

Journal Home Page: <https://sjes.univsul.edu.iq/>

Research Article: The Impact of Environmental Design Solution on Livability in the Traditional Houses of Sulaymaniyah City

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Article Information

Article History:

Received June 27th, 2025

Accepted : November 29th, 2025

Available online: December 2025

Keywords:

Livability. Environmental Design Solutions. Computational Simulation. Thermal Comfort. Passive design

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DOI <https://doi.org/10.17656/sjes.102007>



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Abstract

This study aims to address the gap in prior researches, which often lack a comprehensive evaluation of traditional buildings in the city of Sulaymaniyah, by examining the environmental design techniques inherent in the traditional dwellings of Sulaymaniyah city and their influence on livability, highlighting passive systems that align with the local climate. Despite the architectural and cultural importance of these residences, previous studies have not provided thorough assessments that combine both qualitative and quantitative approaches. This work fills the gap by examining the Faqe Shally house as a case study, utilizing computational simulations to evaluate five critical environmental parameters: thermal comfort, daylight access, direct solar radiation, natural ventilation, and relative humidity. The study employs Autodesk Revit and CFD techniques to recreate the original architectural configuration and material layers to model environmental performance employing historical climatic conditions, aligning with a questionnaire survey for thirty houses in the traditional neighborhoods, concerning ecological adaptation. The study's findings indicate that design features, including courtyard orientation, high thermal mass materials, strategic window placement, and seasonal spatial utilization, work together as an integrated system to markedly improve livability in traditional houses. While the upper floor exhibits enhanced environmental comfort for residential purposes, depending on experimental results, the ground floor is more appropriate for storage and services. The findings highlight the significance of traditional environmental design strategies for modern sustainable housing and provide a framework for incorporating historic architecture into climate-responsive urban planning.

1. Introduction

Environmental design is a historical discipline that developed in reaction to climatic challenges affecting terrestrial constructions, as evidenced by vernacular architecture's adaptation to heat and light, to ensure sufficient illumination and temperature regulation to accommodate various environmental conditions: in colder regions for mitigating gloomy skies and winter heat loss, and in warmer regions for managing intense sunlight and heat retention (Thomas, 1996). Prior to the Industrial Revolution, traditional architecture predominantly relied on passive design strategies,

whereas the subsequent evolution of architecture facilitated rapid advancements in scientific capabilities for environmental engineering, enabling the creation of thermal comfort and appropriate lighting in architectural designs (Sassi, 2006). Gradually, technological improvement resulted in visually striking building that frequently depends on high quantities of energy to ensure indoor environmental comfort. This dependence on fossil fuel-derived energy renders construction unsustainable in the long term. The result of the approach necessitated the analysis of historical

passive architecture to inform the construction of more sustainable architecture moving forward (Tosin Olatunde, 2024). In this context, this study examines the convenience of environmental adaptation in the lives of our ancestors within their homes, highlighting the absence of prior research on the traditional dwellings of Sulaymaniyah city. The benefit of this study can be derived from its objective to comprehend the livability ratio of traditional dwellers. The methodologies developed to analyze and assess the characteristics and mechanisms functioned as environmental design solutions in the configuration and overall structure of houses, which is crucial to examine to uncover the historical approach to adapting regional climates in architecture for a more sustainable lifestyle. This procedure encompasses interdisciplinary approaches, requiring comprehension of building materials, components, specifics, and design, alongside climate data pertinent to the site. A multitude of scholars have examined the evaluation of traditional dwellings using many techniques, prompted by the heightened emphasis on sustainability, the global energy problem, and the rampant exploitation of natural resources. Recent research in this field regards traditional buildings as a valuable repository of passive systems and comprehensive solutions for greener structures that leverage natural climatic components in passive systems, aiming to harmonize human existence with nature rather than relying on costly active systems. The research conducted by (Saliha Erdurmus, 2024) assessed the thermal performance of traditional houses and juxtaposed the findings with the Turkish standard (TS825) using Design Builder software, concluding that the incorporation of modern heating systems could enhance the thermal performance of historical houses by 30-35%. A separate study analyzed the energy consumption of old buildings vs contemporary houses for achieving thermal comfort, utilizing a field survey data recorder sensor (UNI-T USB). determining that conventional houses offer thermal comfort independently of energy-dependent systems, with potential for enhancement (Amal Chkeir, 2023). Another study from China assessed the indoor thermal range and habitability of traditional residences in five villages in Northeast Sichuan during the summer using a field survey. Survey regarding the social and environmental dimensions of the efficacy of traditional buildings in sustaining thermal and humidity comfort for indigenous residents, who demonstrated greater resilience to the indoor conditions of these houses

compared to non-locals (Chaoping Hou, 2024). Regionally, a study conducted in Baghdad assessed the courtyard area to determine the duration of user comfort in everyday activities. The practical calculations indicated that courtyards in Iraq, particularly in Baghdad, offer up to 38% of potential occupancy hours with appropriate thermal conditions annually. The study indicates that the design of courtyards and the width-to-height ratio of the area significantly influence temperature conditions, among other aspects (Al-Hafith, 2022). These investigations, along with numerous others from different locations, assessed environmental adaptation by concentrating on a specific aspect or area within traditional buildings to comprehend the mechanisms regulating comfort levels. This research aims to identify the deficiencies in existing literature and address them by evaluating five environmental indicators of the comfort zone: thermal comfort, daylight, direct solar access, natural ventilation, and relative humidity. Contrast the outcomes of these assessments with the standard of livability in conventional residences. In comparison to ASHRAE 55-2004, recognized as one of the most dependable standards globally for Thermal Environmental Conditions for Human Occupancy (Oyuni, 2023). This study employs computational simulation software to evaluate the hypothesis regarding the potential of environmental design solutions, representing one of the initial investigations yielding numerical data on the traditional houses of Sulaymaniyah city, emphasizing their capacity to improve environmental livability. The article constitutes a case study for a master's degree requirement under the same title, under the Department of Architecture at the College of Engineering, University of Sulaymaniyah. Representing the terms regarding this study, starting with the environment in architecture, is the context of developing and running buildings, including both the immediate physical surroundings and ecological sustainability. This entails designing structures and places that align with their ecological setting, focusing on energy efficiency, enhancing occupant quality of life, and minimizing environmental consequences (William P. Cunningham, 2019). The term was initially employed in architecture as a pivotal concept in Ian McHarg's influential mid-20th-century publication, "Design with Nature." In this seminal work, McHarg presents methodologies and ideas that emphasize the integration of ecological principles of the natural environment into the design

process, advocating for collaboration with the environment rather than opposition (McHarg, 1969). To do this, architects began to concentrate on the influence of buildings on their natural environment and the ecosystem as a whole. Simultaneously, the concept of sustainable architecture gained prominence alongside the environmental movement in response to the 1970 energy crisis. Architects and builders commenced prioritizing energy efficiency and sustainable techniques. After three decades, efforts became increasingly professional and methodical, and by the 1990s, sustainable architecture emerged as a crucial concept for designers. In 1994, the introduction of the Leadership in Energy and Environmental Design (LEED) Standards was proclaimed as a worldwide acknowledged framework for implementing sustainable and cost-effective construction practices (Boeing, 2014). Another term is the livability, which indicates the comprehensive quality of life in a particular area, encompassing affordable and suitable housing, beneficial community amenities and services, as well as sufficient transit options. The user experience serves as a framework for assessing the livability of architecture through a phenomenological lens, underscoring the necessity for architecture to be "lived" and "experienced. The architecture improves quality of life by promoting sustainable, healthy, safe, and lively living circumstances, and is professionally defined as livable architecture (David Allison, et al., 2005). A constructed environment infused with natural light not only promotes health and well-being but also elevates aesthetic value, rendering spaces more pleasant, inviting, and conducive to a superior experience. Natural lighting enhances the depth and richness of places through the interplay of light and shadow (martino Stierli, 1997) Another environmental factor that affects livability is thermal comfort, which is crucial in the daily experience of architecture for its users, as a difficult and essential factor in building environmental design, as it directly influences human health and productivity (dessi, 2019). Numerous elements affect thermal comfort in buildings, including air temperature, relative humidity, air movement, personal preferences, and variables such as clothing characteristics and metabolic rate, which are influenced by age, health, and the type of activity of the individual (Arif, 2023). The procedure of replacing interior air with fresh outdoor air to uphold superior indoor air quality, manage pollutants, and guarantee thermal comfort through temperature regulation. Architectural

components can contribute to ventilation through moveable windows, vents, atria, and courtyards, which are design methods that enhance cross-ventilation and boost energy efficiency in structures (writer, 2019). Another factor is direct solar, as the rhythmic timing of natural processes affects human behavior and emotions. Individuals coexisting harmoniously with natural systems can more effectively see, understand, and interact with them. An essential environmental aspect that significantly impacts individuals is the sun. It provides energy, warmth, and clarity of vision while shaping our perception of time and encapsulating the rhythm of our existence. Our worldview would be entirely altered in the absence of the sun (Al-Saffar, 1993). Another factor is the relative humidity (RH), quantified as a percentage of the water vapor present in the air compared to the maximum capacity of the air at a specific temperature. This percentage ranges from 30% to 50%, defining a comfort zone for occupants. Elevated relative humidity (RH) induces a sensation of warmth, whereas diminished RH results in a colder perception (Joshua Thompson, 2024). The sustainable materials comprise recycled, upcycled, bio-based, biodegradable, and high-performance insulating technologies. Employing these materials in architecture correlates with human well-being and an energy-efficient habitat. The non-toxic and low-VOC (volatile organic compounds) characteristics enhance the safety and comfort of interior environments (Gil-ozoudeh, 2024). The materials came from nature, with the least processed production, the more benefits human livability, as we are part of the universe. The utilization of sustainable materials exhibits greater resilience to environmental stress, hence ensuring the stability of the built environment to stay safe and functioning against climate change (DeKay, 2022).

2. The Architecture of the Traditional Houses in Sulaymaniyah

The traditional house typology varies by location due to both tangible and intangible aspects, and Sulaymaniyah city's unique typology exhibits both parallels and contrasts when compared to the architecture of its adjacent cities and areas. In his 1918 publication, the History of Sulaymaniyah, the eminent Kurdish historian Muhammad Amin Zaki Beg claimed, "No community in the annals of human history has neglected its duty, and Sulaymaniyah is one of the many Iraqi regions that have withstood various events and tragedies." Nonetheless, our forebears insufficiently chronicled the city's narratives and history, hindering our comprehension of the past; instead, they delegated this obligation to subsequent generations, a truth we must

acknowledge and endeavor to rectify (Zaki, 1939); (Rasha, 1987). Unfortunately, this assertion applies equally to the architectural history of the city; there exists no definitive documentation regarding the city's architecture to serve as a reliable resource for researchers investigating the factors contributing to the preservation of traditional structures in the city's historic district. The architectural typology of the dwellings at the city's inception was influenced by the existing village house styles in the region, as noted by Malkandi and Julakan (Qaradaghi, 2020). Initially, the accessible building materials comprised sun-dried bricks and stone; the stone was relatively more expensive, whilst the brick was the most pragmatic choice. The environmental design solutions implemented within the boundaries of the houses, irrespective of their intended purpose, may function as protective measures for both the building and its inhabitants against natural environmental elements. are articulated in the following aspects;

2.1. Building material

The indigenous construction materials in the area are derived from the ancient Mesopotamian dwellings: mud brick. Mud plaster, mud and poplar roofs, wooden doors, and door frames are all naturally sourced materials prevalent in the vicinity of the cities; yet, the architecture reflects meticulous craftsmanship, characterized by robust, well-constructed walls and meticulously applied floor and wall plaster. (Postagate, 1992). In Sulaymaniyah city, this methodology encompassed 19th-century residential edifices, with building facades extending approximately 360° from the foundation to the apex, both internally and externally. The physical characteristics of these materials play a pivotal role in establishing conducive living conditions for families. One objective of this study is to evaluate the comfort level within these residences (see Table 1). In Sulaymaniyah city at the onset of the 19th century, the flooring material in both the ground and first-floor areas consisted of either a compacted layer of clay and mud or a layer of square bricks (20 cm x 20 cm) bonded with a lime plaster mixture. In a few exceptional instances, glazed mosaic tiles are employed for stair and room flooring (Figure 1). The bearing walls were the most effective component in defining spatial configurations, regulating roof height, and significantly influencing thermal comfort levels. The choice of building material, the vertical wall layers, and the proportions of the bricks contribute to the distinctive style of elevation, geometric ornamentation, and decoration in these dwellings (Archive, n.d.). The exterior walls comprise layers commencing with a mud-hay combination, culminating in a 3-5 cm sun-dried brick (20*5*5 cm) encased in mud mortar, with an overall thickness of 80-120 cm. This wall form incorporates wooden beams throughout its thickness, with free ends to facilitate

ventilation of the wood. These timbers typically measure approximately 5 cm in diameter and are arranged at intervals of 1 meter both vertically and horizontally within the wall area as a reinforcement element, ultimately covered with a mud-hay mixture finish (3-5 cm) in the interior space. The transition from outdoor to indoor construction involves baked mud bricks with a thickness of 7-10 cm, followed by sun-dried bricks of 20x5x5 cm, bonded with mud mortar and around 80-100 cm thick, culminating in a lime mixture finish of 2-3 cm for the indoor areas. The stone walls are composed of Malkani-type sedimentary stone, as stipulated by Sulaymaniyah city, with a thickness of 50-80 cm, bonded with lime mortar. The finishing consists of a lime mixture of 2-3 cm or is left unfinished due to the stone's inherent strength. The bearing walls within a single residence often fall into two categories; Firstly, a robust wall comprises a mud-hay mixture finish (3-5 cm), followed by sun-dried bricks (20 x 5 x 5 cm) bonded with mud mortar, achieving an approximate thickness of 80-100 cm, and concluding with a mud-hay mixture finish (3-5 cm) on the opposing side of the wall. The second type comprises a lime mixture finish (2-3 cm), followed by sun-dried bricks (20*5*5 cm) bonded with mud mortar, approximately 80-100 cm in thickness, and concluding with a lime mixture finish (2-3 cm) (Figure 2) (Archive, n.d.). The roofs possess a distinctive quality of integrating layers and components to create a no-slab roof, enabling the coverage of spaces while allowing for the maintenance or removal of individual room roofs without compromising adjacent roofs. The timbers, which rest on the robust walls and extend approximately 30 cm beyond the walls on either side for each space. The roofing material may be layered as follows (Archive, n.d.): the first type, **the (Timber-matt-soil) roof**, from inside to outside, cleaned wood timber (Spydar-white wood) with a diameter of 12-18 cm is laid 25-40 cm center to center on the shorter side of the space, with a typical span not exceeding 3 meters. The shorter span of the space was consistently limited by the length of the natural tree. A palm leaf or sugar straw-woven mat is placed on the timbers to prevent the clay from falling. The roof's thickest face consists of compacted, clean red clay, applied in layers of approximately 30cm, designed to cover the entire building area with a slight angle for effective water drainage. In certain instances, this layer includes a lime component to enhance its hardness (Figure 3). During the spring season, this layer is adorned with plants that offer additional insulation and help mitigate the urban heat island effect. The second type was **the brick roof (Aqada)**, which serves as an internal component, while the flooring for the first level of the house (Sarkhan) is typically constructed from an iron beam featuring an I-beam. This beam is supported by the load-bearing walls or thresholds, oriented towards the shorter span, with spacing intervals

between 75 cm and 90 cm. The gaps between the I-beams were constructed using bricks and plaster, featuring an arch that varied in height from one to three centimeters, based on the distance between the sections. The beam has a thickness of 12 cm, as the bricks are arranged in the building in the shape of a kerosene, commonly referred to as the I-beam roof in brick construction. The identical mortar is utilized to fill gaps, level the upper surface, and ready it for the application of the subsequent finishing layers of the floor. Metal sheets, coated with oil paint, are affixed to the roof's timbers, accompanied by a delicate layer of wooden ornamentation, either painted or unpainted (figure 4). Occasionally, roofs are left without ceilings, particularly on the bottom floor (zherkhan) (Archive, n.d.). The doors are constructed from walnut wood, a locally sourced resource, featuring either simple or intricate designs that incorporate botanical and geometric motifs, characteristic of Islamic architecture. The door apertures typically measure 2 meters in height and 1 meter in width for the rooms, including a double-sided design at the center; the breadth progressively expands until the gate door reaches 2 meters in certain instances. The doors on the ground floor lack an upper opening; however, on the first store, the majority of doors feature an upper opening, adorned with decorative elements integrated into the door frame or distinct from the door, embellished with gypsum lace embellishments, as illustrated in (Figure 5) (Archive, n.d.). The window's placement within the wall thickness, its dimensions, the wooden frame, the basic 4mm transparent glass, whether colored or clear based on spatial specifications, the operable components, and the connecting material between the glass and the wooden frame often consisted of small nails. The window frame is constructed from wood, with a thickness of 5-7 cm. Standard, clear glass is utilized for inside windows, while tinted glass is employed for exterior windows to enhance privacy and aesthetics (Figure 6), (Archive, n.d.) Metal panels for the shading of external windows and doors preserved the building, and the exposed section of the ceiling was shielded with a metal plate encasing the vulnerable layers to avert external corrosion and for aesthetic purposes (Joan Atheel Ahmed, 2024). Another feature was the fireplace, a distinctive design embedded into the wall thickness on the first floor of the house, typically situated in the guest room, serving both heating functions during colder seasons and as a symbol of the family's ECO-social status due to its aesthetic appeal.

2.2. Configuration of layout

The configuration of the dwellings comprises multiple elements that influence their environmental solution performance, which can be categorized as follows:

The orientation, crucial for optimizing the utilization of natural environmental resources, includes solar radiation in winter, daylight for illumination, seasonal

breezes for ventilation, and shielding from direct sunlight during summer. The documented traditional houses of Sulaymaniyah indicate that two-thirds of the primary elevation of the living areas (Haiwan and the adjacent rooms) face East-South, South, and West-South, aligning with the sun's longest trajectory during daylight hours (Qaradaghi, 2022). The courtyard, a square or rectangular area, preceded the primary spaces of the residence, serving as a communal zone for the Iwan, the ground floor rooms, and the staircase ascending to the first floor (Sarkhan). This area may also feature a water source, such as a well, or occasionally a small basin utilized for the daily tasks of the household (AlAthari, 2010). A space where the several stratifications of the houses came together (Fethi, 1982), designed for natural illumination and ventilation, also serves as a space for the occupant's daily activities or social gatherings, with a sitting area paved with stone or brick in front of the Iwan, referred to Barhaiwan, also served as the home's link to nature, featuring a garden and a space for agricultural output for economic gain. The courtyard's natural cooling system facilitates cross-ventilation and mitigates heat through substantial shadowing, influenced by the sun's position throughout the day (Joan Atheel Ahmed, 2024). Another layout element in the traditional houses of Sulaymaniyah city is the Iwan, an essential feature that fulfills various functions, including providing shaded comfort areas for habitation during moderate seasons, enhancing natural ventilation, optimizing solar performance, and serving as a protective roofed space for rooms adjacent to the Iwan, shielding them from rain and direct sunlight during hotter seasons (Figure 8). The width-to-depth ratio of this three-walled core space is deemed optimal for enhancing its environmental performance. Also, the orientation of Iwan optimally enhances solar performance by facing south (Hendren H. Abdulrahman, 2019). While the term Iwan refers to a miniature Iwan, a space resembling an Iwan, enclosed by three walls between two rooms (Fethi, 1982), it possesses the attributes of an Iwan but occupies a smaller area that may not be suitable for activities such as sitting, unlike a traditional Iwan. Nonetheless, it provides privacy and environmental protection for the adjacent spaces and elements. Another element is the Arusi, which typically refers to spacious rooms with a one-sided windowed wall adjacent to the Tarma, and, on rare occasions, it is applied to "Kabshkan" rooms or the smaller "Shanashil" rooms, which generally have sliding Arusi windows; this occurrence is prevalent in central Iraq. The term is also applied to a space characterized by many double-leaf glass doors in lieu of a huge sliding window. This particular variety is predominantly located in Kadhimiya and Karbala, and is notably prevalent in Chinese residences. It is entirely inappropriate due to the inadequate closure of the windows. The Arusi

serves as a chamber during chilly periods, including severe winter days. Another element is the Tarma, as the term originates from the historic Baghdadi buildings, which refers to a space enclosed by two walls, featuring doors and windows from adjacent rooms, while remaining open to the courtyard on one side, which is supported by columns. It is situated on the first floor, opposite the rooms, approximately 1 meter in width, including an 80 cm iron handrail encased in a wooden frame (Reuther, 1910). Consequently, this cantilevered structure safeguards the walls, roofs, and windows from precipitation and direct sunlight, while also serving as a passage to the rear areas of the Tarma. Besides the above, the Majaz represents the bent entry that provided direct access to the courtyard, which predominantly had a rectangular configuration, with or without windows and doors on the adjoining rooms (Fethi, 1982). This element was widely identified in the courtyard buildings of traditional Sulaymaniyah city architecture (Archive, n.d.), serving as a design solution that ensured privacy and environmental protection in the layout, as illustrated in the figure. One of the other features that may be considered as environmental solutions is a circular window (Rozita), frequently observed in Italian churches dating back to Roman times (Calabria, 2012). This element is particularly utilized in several traditional houses of Sulaymaniyah city, They situated in inconspicuous areas at the rear of the rooms or on the front elevation, with a circular aperture centered in the upper section of the large arched doorways (Archive, n.d.), aiming to allow excessive humidity to vapor and the structure to breathe, enhance air quality in this recessed area and safeguard the structure from mold and premature deterioration by retaining excess moisture. If this void penetrates the wall thickness completely, it may facilitate natural ventilation within the rooms. The placement of this element, as indicated by the sources, may be situated over the doorways, between rooms, or above the fireplace (Figure 7), or as cross-ventilation at the back of the rooms on the outside for natural air movement (Figure 10). In other cases, the parapet of certain houses or wall partitions is constructed with a distinctive perforated design, offering a lightweight architectural element that ensures privacy while allowing for natural ventilation and daylight through the passage of air (Figure 9). Other elements, such as the elevated walls framing the courtyards, together with the constricted alleyways adjacent to the residences, create a distinct air pressure that facilitates air circulation to mitigate temperature during warm seasons, while also providing a shade element for the courtyard in hotter times (Bracken, 2013). The primary entrances of the residences, situated within the thickness of the courtyard wall, facilitate a recess for the doors, providing climate protection and offering shelter for individuals during inclement weather and peak heat

periods (Archive, n.d.).

2.3. Bioclimatic Analysis of Sulaymaniyah City

Bioclimatic analysis focuses on studying the climatic factors that influence thermal comfort and determining when these factors positively impact design, enabling its utilization, and when they negatively impact design, necessitating their reduction (Bouthaina Sayad, 2022). Sulaymaniyah city, located in northeastern Iraq at an elevation of around 834 meters, exhibits a subtropical desert climate (BWh) characterized by scorching, arid summers and cold, comparatively moist winters. A bioclimatic assessment of Sulaymaniyah city indicates significant variations in thermal comfort across different seasons. The Physiological Equivalent Temperature (PET) values indicate periods of heat stress as well as optimal outdoor comfort. Research employing comprehensive meteorological data (1992–2015) from several sites demonstrates that PET readings peak during summer afternoons, often exceeding comfort thresholds. In contrast, spring and autumn offer more favorable circumstances for outdoor activities and passive design solutions. This encompasses the strategic application of shading, ventilation, and thermal mass (DEMİR, 2020). The built environment of Sulaymaniyah can enhance the health and energy efficiency of its inhabitants by synchronizing spatial planning with bioclimatic comfort zones. Sulaymaniyah city experiences a semi-arid climate; summers are typically hot and dry, with temperatures frequently exceeding 40°C during the peak months of July and August. Winters, on the other hand, are relatively cold and wet, with temperatures occasionally dropping below freezing. Snowfall is not uncommon, especially in the surrounding mountains, adding to the city's seasonal charm. Rainfall in Sulaymaniyah is primarily concentrated in the winter months, contributing to a green and vibrant spring season. The average annual precipitation is around 750 mm (30 inches). The wind rose of the city indicates the direction of the wind blows from the South-West (SW) mountainous areas of Sulaymaniyah province, reaching 1000 mm and sometimes more to the North-East (NE). Total annual rainfall is between 400-600 mm (Climate, n.d.) (Figure 11, Table 2).

3. Methodology and experimental conditions

The study assesses the impact of the independent variable, environmental design solutions, on the dependent variable, livability. The methodology employed integrates qualitative and quantitative designs to comprehend the variables and analyze their factors and indicators. Subsequently, it tests the

environmental aspects using a quantitative design method due to the impractical conditions of the case studies for onsite surveys for numerical data measurement. The simulation procedure, functioning as an ongoing mechanism, proved in the previous research to be a suitable scientific approach for the practical component of such studies. The livability is an elastic and multidimensional concept regarding the lifestyle and temporal dynamics effects in both the social and physical environment (Samir, 2023); therefore, precise meteorological data for Sulaymaniyah city were crucial for assessing the environmental solutions of a residence constructed over a century ago. Consequently, the climatic data from 1910 were utilized in the experiment within the computational software corresponding to the nearest weather station to the traditional neighborhoods of Sulaymaniyah city (Table 3), where the case studies are situated, accounting for the impact of global warming, which has raised temperatures by approximately 1.2 °C, and potentially more (as illustrated in Figure 12, 13) (Anon., n.d.), to approximate the period of the house's construction. The present configuration of the building diverges from its original design due to the adaptation process for its transformation into a museum since 1970. Through the examination of historical documents, photographs, narratives from the owner's family (the Faqe Shaly family), and on-site analysis, a detailed original layout has been reconstructed, highlighting layers of building materials and other architectural elements (Figure 14).

3.1. Case Study: The Residence of Faqe Shally

This house was selected as a representative case study due to its design, which exemplifies the prevalent typology among traditional houses in the city, characterized by an I-shaped mass-void composition. Its façade incorporates the most common environmental solutions of its era, including building materials, techniques, and the proportions and placements of openings. Additionally, it possesses distinctive features compared to other houses, such as a perforated curtain wall on the backside, which facilitates natural ventilation while maintaining the privacy of the interior spaces. The residence was constructed in 1901 on a land area of 700 m², located in the Dargazen area. The present location is 14th Street Dargazen, adjacent to the Nalli roundabout, in the heart of Sulaymaniyah (Figure 15). The front elevation of the house is oriented southeast (Figure 16) towards the courtyard to maximize solar exposure and align with the Kaaba, a common orientation among residences. It features elongated, narrow windows on this facade and small, elevated round openings on the opposite side to facilitate natural ventilation and enhance indoor air quality. This architectural strategy is also evident in

other traditional houses in the city, contingent upon the positioning of neighboring structures and the site layout. The courtyard occupies approximately two-thirds of the plot area, effectively separating the house from its surroundings. Additionally, the main gate is distanced from the building, allowing sufficient space for service rooms and utilities, thereby ensuring privacy and accommodating family activities. The courtyard serves not only as an exterior space but also as an extension of internal living during moderate seasons. The photograph of the house from the 1940s illustrates the original configuration, characterized by an I-shaped typology featuring a spacious Rewaq beneath the Iwan on the ground floor. Notably, the Iwan lacked a curtain glass wall (Jamkhana) on the upper level, which currently serves as a closure for the Iwan space. Numerous aspects were altered from the original configuration of the house, including the position and material of the windows and doors. The walls were finished with cement, and the flooring with various modern materials throughout the transformation period. This study analyzed the building components and the architectural layouts of the residence. The old photographs represent the house's original layout before modifications were made to accommodate its transformation into a local museum. More information and the building materials of the building (Table 4).

3.2. Experiment tools

The investigations were processed in a computational environment to simulate extreme weather from the weather station near the location of the house. (Table 3) in winter and summer, after the necessary documents and information were collected. The model implies the 3D modeling of the case studies using Autodesk Revit 2026 (Figure 14). This process involves the creation of the actual layers of the walls, floors, and roofs, which are critical components of an environmental design solution.

- Insight plugins for daylight simulation data.
- Insight plugins for direct solar simulation data.
- Autodesk CFD 2026; for natural ventilation analysis.
- Autodesk Revit 2026; for Annual discomfort hours analytical report in accordance with ASHRAE 55 2004.
- Analysis reports from Autodesk Revit 2026 for annual Humidex hours data. The investigation was conducted using an Autodesk student access license. The livable benchmarks of daylight amount range from 100lux to 500lux (Daylight Access Analysis, 2015), with the minimum required amount of lux in circulation spaces, storage, and dormitories, and the maximum required amount of lux in the living room and kitchen. The study simulation considered a threshold range that encompassed the minimum and maximum range of the

habitable daylight amount (300-1000) in the house spaces, whereas the rooms were typically used as multipurpose spaces for various activities during the daytime in the majority of traditional houses of the Sulaymaniyah city. The Revit analytical report yielded data regarding the building's Energy Plus program. The livable range for humidity in the spaces is 30%—50%, and the average humidity of Sulaymaniyah city is approximately 30%—65% annually. This makes the issue of moisture buildup less severe due to the optimal condition of the buildings and the good range of natural ventilation. It does not consider any humidity problems caused by building issues, such as cracks and back drainage of the roofs, in the optimal situation. The livable benchmarks are considered as testing thresholds (Table 5). ASHRAE Standard 55-2004, *Thermal Environmental Conditions for Human Occupancy*, (which is used in the Revit analysis for the case study), sets acceptable architectural standards by setting the right degrees of temperature and humidity. The 2004 version was different from the 1966 first version because it combined the Predicted Mean Value (PMV) and Predicted Percentage of Dissatisfied (PPD) models into adaptive comfort methods. These models take into account things like metabolic rate, how well the clothes keep heat in, and the environment, such as temperature, humidity, and radiation heat. In buildings that use natural ventilation, flexible comfort allowed for a wider range of temperatures that were affected by the weather and the activities of the people living there. This made the basic passive system suitable for use in homes (Oyuni, 2023). ASHRAE 55-2004 helps people feel comfortable in places where there isn't much mechanical heating or cooling. The standard uses physiological and environmental parameters to determine comfort to encourage energy-efficient, occupant-centered, and climate-responsive design. As the basic ideas of livable architecture. The study employed a questionnaire survey to ascertain the everyday experiences of residents in traditional dwellings concerning environmental adaptation, serving also as a calibration method to further validate the findings of the simulation tools process. The sequence of questions aimed to assess the satisfaction levels of inhabitants during both winter and summer seasons, based on physical data about the addition or removal of elements in the house, as well as the annual energy consumption to enhance livability. The procedure for the questionnaire survey included.;

i) Assessing the impact of architectural design on the thermal comfort of residences. ii) Analyzing the environmental quality of architecture in relation to energy consumption and user cultural satisfaction. iii) The survey selected 30 of the traditional houses with minimal alterations from the original design, which posed significant challenges due to the prevalence of modifications and renovations in most homes. iv) The

majority of houses retaining their original layouts and styles remain uninhabited. Numerous external factors might influence the quality of life in the remaining traditional houses, as alterations in the urban environment and shifts in the demographic composition of the neighborhoods may all present issues that impact the overall quality of the buildings. v) All participants are apprised of the confidentiality of the process and that academic applications are solely endorsed by an official document from the government. vi) The study examined 30 residences in the residential zones less impacted by commercial land use expansion, specifically in the Malkandi, Sabunkaran, and Julakan neighborhoods, during July and August 2025. vii) The survey applied the Kobo Toolbox free open-source platform, as it is designed for data collection, management, and analysis, particularly in challenging situations, such as the traditional neighborhoods in the city of Sulaymaniyah, experiencing this platform originally developed for the humanitarian contexts, which has become a widely adopted tool across governmental, academic, and NGO sectors. The Kobo Toolbox allows the assignment of each house's position and real-time upload of data images and location, which are structured in the final reports.

4. Results and Discussions

The assessment method for the case study residence (Faqa Shally House) encompasses quantitative data about thermal comfort, daylight, direct sunshine, natural ventilation, and relative humidity evaluations. culminated in the subsequent: The thermal comfort hours for winter and summer, according to ASHRAE 55, are evaluated using an analytical report generated by the Revit application, which presents the average data. This evaluation examines the dependability of dry-bulb temperature and relative humidity thresholds, factoring in the thermal characteristics of building materials, the thickness of structural components, the architectural design, orientation, and the meteorological data of the city. A graph of uncomfortable hours has been generated (Figure 22). High-performance buildings often achieve 80% of annual comfort hours (about 7008 hours); a decline below this level is alarming, particularly if discomfort hours coincide with occupancy periods. Access to daylight Insight Plugins assesses climate data for winter (January 1) and summer (July 1) at three specific times: 9 a.m., 12 p.m., and 3 p.m., Figures 17, 18, and 19. Fifty-five percent of regions satisfy the minimal criterion for direct sunlight exposure, giving a practical standard of two to four hours (Figure 20, 24). The parameters for natural ventilation consist of a summer average velocity of 3.5 m/s and an average temperature of 38.8°C, applied to an environmental box measuring approximately 100m by 180m by 18m, in accordance with the program's optimal conditions for a building measuring 20m in length, 28m in depth, and 6m in height. The building's windows

and doors were designed in an open position within the simulation to evaluate the structure's effectiveness in enhancing air quality and the role of air movement velocity in alleviating thermal discomfort for occupants via natural ventilation, with a velocity range of 0.15-0.5 m/s deemed acceptable for habitability. (Figure 21). Notwithstanding humidity apprehensions, the residence is considered secure by Humidex (Figure 23). The majority of homes featured brick walls, whilst hardly 3% possessed stone walls, and 60.67% included both materials. Timber-matt-soil layers constituted 83.33% of the homes' roofs, while 10% utilized brick (Agadda), and another 10% substituted their original roofs with concrete due to maintenance challenges. The older individuals reported residing on compacted mud floors both indoors and outdoors before the subsequent installation of the concrete coating. 93.3% of the residences use environmental design features, including robust walls constructed from local materials, courtyards, iwans (Dallan), and semi-open areas. Numerous residences included cross ventilation and robust walls. In the third series of questions, respondents ranked their home's thermal comfort and the duration of mechanical systems required to get it during summer and winter. Residents assert that energy use during winter is less than in summer, enhancing residential comfort. The majority reported satisfactory levels of thermal comfort. The fourth series of inquiries concentrated on energy efficiency, assessing if particular architectural elements enhanced thermal comfort and energy efficiency more effectively than contemporary alternatives. The responses indicate that most participants considered sturdy walls and the courtyard to be significant elements. Most residences above 100 years in age have had structural modifications. Consequently, the majority incorporated Jamkhana to protect environmental and social privacy. To save maintenance, most residences incorporated a water-resistant insulating layer into their roofs. Moreover, all concurred that conventional home design conserves energy. The findings of the fifth inquiry indicated that the cultural compatibility of traditional houses with contemporary lifestyles is questionable; therefore, over half of the respondents favored modern home designs, asserting that they better align with the requirements of current society.

5. Conclusion

The research indicates that the livability of traditional houses in Sulaymaniyah city is influenced by a combination of various design strategies rather than a singular environmental factor. Computational simulations and field surveys indicate that although thermal comfort alone may not achieve optimal annual benchmarks, the integration of passive design elements—such as courtyard orientation, natural

cross-ventilation strategy, and material selection—effectively mitigates climatic extremes. The house's spatial configuration demonstrates a socio-cultural adaptation that enhances environmental livability beyond enclosed spaces, particularly in summer. characterized by the Iwans, courtyards, and rooftops, Seasonal behaviors, including congregating around fireplaces in winter and utilizing semi-open spaces in summer, exemplify the dynamic nature of comfort in these dwellings. The research highlights that traditional architecture provides significant insights into sustainable living via its climate-responsive design and cultural integration. Future research should broaden its focus to encompass various units within the urban environment, utilizing advanced simulation tools to analyze the intricate interactions between microclimate and architecture.

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أثر حلول التصميم البيئي على جودة الحياة في البيوت التقليدية بمدينة السليمانية

المستخلص

تركز الممارسات المستدامة لبيئة مبنية صالحة للعيش على تعزيز راحة الإنسان وكفاءة الطاقة مع تقليل الاعتماد على مصادر الطاقة غير المتجددة. فيما يتعلق بالتصاميم والاستراتيجيات السلبية، قد يوفر التعامل مع العمارة التاريخية استراتيجية عملية لتحقيق حلول مستدامة. تهدف هذه الدراسة إلى معالجة الفجوة في الأبحاث السابقة، والتي غالباً ما تقتصر على تقييم شامل للمباني التقليدية في مدينة السليمانية. تدرس هذه الدراسة تقنيات التصميم البيئي المتأصلة في المساكن التقليدية في مدينة السليمانية وتأثيرها على قابلية العيش، مع تسليط الضوء على الأنظمة السلبية التي تتوافق مع المناخ المحلي. وعلى الرغم من الأهمية المعمارية والثقافية لهذه المساكن، إلا أن الدراسات السابقة لم تقدم تقييمات شاملة تجمع بين كل من النهج النوعي والكمي. يملأ هذا العمل الفجوة من خلال فحص منزل فقي شالي كدراسة حالة، باستخدام المحاكاة الحاسوبية لتقييم خمسة معايير بيئية مهمة: الراحة الحرارية، والوصول إلى ضوء النهار، والإشعاع الشمسي المباشر، والتهوية الطبيعية، والرطوبة النسبية. تستخدم الدراسة تقنيات Autodesk Revit و CFD لإعادة إنشاء التكوين المعماري الأصلي وطبقات المواد لنمذجة الأداء البيئي باستخدام الظروف المناخية التاريخية، بما يتماشى مع استبيان استقصائي أُجري على ثلاثين منزلاً في الأحياء التقليدية، فيما يتعلق بالتكيف البيئي. تشير نتائج الدراسة إلى أن ميزات التصميم، بما في ذلك توجيه الفناء، واستخدام مواد ذات كتلة حرارية عالية، وتوزيع النوافذ بشكل استراتيجي، والاستغلال المكاني الموسمي، تحسن بشكل ملحوظ من قابلية العيش في المنازل التقليدية كنظام متكامل واحد. في حين يظهر الطابق العلوي راحة بيئية مُحسنة للأغراض السكنية بناءً على النتائج التجريبية، إلا أن الطابق الأرضي أكثر ملاءمة للتخزين والخدمات. تسلط النتائج الضوء على أهمية استراتيجيات التصميم البيئي التقليدية للمساكن المستدامة الحديثة، وتوفر إطاراً لدمج العمارة التاريخية في التخطيط الحضري المراعي للمنا

الكلمات المفتاحية

جودة الحياة , حلول التصميم البيئي , المحاكاة الحاسوبية , الراحة الحرارية , التصميم السلبي .



Figure 1. The original floor finishing material in the traditional houses in Sulaymaniyah city (Archive, n.d.)



Figure 2. Wall material (researcher)



Figure 3. The timber-matt-soil roof materials from inside and outside



Figure 4. Ceiling material (by researcher)



Figure 5. A door with an opening on the top (by researcher)



Figure 6. Windows from wood material (by researcher)



Figure 7. The fireplace of Faqe Shally's house (by researcher)



Figure 8. The Iwan of the Faqe Shally's house (by researcher)



Figure 9. The decorative pattern used for privacy and natural ventilation (by researcher)



Figure 10. The cross-ventilation mechanism in Faqe Shally's house (by researcher)

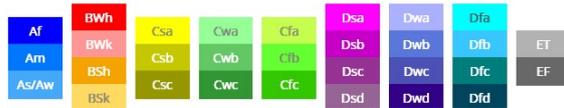
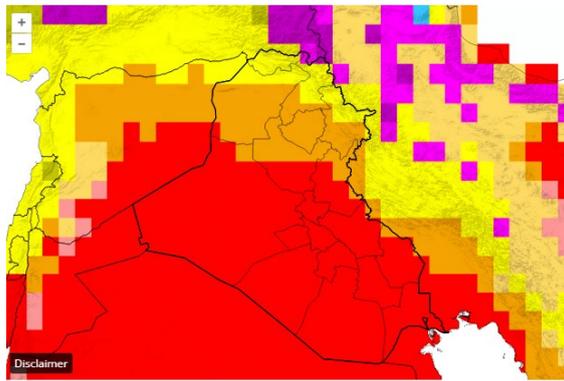


Figure 11. Köppen-Geiger Climate Classification- Iraq from 1991-2020 (Portal, 2023)

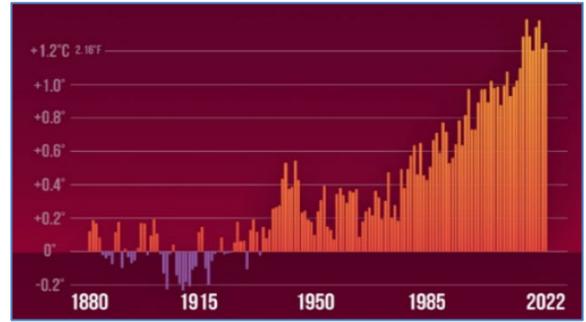


figure 12. The global average temperature anomalies (Anon., n.d.)

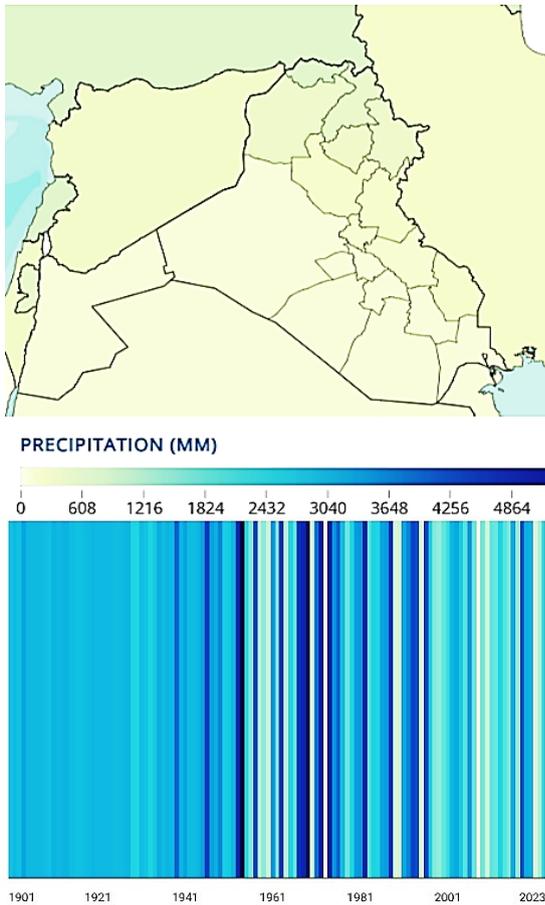


Figure 13. Observed annual precipitation from 1901-2023 (Anon., n.d.)

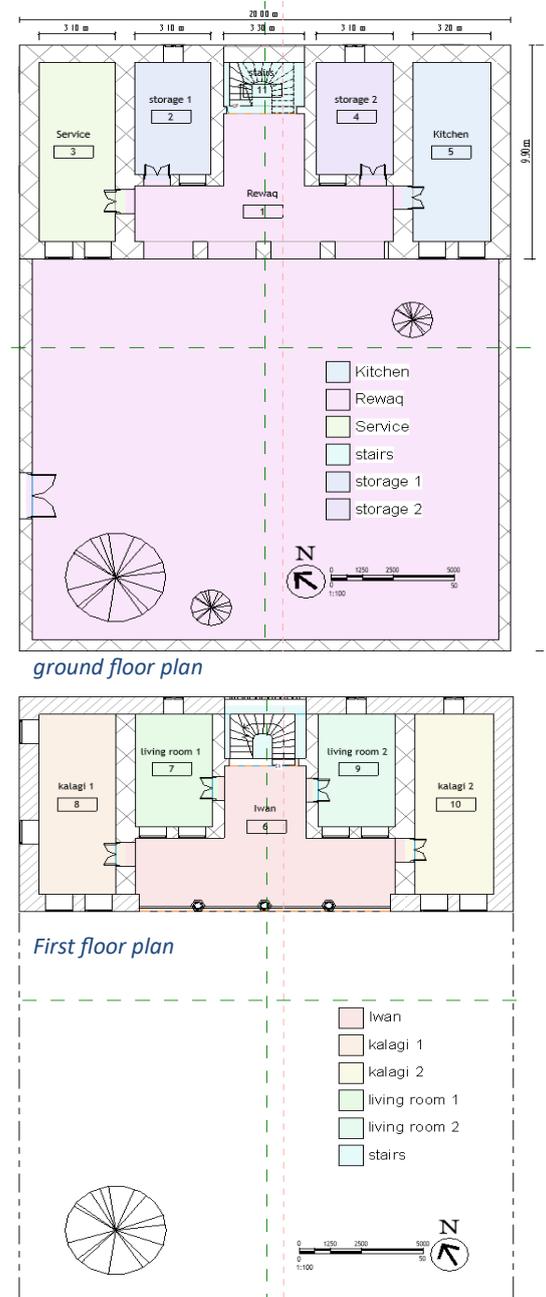


Figure 14. The house's original layout by the researcher



Figure 15. The Master Plan of the Historical Neighborhood and the Location of the House in the Dargazen District

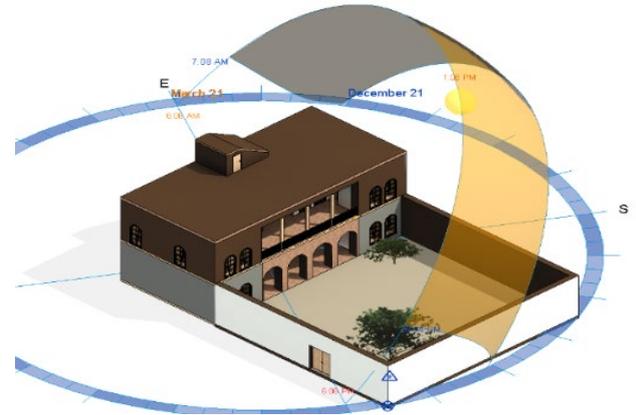


Figure 16. 3D View of the house with annual sun path

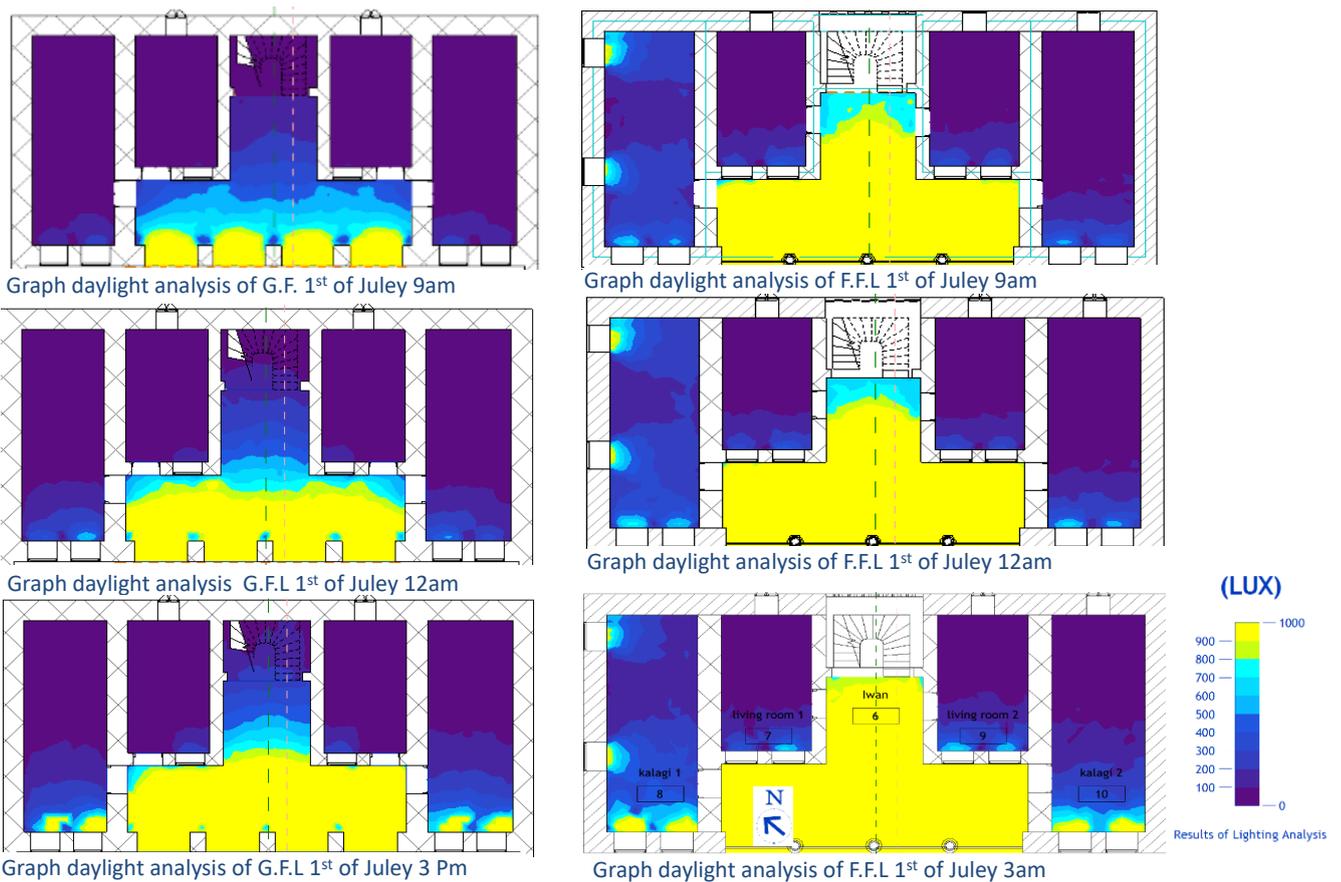


Figure 17. Daylight amount in summertime at three different times of a day, 9 am- 12 pm- 3 pm, the livable threshold is between 300-2500lux (by researcher)

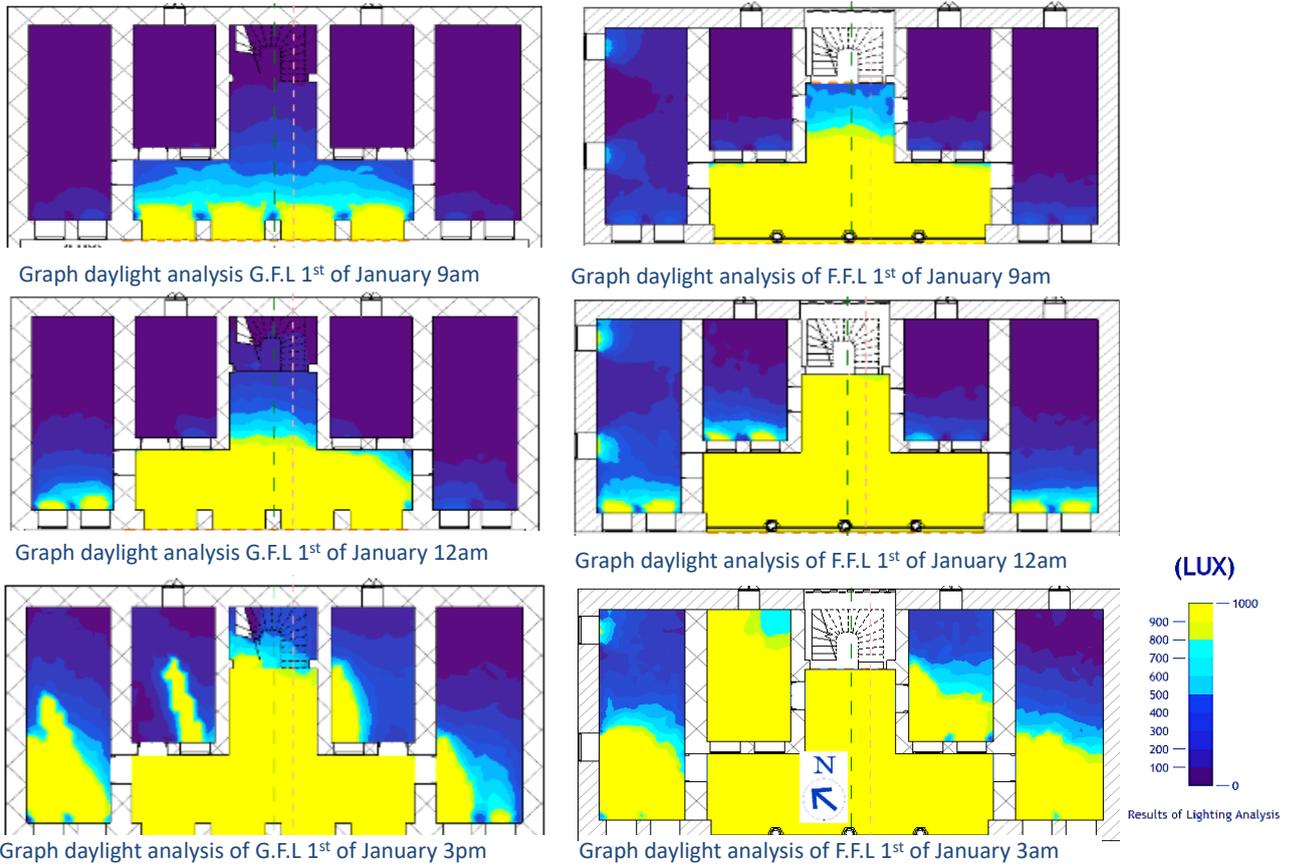


Figure 18. Daylight amount in winter time in three different times of the day, 9 am- 12 pm- 3 pm, the livable threshold is between 300-1000ux (by researcher)

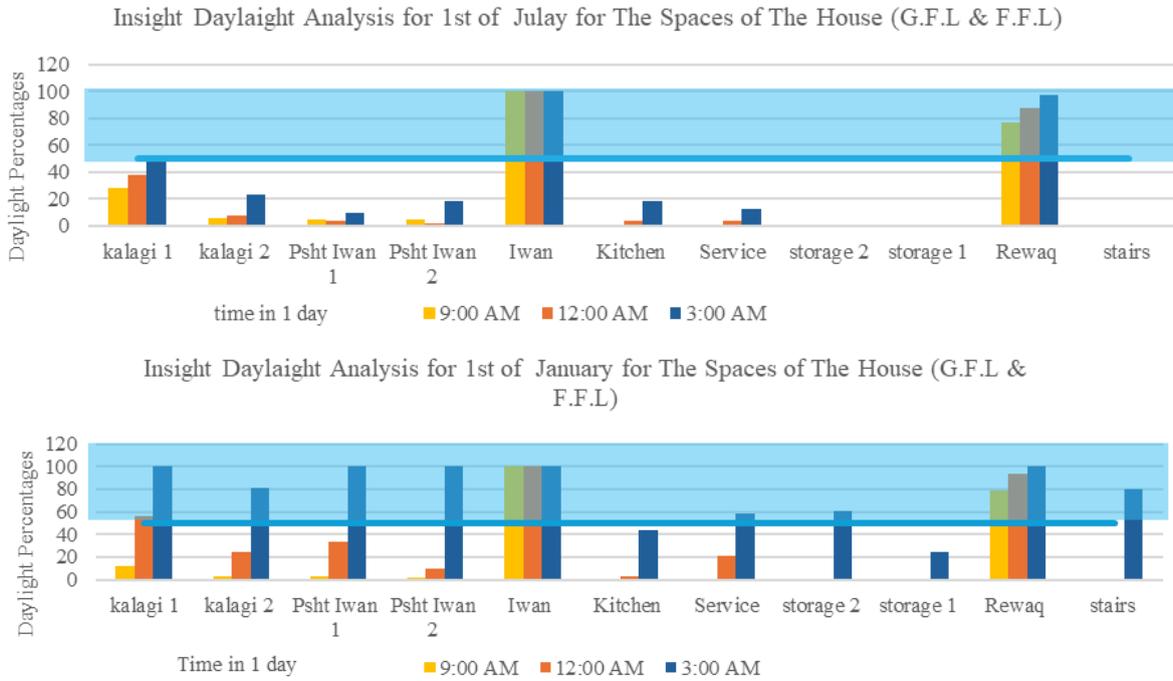
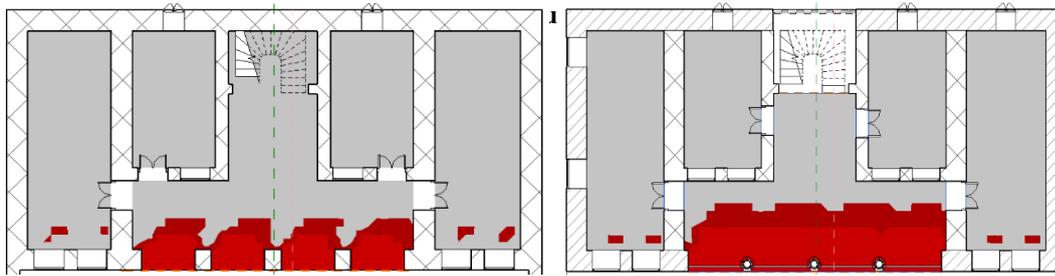
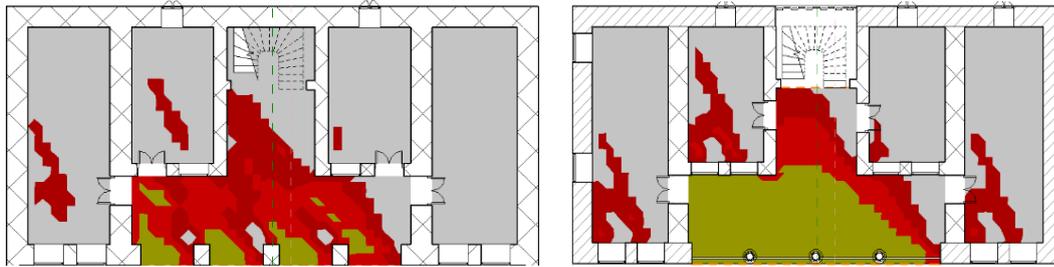


Figure 19. The illustration graph of the daylight analysis in summer and winter (by researcher)



Graph the number of hours of direct solar enters the house in summertime, from two hours a day with 50% of the space's area thresholds considered livable.



Graph the number of hours of direct solar enter the house in winter time, from two hours a day with 50% of the spaces area thresholds considered livable. Lighting hr: Hours Direct Sun

Figure 20. The direct solar analysis graphs in winter and summer time (by researcher)

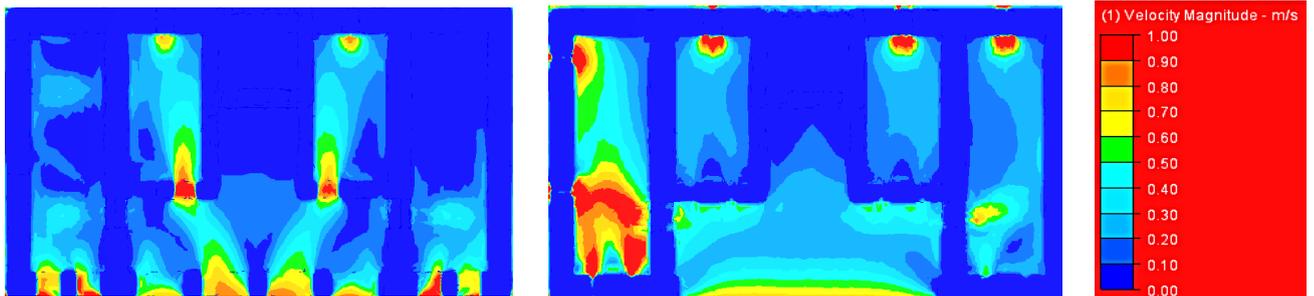


Figure 21: The natural ventilation graph in the summer, with all windows and doors opened, the magnitude velocity in between 0.1- 1.5 m/s is considered a livable threshold, covering 50% of the room area (by researcher)

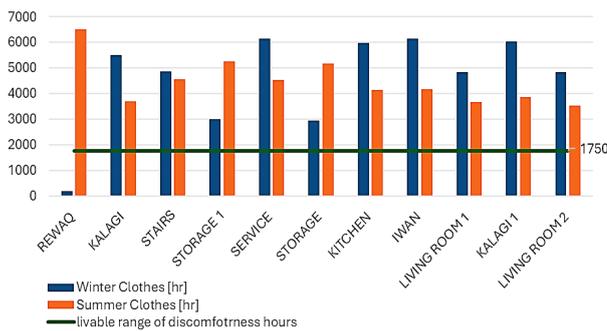


Figure 22. the ranges of thermal discomfort hours by ASHRAE 55 2004 (by researcher)



Figure 23: Annual Humidex hours chart (by researcher)

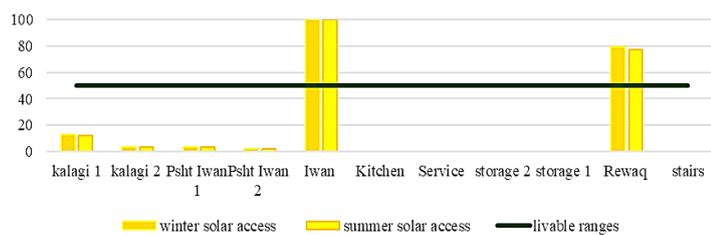


Figure 24. Solar access analysis in winter and summer time (by researcher)

Table 1: The physical properties of the building materials in constructing the traditional houses of Sulaymaniyah city (Saif Rashid, 2019)

	Density kg/m ³	Thermal conductivity W/m.K	Specific heat capacity J/kg. K
Brick*	1600-1920	0.60-1.00	800-1000
Soil	1600-2000	0.25-0.35	1400-2200
Mud	1200-1800	0.15-1.50	800-2000
Settlement Stone	2500-2800	1.80-3.50	900-1000
Wood	400-700	0.10-0.20	1200-2400
Gypsum	2300-2500	0.17-0.40	1090
Iraqi clay brick	1790	0.60	840

Table 3. The weather station information (Revit software)

Sulaymaniyah	
Weather Station:	1279238
Year:	2006
Latitude:	35.55704879760742
Longitude:	45.442596435546875
Distance:	3.53 kilometers away
Elevation:	950.0000

Table 2. The bioclimatic data of Sulaymaniyah city (Anon., 2024)

Sulaymaniyah		
Geographical data	Latitude	35.5447° N
	Longitude	45.4353° E
	Altitude	≈1000m above sea level
	Climate zone (Koppen-Geiger classification)	Mediterranean climate Hot, dry summers and mild, wet winters
Temperature	Annual average Min	12.0°*
	Annual average Max	28.6°*
	Thermal amplitude	39°
Solar radiation	Direct	600-700 W/m ²
	Diffuse	100-200 W/m ²
	The solar angle of incidence	Intense
Wind	Nature	Moderate But it can be changed with the seasons
	Speed	6-7 m/s
	Direction	Blows from the northeast
Relative humidity		30% - 60%
Precipitations		3.9 %

Table 4. Architectural information about the case study, the Faqe Shally house (by researcher)

Orientation	The house is oriented south-west		
Building elements	Walls	Floors	Roof
Construction materials	The G.F.L external walls consist of malkandi stone, the other walls of the house are brick, 5*5*20cm	Square oven brick 20*20 cm	The timber-matt-soil roof Ø 10-15cm timbers every 30cm-organic matt to protect the soil from falling, and a thick, compacted, clean soil 25-30cm depth.
Windows	Wooden side-by-side single-glazed window, divided by 4 openings, located on the outer side of the wall, With an arched fixed upper part		
Doors	The wooden side-by-side door is 2.2*1m in dimension on the inner side of the wall.		

Table 5. The experimental tools and the livability benchmarks (by researcher)

Environmental Aspects to be tested	Livable thresholds	Tools of testing	Livability Benchmarks
1. Thermal comfort: the annual discomfort hours according to bulb temperature and relative humidity, with air temperature of <20c and >27c	20- 43% of the annual hours of discomfort, 1755- 3760 hours out of 8760	Revit -OpenStudio analytical report	Simple ASHRAE 55-2004
2. Direct solar penetration in winter and summer	>= 2 hours a day for living spaces	Insight plugin analysis	Simple ASHRAE 55-2004, LEED, and WELL
3. Daylight amount in winter and summer	300- 1000 lux	Insight plugin analysis	Simple ASHRAE 55-2004, LEED, and WELL
4. Ventilation by testing the velocity magnitude when all the windows are opened	0.15-0.5 m/s	CFD	Simple ASHRAE 55-2004
5. Humidex hours*	Humidex scores <=40	Revit -Open Studio analytical report	PMV/PPD and SET