on the private rental market. government funding for the development and operations of facilities' (Lee, 2022)
Housing Life-Cycle Costs				
1	Maintainability of housing (cost of maintenance or retrofitting)	SS03	maintainability of housing units and facilities	'Refurbishment, repairs, retrofitting cost; low-cost maintenance features in house; ease of maintenance, effort in upkeep of housing facility' (Adabre and Chan, 2020; Mulliner and Maliene, 2011)
2		ES15	Cost effectiveness	'Renewable materials; Recover the costs of services by proper functioning and maintenance, organization of economic activities financial' (Singh and Pandey, 2012)
3		ES23	Value of housing units after use	'durable materials, economical design' (Nainggolan et al., 2020)
4	Other lifecycle cost of housing Energy and water efficiency (utility bills)	ES04	Reduced Housing Life cycle cost	'Taxes or charges on housing facility; Passive thermal design, low embodied energy materials' (Nainggolan et al., 2020)
5		EN01	Energy efficiency	'Operation cost of major electrical appliances; lighting efficiency; renewable energy use; efficient energy design of housing facility; energy efficient systems; Renewable energy' (Nainggolan et al., 2020) 'An architectural solution to energy consumption issues as ventilation, lighting, building morphology' (Ibem, 2011) 'Combine energy with other interventions, renewal or fossil fuel-based energy sources, shift energy sources, and improve energy efficiency' (Singh and Pandey, 2012). 'Better understanding of the home energy system, ability to specify higher standards of energy efficiency, sharing information and awareness about zero carbon, lifestyle choice, shared energy system, stimulate demand for zero carbon/energy efficient homes, lower cost frees up funding, explore lower impact materials and methods' (Heffernan and Wilde, 2020)
6		EN03	water efficiency	'access to quality and portable water; water conservation strategies (rainwater harvesting)' (Adabre and Chan, 2020; Mulliner and Maliene, 2011) 'availability of low-flow aerators in household faucets; water efficient systems, water efficient landscaping'

Environmental Effectiveness				
7	Environmental friendliness	EN02	Housing environmental performance	'Reduction in emissions of greenhouse gasses (NO2, CO); environmental friendly waste management; environmental friendly design; environmental-friendly materials; circular economy (materials and products reused)' (Adabre and Chan, 2020; Mulliner and Maliene, 2011) 'purification of air and water, pollution control, mitigation of floods and droughts, re-generation of soil fertility, moderation of temperature extremes, carbon sequestration climate change mitigation and enhancing the landscape quality' (Singh and Pandey, 2012)
8		EN12	Waste management for housing project	'Waste management and facilities' (Mulliner and Maliene, 2011)
9		EN19	Recycle and reuse construction material	'Design for disassembly, Reuse waste materials, Reuse old building, Grey water systems; (Adabre and Chan, 2020; Mulliner and Maliene, 2011) use Recyclable materials/design for recycling, Use of recycled materials, Recycle construction waste & other' (Nainggolan et al., 2020)
Quality of Housing Performance				
1	Aesthetic view of completed house	SS09	Project Aesthetics	'Compatibility of design features of affordable housing facility with neighboring housing facilities; landscaping design; color of materials or building elements; preservation of key local / traditional architecture / designs' (Adabre and Chan, 2020; Mulliner and Maliene, 2011). 'the contribution of public housing to the aesthetics of urban landscape and morphology' (Ibem, 2011)
2	Technical specification of housing facility	SS10	Technical specifications of housing units	'Entails assessing the level that elements of housing facilities meet technical requirements / performance output' (adabre and chan, 2020; mulliner and maliene, 2011) 'Application of passive solar, using strategic shading of trees and plants, local construction materials, use energy efficiency and renewable energy sources, optimization building orientation and configuration, application of green roof technology, optimization building envelope thermal performance, insulation (roofs, windows, floors, walls and exterior doors), application of natural, ventilation, ample ventilation for pollutant and thermal control, using small-scale solar panels, installing reflective window film, overhanging roofs bin verandas and painting outside walls with reflective paint and color' (bredenoord, 2015; roufechaei et al., 2014)
3	Technology transfer	SS11	Application of building technology	'Innovation in design and construction of affordable housing facilities to improve quality, energy efficiency and reduce housing cost' (Adabre and Chan, 2020; Mulliner and Maliene, 2011) 'Cooling and heating system (environmental friendly materials for HVAC system), Application of ground source heat pump, Application of efficient water heating, Application of solar water heater, Insulation tank and pipes, Demand tank less water heater, Application of thermostats Making clean electricity (application of solar system technology),

				Application of lighting choices to save energy, Application of lighting product, Application of artificial lighting, use off efficient type of lighting (lighting output and color), Integrative use of natural lighting (day lighting) with electric lighting system using water saving measures in showers and toilet' (Bredenoord, 2015; Roufechaei et al., 2014)
4		SS17	Tenure security	'Have legal protection against forced evictions, harassment, and other threats.'
5		SS21	Security	'security and safety issues' (Ibem, 2011) 'The housing should be a safe and healthy place to stay' (Badyina and Golubchikov, 2012) (roshanfekr et al., 2016)
6		SS22	Privacy	'quality of internal spaces of housing units, privacy in dwelling units' (Ibem, 2011)
7		SS23	Suitability	'Create a healthy environment with Nontoxic products/safe appliances, green and open space, natural, permeable materials and ventilation ,appropriate site and position as well as flexibility.'
8		SS01	Performance of housing units	'Healthy, safe and secure; durable, resilient to sustain potential natural disasters and climatic impacts' (Badyina and Golubchikov, 2012)
9		SS24	Quality of housing units	'Meet certain quality standards; Quality of indoor and outdoor environment; quality of materials or workmanship' (Adabre and Chan, 2020; Mulliner and Maliene, 2011) 'humane building contributing to overall wellbeing, durable materials and structure, aesthetically pleasing as well as functional and appropriate to needs'
10		SS25	Multi type and size of housing units	'Multi type and size of housing units'
11		SS26	Organizing the human scale	'consider the Human scale into design, which is the set of physical qualities, and quantities of information, characterizing the human body, its motor, sensory, or mental capabilities, and human social institutions.' (Baldwin, 2021)
12	Quality performance of housing facility	EN08	Disaster resistance	'Be aware of the different hazards occurring in the area; Identify the most suitable areas for settlement purposes; Assess the best construction solutions in order to minimize the risks and possible losses; Determine the best options in order to deal with the different possible risks' (GFDRR, 2013)
13		EN09	Adequate living space within small size units	'Fitting good life into a small space'
14		EN10	Housing quality (reliability and durability)	'adaptability of housing units for future needs' (Ibem, 2011) 'Long-Lasting The finest construction methods, service lifespan of around sixty years without the requirement for uncharacteristic repairs or replacements' (roshanfekr et al., 2016)
15		EN11	Effective utilization of resources	'Track resource availability, optimize resource time, effort, and cost, ensure project teams have the right skills and experience, reallocate resources in response to project changes, Track utilization rates to avoid underutilization, Identify and resolve resource conflicts and Forecasting future requirements. Renewable energy sources should be utilized optimally, infrastructure, land, and energy should be utilized effectually, well-located in terms of conveyance, services, and facilities, design as well as house position to manage negative wind

				impacts and maximize the advantages of daylight, sunlight, and solar paybacks.' (roshanfekr et al., 2016)
16		EN13	Local design	'Using the design that is specific to a location, the materials available in that location, and the culture of the people. Using traditional local materials and techniques that compatible with cultural values' (Díaz López et al., 2019)
17		EN15	Functional and structural Space flexibility	'Service flexibility, modifiability, and long-term adaptability' (Saari and Heikkila, 2008) 'houses should be adaptable enough to the varying needs' (roshanfekr et al., 2016)
18		EN16	Building material efficiency	'finding ways to optimize the waste generation and material usage of a building project throughout the building's life. (value engineering, good waste management, reusing and recycling materials, and procuring more sustainable products)' (Allplan, 2019) 'Renewable materials, durable materials' (Nainggolan et al., 2020). 'The process of sourcing, transportation, manufacturing, and construction of materials is vital to reduce the embodied energy used in housing production' (Olotuah et al., 2018)
19		EN17	Environmental design criteria	'environmentally management system/EIAs, Environmentally friendly materials, restore natural systems, replant vegetation, produce minimal waste, design with nature (natural vegetation), mixed-use and high density layout, and also suitable sanitation system.'

6.3. HOUSING DESIGN AND CONSTRUCTION PROCESSES IN HEBRON CITY

The sequence of the design and construction process in Hebron city was identified and summarized, through several interviews with a group of engineering offices in Hebron and inquiring about the design and construction process for residential buildings, its stages, and the most important things included in each stage.

6.3.1. Design process

1. Design brief (client meeting); at this stage, an interview with the client will be conducted to determine what is needed for the project.
2. Research and measurements, research for design based on client information. Looking at industry leaders' successes and failures provides insight into what works.
3. Sketching, begin sketches based on client needs, as well as subsequent industry research and successful pieces seen in it.
4. Following the presentation of sketches and concepts, the client will provide feedback on what they like and dislike.
5. Revisions and changes to the designs requested by the client are completed. The client will have chosen a final direction, and the design will be nearing completion.
6. Create a 3D visualization model.
7. Delivery and final construction documents, the stage at which all necessary files are delivered to the client. This stage entails selecting finishes and fixtures, as well as preparing the technical documentation needed for construction and obtaining agency approvals. This stage may be preceded by several stages of revision and concept presentation.
8. Prepare structural, plumbing, and electrical drawings, consult a structural consultant (mechanical, electrical, and plumbing) engineer, and have the drawings prepared. Individual home owners do not frequently go for structural designs. This is a problem for two reasons:
    a. Most of the time, contractors overdesign structures, resulting in the waste of construction materials. A good design would optimize material consumption based on what is needed.
    b. Designs are created based on user input, whereas contractors work with regard to rules. So, if one has plans for future expansion, a designer can provide the best solution based on the requirements.

9. Bills of quantities (BOQ), are documents generated by a quantity surveyor or cost consultant that specify the quality, quantity, and cost of work needed to accomplish a project.

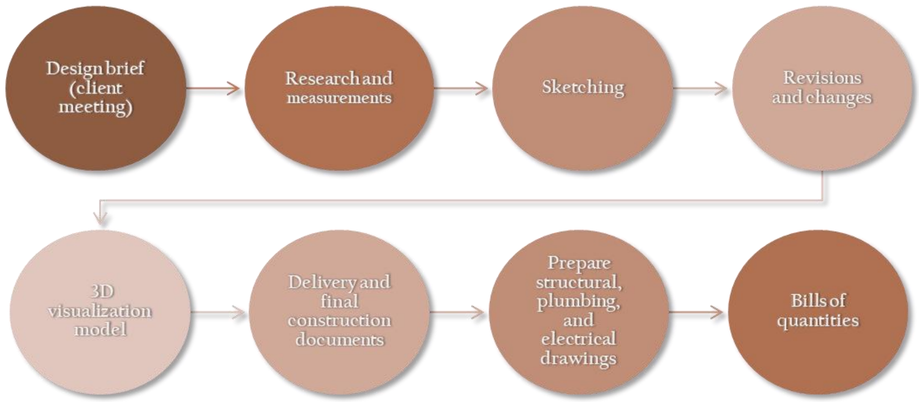


Fig. 6. 1: Housing design and construction processes in Hebron city

6.3.2. Construction process

1. Submit plans to the government (local authorities). You must pay a portion of the area you are constructing for approval, and all plans must be approved before construction begins.
2. Building site preparation is the initial phase of constructing a house. This includes not just clearing the site of trash and vegetation but also making sure that the laborers have access to the required services and facilities.
3. The following phase is to lay the foundations. The cost of creating foundations is one of the most crucial aspects in a project, therefore anyone who wants to stay within their budget and time frame must choose the best foundation system. Foundations can be laid once the best cost-effective solution has been selected - often through a geotechnical study that entails boring or digging trial holes around the proposed new building site.
4. Building superstructures, which include:
   - Columns casting
   - Floor installation
   - Walls building
5. Interior and exterior fittings tasks
6. External works and drainage
7. Decoration
8. Landscaping

CHAPTER 7

RESULTS AND CONCLUSIONS

7.1. INTRODUCTION

Due to the global housing shortage, it is imperative to have sustainable and affordable solutions that specifically cater to the most affected areas across the world. In Palestinian cities, the shortage of affordable housing options is still a significant concern, which necessitates architects to design innovative and alternative solutions that can replace the outdated models of modernist architecture.

This research concentrated mainly on the design aspects and considerations of appropriate and adequate sustainable and affordable housing to address Palestine's existing housing challenges. It is essential to incorporate sustainability and affordability considerations early in the design process. Life cycle costs and environmental impacts, for example, are easier to assess during the conceptual stage as they demand fewer details in building information. This allows for a more comprehensive analysis of the potential impacts and costs of the design, resulting in more informed decision-making and a more sustainable and affordable outcome. This study employed information sources from a variety of countries around the world to identify critical criteria, success factors, design challenges, and drivers for achieving sustainable affordable housing. in order to develop an assessment model for housing sustainability and affordability performance, allowing design practitioners to ensure that these factors are taken into account in their decision-making in the design process.

When designing and delivering sustainable and affordable housing in Palestine, individual and regional factors must be carefully considered. A scoping study was carried out to thoroughly investigate these factors and establish local design considerations. This chapter identified and presented findings as design strategies in all stages of housing design within a framework of sustainable and affordable housing design. that can be used to guide appropriate design responses as well as the implementation of sustainable and affordable housing in Palestine.

7.2. DESIGN PROCESS FOR AFFORDABLE AND SUSTAINABLE HOUSING

Achieving sustainable and affordable designs requires an integrated design process that surpasses the conventional approach. Implementing an approach that focuses on building performance, involving an interdisciplinary and integrated project team, and preparing the project for optimal performance are the keys to ensuring high design quality. Consequently, the design process is critical since most decisions governing building performance during use are made at this stage.

Following a thorough review of the literature and case studies on the strategies for achieving each of the indicators of sustainability and affordability performance in housing, as well as identifying the stages of designing residential buildings in Hebron City, these strategies were reformulated within the project design stages to make them easier for engineers and housing developers to follow and implement.

Fig 7. 1: Design stages and categories in the Palestinian affordable and sustainable housing design process

7.3.1. Design Brief

A well-designed sustainable and affordable housing should have certain characteristics such as architectural appropriateness, social and environmental suitability, affordability, accessibility, durability, health, security, safety, adaptability, and resource efficiency (Heritage and Local Government, 2007). To ensure that a housing scheme is properly designed, the following factors should be considered in its approach:

- The client's requirements and the constraints the designer must work within should be explicitly stated.
- The key decision-makers within the client organization responsible for making decisions related to the project should be identified early in the process.
- Early and appropriate architectural and other professional input.

7.3.2. Site selection

The process of providing sustainable and affordable housing is dependent on the selection of an appropriate site, which is critical to the development of a self-sustaining community in the future. The location, size, and accessibility of the site, as well as its proximity to amenities and services, are essential considerations in this process. Furthermore, any new housing development will have a significant impact on the surrounding area, making site selection even more critical. Opportunities for improving an area's general environment may be lost or greatly reduced unless proper care is taken in selecting suitable sites. The care taken in evaluating the site so that its limitations are recognized and its benefits can be capitalized on will have an essential effect on the quality of the resulting housing development (Heritage and Local Government, 2007).

Site selection should be carried out systematically based on predetermined criteria. When selecting a location, the following factors must be considered:

- Access to supplementary facilities such as health care services, shops, childcare facilities, leisure facilities, employment opportunities, educational institutions or facilities, recreational and sporting facilities, library facilities, waste management facilities and adequate drainage system.
- Access to the city center, social infrastructure, community living space and attachment, open green public space, and places of work and worship.
- Existing transportation facilities, such as pedestrian walkways, roadways, and bikeways. Locational appropriateness to reduce reliance on the automobile.
- Ensuring public transportation accessibility through a high-quality and affordable mass transportation system, as well as traffic planning, fuel quality, and road infrastructure.
- Existing infrastructure and facility access. For easy access to amenities and trails, locating a home near the street is ideal and cost-effective. Septic tanks, well water, gas tanks, and so on. The greater the distance between them, the more expensive it is to work on-site.
- Mix land use Planning and various land use functions, with varying densities in terms of building height and placement.
- To ensure a secure level of tenure that ensures legal protection against harassment, evictions, and other threats.

- Issues about security and safety. The housing should be in a safe and healthy environment. Understand the various risks in the area and choose the best areas for settlement

7.3.3. Research and measurements

The development of new proposals necessitates a thorough understanding of the context of the site, as well as its possibilities and limitations for providing sustainable development. It is critical to create an integrated and positive sense of place that promotes inclusion and community cohesion in order to achieve good health and well-being, sustainable communities, and social value. The following considerations must be included in the design process in this regard:

- To begin, it is critical to understand the context when delivering high-quality and well-integrated development. the Constraints, opportunities, and existing features of the site, such as orientation, topography, trees, and surrounding networks of buildings, landscapes, ecology, routes, and must be identified early in the design process.
- It is important to understanding the residents' cultural values and natural way of life, as well as their reflection of the region's distinct cultural and historical characteristics.
- The emphasis should be on connecting people and nature, with the goal of increasing biodiversity within the site by 20%. The development must blend in with its surroundings, foster community cohesion, and improve sustainable lifestyles for new and existing residents.
- Explore options for adequate financing and provision, as well as funding organizations.

7.3.4. Building design

7.3.4.1.Site Planning

- Response to Context
    - Consider the footprint of the building in relation to neighboring buildings and their front yard setbacks. This will help to ensure that the building blends in with its surroundings.
    - To minimize disruption and maintain privacy, exterior open spaces, pedestrian and bike paths, vehicle routes, parking areas, utility/service areas, and other features should be planned with neighboring buildings in mind.

    - Mechanical equipment, trash collection, and parking should be placed in areas that could cause the least amount of disruption to neighboring residents or the general public.
    - Position the landscape and building so that it has the least impact on surrounding existing structures, consider neighbors' privacy, and provide them with access to natural air and daylight.
- Open Space and Landscape Design
    - Consider including yards, roof terraces, balconies, loggias, porches, interior courtyards, entry courtyards, and upper-level decks that are appropriate for the site, context, and building form.
    - Make it possible for residents to enjoy nature by providing play areas and gathering places.
    - Seating should be available to promote social interaction.
    - Increasing vegetation while considering summer shading and winter solar access.
- The design of pedestrian and bike-accessible sites should encourage non-motorized mobility.
- Parking and driveways should be designed to have as little impact on inhabitants, the general public, and neighbors as possible.
- Outdoor lighting should be provided for functionality and safety while reducing negative effects and energy consumption.

By taking these factors into account, a building can be designed to blend in with its surroundings and provide a comfortable living environment for residents.

7.3.4.2.Massing (Built form)

Several issues must be considered when designing the building form:

- When designing, take into account site features such as grading, topography, soil conditions, vegetation, and so on.
- The human scale, which refers to the quantities and qualities of physical information that characterize the human body, its mental, sensory, or motor capabilities, and social relationships, is also required in building design.

- Compact planning and design should be used to maximize land use while keeping in mind the need to support greater density and reduce the burden of providing additional active living elements.
- Reducing the number of ins and outs in perimeter walls to simplify the footprint and layout. The design will be more efficient if curved and angled walls, arches, and complex roof lines are avoided.
- Instead of having small level changes, consistent floor levels should be maintained.
- It is best to group or centralize mechanical, electrical, and plumbing systems.

7.3.4.3.Facades

- Consider architectural history, regional significance, culture, heritage, and the well-established pattern of residential neighborhoods and conservation districts.
- Design building facades that maximize daylighting while protecting residents' privacy in both existing and new buildings.
- Consider the architectural styles of the surrounding area as well as the urban characteristics of the street.

7.3.4.4.Architectural Details

- Included in this are the centralization or grouping of mechanical, electrical, and plumbing systems.
- The building methods used are of the highest quality and are designed to last for approximately sixty years without the need for any unusual replacements or repairs.

7.3.4.5.Building materials

- Use and incorporate recycled content materials without sacrificing material quality or durability.
- It is critical to use natural and permeable materials, safe appliances, nontoxic products, and proper ventilation placement in the site.
- Building materials should be recycled and reused whenever possible to reduce environmental impact, and waste should be properly recycled.
- building disassembly design should be considered in order to facilitate future reuse and recycling of materials.

7.3.4.6.Building interior

- Minimize design standards to lower the costs.

- Interior living areas should be comfortable as well as attractive. access to fresh air and daylight, Interior living space, and common storage should all be included in units. Interior living spaces have to be functional as well as comfortable. Bedrooms are required to be large enough to contain standard bedroom furniture and provide enough daylight and ventilation. The kitchen counter and storage space have to be plentiful. Residents' homes or the development should have laundry facilities.
- Get rid of redundant spaces and spaces that serve the same purpose, consider multi-purpose spaces and functions so that entire rooms of space can be eliminated, and consider dead spaces in the plan that can be usable areas for other purposes. Reduce the need for extensive storage.
- Reduce square footage wherever possible. Housing floor plan, Room or house size; placement of various rooms; adequate living space within small size units. Trying to squeeze a good life into a small space.
- Interior fixtures and finishes should be of high durable, quality, eco-friendly, and energy-efficient.
- provide a range of unit sizes and types. This will meet a variety of needs while also contributing to a comprehensive community.
- Consider long-term adaptability and design for adaptability and modifiability to allow for future adaptation to changing occupant needs and to maximize the building's lifespan.

7.3.5. Sustainable Design

The primary goal of developing a housing scheme should be to ensure its social, environmental, and economic sustainability by:

7.3.5.1.Energy

Energy efficiency is a critical component of the design and construction of sustainable and affordable housing. It entails employing a variety of energy-saving techniques to reduce the amount of energy used for lighting, cooling, and heating. Buildings that are energy efficient have significant regulatory, economic, energy demand, and environmental implications. Energy efficiency in housing can be attained by:

- Design and implementation of energy-efficient systems (lighting, heating, cooling, etc.) in housing facilities.
- Integrate energy with other interventions, such as renewable or fossil-fuel energy.
- Providing an architectural solution to energy-related issues such as building morphology, lighting, and ventilation.
- An improved comprehension of the home energy system, as well as the specification of higher energy efficiency standards.

7.3.5.2.Water

- The ability to have access to portable and high-quality water, along with conservation techniques for harvesting of rainwater and safe storage, as well as its use for a variety of purposes.
- Availability of low-flow aerators in house fittings, such as showerheads, taps, toilet cisterns, and other appliances; to achieve water-efficient systems and landscaping.
- Use greywater recycling systems and strategies to recycle gray water and reuse it for irrigation or toilet flushing.

7.3.5.3.Waste

- Construction waste minimization, with provisions for recycling both construction waste and domestic waste generated during building maintenance.
- Environmental-friendly waste management and facilities for housing projects.
- Prioritize durable items, equipment, materials, and other interior or non-constructional components that can be easily fixed and, if necessary, recycled.
- Design with the building's end-of-life and efficiency in mind, using materials that can be deconstructed and reused in future structures. Reduce the use of parts, glues, and fasteners, and investigate how to provide disassembly instructions and reuse pathways for recently built or restored facilities.

7.3.5.4.Resources

- Effective utilization of resources and Track resource availability
- Reallocate resources in response to project changes
- Track utilization rates to avoid underutilization
- Ensure project teams have the right skills and experience

- Optimize resource time, effort, and cost
- Identify and resolve resource conflicts and Forecast future requirements
- Optimal use of renewable energy sources, as well as reduced use of natural and precious resources throughout the building's lifetime, through the use of low-maintenance and efficient systems, components, and fittings.
- Use of infrastructure, land, and energy efficiently
- Select a convenient location in terms of transportation, services, and facilities.
- House design and positioning to reduce wind effects and maximize the benefits of sunlight, daylight, and solar paybacks.

7.3.5.5.Indoor Environmental Quality

- Achieve humane building that contributes to overall well-being.
- Improve the indoor air quality
    - Use nontoxic and safe appliances, natural, permeable materials, and an appropriate ventilation site and position.
    - o Using zero-VOC products in all walls, ceilings, floorings, acoustic and thermal insulation, furniture and exterior-applied products.
- Improve the indoor thermal quality
    - Include operable windows in the design to increase natural ventilation and provide occupancy controls in all regularly occupied spaces.
- Improve the indoor lighting quality
    - o Design building facades in both existing and new buildings to maximize daylighting while protecting residents' privacy.
- Improve the indoor sound quality
- Improve the indoor odor quality

7.3.5.6.Cost

- Investigate low-cost materials and methods. And, where possible, greater use of materials derived from local, sustainable sources.
- To reduce housing life cycle costs, use passive thermal design and low-energy materials.
- The compactness, orientation, thermal insulation, and air change management of the building should be prioritized in its design. To avoid incurring significant additional costs, these factors should be considered during the design stage. Addressing these factors

correctly during the design stage can result in cost and comfort savings over the life of the building.

- Recover service costs through proper operation and maintenance, as well as financial organization of economic activities.
- It is critical to carry out a successful project in order to maximize facility construction cost performance. Furthermore, to guide the design process, cost-in-use assessments that compare capital and operating expenses are recommended.
- Maintaining the value of housing units after use through employing durable materials and cost-effective design
- Economic and market instruments must be aligned in order to provide incentives.
- Obtain government funding for the development and operation of facilities.
- Reduce The waiting time before receiving a housing unit which is the amount of time that a building construction is awaiting further processing.
- Consider the maintenance of housing units and facilities. Include low-cost maintenance features such as ease of maintenance and effort in housing facility upkeep in the house. Consider the cost of refurbishment, repairs, and retrofitting.

7.3.5.7. Social and Cultural

- Use location-specific design by incorporating local materials and cultural traditions. Implement traditional techniques and materials that are culturally appropriate.
- Create supportive housing policies to increase residents' options for preferred long-term or permanent housing.
- Reduced occurrence of disputes and litigation, and achievement of community cohesion among households and neighbors.
- Housing facility safety performance (crime rate) A secure indoor and outdoor environment; a low number of crimes (burglaries and robberies) reported in housing facilities. In addition, techniques like Crime Prevention Through Community Design, which includes:
    - Maximizing the visibility of people, parking areas, and building entrances and creating great pedestrian spaces with ‘eyes on the street’ through permeable building facades
    - Providing adequate lighting at night

  - Creating well-defined property edges through landscaping, pavement and sidewalk design, signage, and open fences
  - Creating transition zones from public to private space with features such as large front porches, entryways, and so on.
- Achieving social acceptance, alleviating poverty, ensuring human well-being, and promoting employment opportunities.
- Consider the ability of the housing facility to meet the evolving needs of the household. and achieve a high level of privacy in housing unit interiors.

7.3.6. Simulation

Building simulation for design, valuation, and analysis has become an essential tool for improving the built environment and focusing on building energy efficiency. The heating, ventilation, and air conditioning (HVAC) systems that regulate indoor comfort consume the majority of a building's energy. To establish absolute energy-efficiency standards for residential buildings, it is critical to incorporate efficient technology and materials appropriate for the site and conditions, provide amenities and services that align with the building's intended use, and consume less energy than other similar buildings. Minimizing thermal loads, designing efficient HVAC systems, utilizing passive strategies, and utilizing renewable energy are all part of designing an energy-efficient building. The use of simulation programs can speed up the design process for engineers, prevent significant design flaws, and increase efficiency.

7.3.7. Prepare structural, plumbing, and electrical drawings

In architecture, effective communication is critical. Drawings are essential for communicating information between clients, consultants, and contractors. However, if the design lacks clarity, accuracy, and detailing, such as cross sections of structural elements, joints, plumbing, and electrical connections, misinterpretation of the drawings may occur, resulting in defects. Drawings and other forms of communication must be meticulously documented and well-organized to ensure the effectiveness of the information transfer process.

7.3.8. Construction process

- **Site preparation for a building**

Site preparation costs Reduce the costs of the multistep construction process of all the prep work you do before construction on a site; which involves site surveying, grading, leveling, clearing land, drainage, earthmoving, and demolition. (BigRentz, 2022)

7.3.9. Maintenance and strengthening

Once the construction has been completed, it is necessary to schedule regular maintenance of it. In fact, the choice of the proper site, the correct use of the materials, and good construction techniques are not enough to guarantee the long-term quality of the house. The provision of regular maintenance of the different parts of the building is the only solution against the deterioration and aging of the different components. Maintenance may be at the structural level or imply minor works, but each action devoted to the strengthening of the house will positively impact in the longevity of the house.

7.4. BROCHURE FOR DESIGNERS

A brochure has been created to effectively articulate and disseminate the research findings (Fig. 7.2, 7.3). This brochure encapsulates the framework for Palestinian housing design, which has been carefully developed to meet the region's unique needs and challenges. The brochure presents the design framework in a clear, concise, and easy-to-understand manner, allowing designers to implement the framework in a practical and effective manner. The brochure provides a variety of information, insights, and practical guidance on how to successfully navigate the complexities of sustainable and affordable housing design in Palestine. It is a valuable resource for anyone working in the field, providing them insights and advice.

NOOR ALI M. ABUREESH

WE ARE ALWAYS COMMITTED TO
ONLY BUILD WITH THE BEST QUALITY
IN AFFORDABLE PRICE

HOUSING DESIGN

Housing affordability

"Housing affordability is broadly defined as households' ability to purchase or rent adequate housing without compromising their ability to meet essential living costs."

Sustainability Achievement in Affordable Housing

Sustainability can be characterized as minimizing the impact on the environment and natural resources, using less energy, improving air quality with nontoxic substances, and lowering greenhouse gas emissions.

Sustainability is a foundation of housing affordability because it reduces spending on energy bills, transportation, and health care. Therefore, in addition to building solutions (resource and energy efficiency, water efficiency, and environmental, ecological, and health safety), sustainable housing policies should address affordability, social justice, and the cultural and economic impacts of housing.

Fig 7. 2: BROCHURE FOR DESIGNERS (Pages 1 and 2)

Fig 7. 3: BROCHURE FOR DESIGNERS (Pages 3 and 4)

7.5. CONCLUSION

Given that sustainable and affordable design necessitates a more involved approach and an integrated design process than a conventional design process, this Thesis presented the findings of a scoping study examining the various factors influencing the design and delivery of affordable and sustainable housing in Palestine.

The research study identifies various design drivers that can contribute significantly to the provision of sustainable and affordable housing in Palestine. The study focuses on achieving affordable housing with sustainability aspects that go beyond environmental concerns alone. The study considers economic and social aspects, which contribute to the triple bottom line associated with sustainable design. The study concludes that informed design decision-making processes that account for critical criteria, success factors, design barriers, challenges, and design drivers for sustainable affordable housing can address the challenges identified in this study.

The research conducted will provide valuable insights to aid professionals and organizations involved in housing design and provision, including architects, engineers, policymakers, governmental and non-governmental bodies, planners, community-based organizations, and developers. The findings will assist in making informed decisions that promote sustainable and cost-effective housing solutions.

7.6. FUTURE WORKS

Future research avenues in sustainable housing design exist, particularly in the examination of sustainability indicators from the perspectives of both households and experts. The brochure shown in Fig. 7.2, which detailing the current research findings of the affordable and sustainable housing design process in Palestine was presented to an engineering office in Hebron City that was responsible for the design of the Farsh Al-Hawa case study. The goal was to use the results to create a new housing design. This design will be thoroughly evaluated at the design stage to ensure that the research findings are effective in providing sustainable and affordable housing in Palestine.

While the current assessment model and index scores are simplistic in nature, obtaining an extensive perspective from households and experts to determine the weights for the sub-indicators could be useful in developing final scores for the criteria. Furthermore, the indicator evaluation, which is based on three options (0: does not meet (X); 1: comes close (); 2: meets or exceeds ()), does not take into account the complexities of each measure. Future research could therefore investigate deeper approaches to evaluating sustainability indicators in order to improve the accuracy and efficacy of sustainable and affordable housing design.

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