

Interior Architecture Sustainability in Heritage Buildings in Historical Jeddah: A Natural Lighting Pattern Analysis

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Abstract. The research investigates the sustainable aspects through the analysis of natural lighting and the interior spaces of the historical Hijazi buildings in Jeddah. This scope of the study lies in the vision of the Kingdom of Saudi Arabia 2030 about preserving heritage and sustainability in construction, and conservation. The research reviews the patterns of natural lighting and cross ventilation and evaluates how they are in harmony with the concepts of sustainability in the rehabilitation of internal spaces that are integrated with it. Three natural lighting patterns were identified for the study. The case study of study involved Al-Kharja, the Roshan, and the Qamaria. The patterns were selected based on the size where Al-Kharja was considered the large source of natural lighting; Roshan was a medium and Qamaria was a small source of natural lighting in old Jeddah houses. Furthermore, the study highlights the crucial role of the cross-ventilation system in effectively regulating the outflow cycle of hot air and promoting cool breezes within houses and buildings. Notably, natural lighting emerges as a fundamental aspect of interior space sustainability, profoundly influenced by space utilization and ongoing rehabilitation endeavors. The findings provide valuable insights for researchers, architects, and governmental entities, guiding the design of sustainable building codes and advocating the adoption of lightweight yet sustainable materials in modern construction practices.

Keywords: Sustainability, Heritage, Jeddah, Architecture.

1. Introduction

Environmental adaptation is essential for maintaining indoor environmental quality and the performance of buildings. In the past decades, modern building performance has undergone significant development through active design strategy and advanced technology. Large quantities of artificial and manufactured products like curtain walls and air conditioning are applied to modify indoor environments to make them more comfortable and controllable ^[1]. Heritage buildings are crucial to the human perception of culture. The lookup for values for an individual heritage building has become a limelight-concerning factor in modern society. Tuan ^[2] explained that

the sense of place on earth is the cultural heritage buildings that are beyond aesthetics looks and harmony. The conservation of heritage buildings is the necessary repairing in terms of saving material and the life cycle of the building with a balanced approach related to the environment and other related surroundings. Conservation is like the preservation of fabric from its original structure, whereas certain variations are required in the basic structure of every fabric but keeping it safe is a deal of concern. Conservation of heritage buildings allows considerable intervention and transition on the architectural and historic interests that enhance and respect the existing building character. It is a process that leads to providing a conducive and life maintaining cycle for the

building along with its ^[3]. Sustainable retrofitting of such buildings represents an opportunity for their reuse while considering sustainability ^[4]. Sun et al. ^[1] have asserted that vernacular architecture had more thermal comfort than modern buildings. Moreover, the vernacular is also the work of contemporary architects whose buildings have certain styles in the region. These popular perceptions provide a contrasting difference between the architecture and buildings held by architects and architectural historians for whom. Typically, vernacular architecture has been categorized as the study of ‘traditional buildings’ ^[5].

Buda *et al.* ^[6] stated that there is systematic complexity of cultural, architectural, and identity value, which needs a particular pinpointing concern to preserve the infrastructure of the buildings over time in a sustainable way. The aforementioned concerns required the implementation of the retrofit system to resolve and improvise the indoor thermal conditions while minimizing the use of energy resources and conserving the culture of heritage buildings. However, often the selection and implementation of retrofit solutions on culturally valuable buildings are limited by socio-technical barriers and regulations, lack of knowledge on the hydrothermal behavior of built heritage, economic viability, *etc.*

Sun *et al.* ^[1] examined the aspects of sustainability of the heritage buildings of Fujian Tulous in China. The buildings were constructed back in hundreds of years as green buildings. A field investigation was performed by the researchers for studying the environmental responsiveness and behavior of the residents in that traditional architecture. The study found that these buildings were built with the five most common features such as solar shading, thermal comfort, waterproofing, ventilation, and natural lighting. Based on the findings, the study has proposed three

principles for sustainable architecture that include;

- Reforming building envelopes.
- Reshaping the spatial layouts of the buildings.
- Using lightweight materials in construction.

Besides, thermal comfort, construction material, and adaptive behaviors regarding vernacular architecture, Michael et al. ^[7] investigated the role of natural lighting in traditional houses of urban settings that were located in the Mediterranean region. The study pinpointed that natural lighting was the primary source of lighting houses in indoor and semi-open spaces of traditional buildings. In the central courtyard, natural lighting was more prevalent. Through conducting an in-depth lighting performance analysis of the architecture of the walled city of Nicosia, Cyprus, the study found that although the natural lighting facilities were adequate on the first floor, it was not sufficient in indoor spaces due to the usage of dense construction material and introverted aspects of the vernacular architecture that restricted the natural lighting at indoor spaces. According to the research by Al-Habaibeh *et al.* ^[8]. The idea of building energy-efficient buildings has become a popular approach nowadays as 40% of the total energy produced is consumed by building worldwide. It raises the need for large-scale retrofit of the existing buildings as well as for ensuring sustainability in modern architectural practices. It will beget two-fold benefits of mitigating unsustainable energy consumption and reducing the cost of construction. Further, this study analyzed the Nottingham Playhouse Theatre and identified that the building needs retrofitting in terms of ameliorating insulation, reshaping doors, and energy saver lights, and improving solar installation and ventilation systems to obtain significant thermal comfort and energy conservation. Similarly, Kristl *et al.*

[9] have proposed retrofitting traditional buildings for enhancing sustainability. The study has asserted that the published literature about sustainability aspects of vernacular architecture has not sufficiently addressed the aspects such as universal design, the person with disabilities concerning heritage buildings, and adaptive reuse of buildings. Gürani [10] has reviewed that natural lighting patterns are the most effective way to adopt for constructing energy-saving buildings. The study has

recommended designing horizontal and vertical openings inside the buildings to allow natural light for a sustainable design in modern buildings.

There are many issues in terms to conserve the heritage building's ambiance concerning fulfilling the demands of a sustainable environment approach. The issues related to building conservation are interlinking with one another as shown in Fig. 1.



Fig. 1. Theme Categorization on Issues for the conservation heritage buildings. [3]

The main research problem lies in the lack of analysis of natural lighting and its suitability to achieve the sustainability of the internal spaces in the process of rehabilitating the historical building and the internal spaces in the historical Al-Balad area in Jeddah. Al-Murshidi *et al.* [11] described the idea of sustainable development as given by the International Commission on Environment and Development, United Nations. It interprets that

it entails an effective usage of all the available resources to fulfill the needs without any compromise or harmful effect. According to Al-Murshidi [11], the idea of sustainability can be further broadened to three aspects; social, environmental, and economic. Most of the published literature has been reliant on the environmental sustainability of vernacular architecture and has not addressed the social as well as economic sustainability of traditional

houses. Examining the social and economic sustainability of the traditional architecture of Jeddah is the subject of this study. The construction style of the historic architecture of Jeddah is reflective of the architecture alongside the Red Sea. These houses have been built with prominent towers with Roshan made of wood which was the emblem of the 19th century's elitist lifestyle. Also, the vernacular architecture comprised houses made of coral stones and an aesthetic style of buildings surrounded by markets and public squares that showed a lively social and economic environment in historic Jeddah. These buildings have comfortable and natural sources of lighting. This historic architecture is found to be harmonized with sustainability ^[12].

1.1 Research Goals

The preservation and reuse of heritage buildings and the commitment to maintain them constitute a sustainable improvement of the surrounding historical urban area. There is a need to highlight use the of natural lighting sources in the building spaces and make the heritage architects more spacious to indulgent the environmental approaches for sustainable development. This represents an imperative element of the Al Balad Historic Jeddah region by preserving an urban heritage, human heritage, and community memory that are listed in the World Heritage of Humanity through the United Nations Educational, Scientific, and Cultural Organization (UNESCO) ^[13].

The primary objective of the research was to investigate the sustainable aspects of natural lighting and interior spaces in historical Hijazi buildings, aligning with the vision of the Kingdom of Saudi Arabia 2030 for heritage preservation and sustainability in construction. By reviewing the patterns of natural lighting and cross ventilation, the study aimed to evaluate their harmony with sustainability concepts and the rehabilitation of integrated

internal spaces. The identification of three distinct natural lighting patterns (Al-Kharja, Roshan, and Qamaria) and the emphasis on their significance within old Jeddah houses provide valuable insights. The categorization of these patterns based on their size and the recognition of the cross-ventilation system as a vital structure in old buildings contribute to our understanding of the historical context and architectural strategies employed in Jeddah.

Moreover, the study emphasizes the crucial role of natural lighting in shaping, configuring, and influencing interior spaces, highlighting its importance in achieving interior space sustainability. This emphasis underscores the need for conscious consideration of natural lighting in the rehabilitation and design processes, aligning with the broader goals of sustainability and heritage preservation.

The findings can aid in the development of sustainable building codes and guidelines, promoting the use of lightweight but sustainable materials in modern construction. By bridging the gap between historical practices and contemporary construction approaches, the study can contribute to the preservation of heritage while incorporating sustainable principles into future building projects.

2. Theoretical Background

By examining relevant literature and theories, it is possible to establish a foundation for understanding the application of sustainable practices in historical contexts. Various aspects, including adaptive reuse, passive design strategies, energy-efficient systems, and materials selection have been encompassed to provide valuable insights into integrating sustainability into the rehabilitation and preservation of historical Hijazi buildings.

2.1 Adaptive Reuse

Adaptive reuse is a key theory in

sustainable architectural design that advocates for repurposing existing buildings to meet contemporary needs while respecting their historical value ^[14]. It involves the transformation of buildings, often with minimal alterations, to accommodate new functions and ensure their long-term viability. By reusing and revitalizing old buildings, we can reduce the environmental impact associated with new construction while preserving cultural heritage.

2.2 Passive Design Strategies

Passive design strategies emphasize the use of natural resources and site-specific conditions to enhance the energy efficiency and comfort of buildings ^[15]. These strategies include optimizing solar orientation, daylighting, natural ventilation, thermal mass, and shading techniques. By harnessing the inherent qualities of the building and its surroundings, passive design strategies reduce reliance on mechanical systems, decrease energy consumption, and create healthier indoor environments.

2.3 Energy-Efficient Systems

Incorporating energy-efficient systems plays a crucial role in sustainable architectural design. By integrating innovative technologies, such as efficient HVAC (heating, ventilation, and air conditioning) systems, advanced insulation materials, and renewable energy sources, old buildings can significantly improve their energy performance ^[16]. Energy-efficient systems contribute to reducing carbon emissions, minimizing resource consumption, and enhancing the overall sustainability of the built environment.

2.3 Materials Selection

Materials selection is a fundamental aspect of sustainable design. Choosing environmentally friendly and locally sourced materials, as well as considering their life cycle impacts, is essential in preserving the historical

significance of old buildings while minimizing environmental harm ^[17]. Sustainable material choices include recycled and reclaimed materials, low-impact construction methods, and the use of renewable resources. Implementing these strategies ensures the longevity and sustainability of historical structures.

By considering adaptive reuse, passive design strategies, energy-efficient systems, and materials selection, among others, architects and researchers can integrate sustainable practices into the rehabilitation and preservation of historical Hijazi buildings. These theories provide a foundation for designing environmentally conscious solutions that respect the heritage value of old buildings while addressing contemporary needs and promoting sustainable development.

3. Research Methodology

The research has adopted an exploratory study design with the case study of the historic architecture of Jeddah. It examines the natural lighting patterns of interior spaces. These patterns were classified, and the sustainability issues were reviewed and applied in the urban, social, and economic aspects as a basic methodology to achieve sustainable development through architectural elements of natural lighting and ventilation system the traditional architecture ideas are evolved, namely Al-Kharja, Roshan, Qamaria and cross ventilation (Fig. 2). These data were then analyzed and come up with results and recommendations can be followed as a reference and a mechanism for evaluating the sustainability of natural lighting patterns for historical buildings in historic Jeddah.

3.1 Natural Lighting Openings in Historical Jeddah

UNESCO ^[18] indicates that Historic Jeddah is the main gateway and commercial port for pilgrims and merchants to Mecca since

the seventh century AD, which led to the prosperity of the city with different cultures and distinctive architectural elements, as it was built by the city's elite merchants in the late nineteenth century [18].

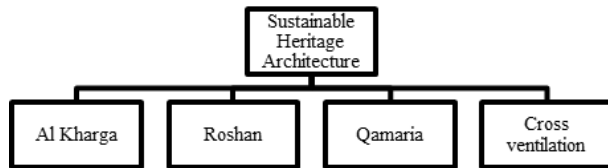


Fig. 2. Flow chart of heritage building for sustainable interior spaces.

Natural lighting is a significant aspect of Hejazi architectural houses, carefully considered in their design and construction [19]. These traditional houses incorporate various elements to maximize the entry of natural light. For instance, they feature unique window designs like the "Roshan" and "Qamaria" windows, strategically positioned to capture sunlight and illuminate the interior spaces. Light shafts or wells are often incorporated, allowing daylight to penetrate deeper into the building, reaching lower floors or inner rooms. A prominent example highlighting the use of natural lighting in Hejazi architecture is the Al-Mimar Mosque in Jeddah [20]. The mosque's design incorporates large windows and skylights that allow abundant natural light to illuminate the prayer hall, creating a serene and spiritually uplifting atmosphere. Moreover, the mosque's interior layout and spatial organization are carefully planned, with public spaces positioned closer to windows, benefiting from ample daylight. The use of light-colored materials for walls, floors, and ceilings further enhances the distribution and reflection of natural light throughout the space, contributing to a bright and inviting environment. These considerations exemplify the attention given to natural lighting in Hejazi architectural houses, promoting sustainable and visually pleasing spaces.

It is worth noting that the specific techniques and features employed for natural lighting in Hejazi architectural houses may vary depending on the location, historical period, and specific architectural style within the broader Hejazi region. Here are some key points regarding natural lighting in Hejazi architectural houses:

3.1 Al-Kharja

Al-Kharja is compensating spaces in the historical building of Jeddah for the inner courtyard that disappeared in its dwellings due to limited spaces. Its exteriors are open to the sky, surrounded by a wall that achieves high privacy. It has a special character that is visually distinct in terms that abandoning its wall. It represents an open space as an extension of a closed space and is used for sleeping and for family gatherings and dry clothes. This is considered to be the largest natural lighting source in historical Jeddah houses Fig. 3 shows Al-Kharja which is an interior and exterior space at the same time as an unroofed space [21]. Al-Kharja is the largest source of natural lighting in Jeddah historical houses which can increase the natural lighting pattern in the surrounding spaces in the house. Also, in terms of the ventilation openings Al-Kharja spaces are a vital source of open-door ventilation. During the night the time the walls surrounded by the space stores the coolness and release the unheated wholesome in the daytime to balance the heat inflow in the infrastructure.

3.2 Roshan

Baik *et al.* [22] explained that Jeddah, Saudi Arabia has a climate zone of warm and humid. To understand the nature of the climate with different architectural ways and the best way to cut back the impact of hot and humid weather conditions is open spaces in the building and shading, with a ventilation system for a steady and continuous flow of air and cool breezes. Similarly, for shading, less sun

exposure and brilliance would contribute to reducing heat absorption. The comparison of the elements of the mentioned factors are ones used in old Hijazi architecture in Al Balad. Roshan was serving the light flow to the interior of the building without forsaking the privacy factor.



Fig. 3. Al-Kharja structure.

The word Roshan is derived from an Indian word (rushandan), which means that the light source (clerestory) is windows near the ceiling. The Roshan has three directions in which it captures the breezes of air and helps spread the light inside the house. In hot and humid climates, ventilation is indispensable for buildings. Roshan acts as a curtain against the sun's rays, as wood is by nature a heat insulator. For this reason, the facades were created from slots with curtains of perforated wood decorated. The Roshan is singular, and functional and originates environmental and climatic benefits and social responsibility. Roshans represent one of the major visual elements that characterize the traditional

architecture in Hijaz Saudi Arabia and in the heritage residential buildings in Jeddah [22].

It consists of several parts and the absence or presence of secondary parts is an indication by which we know the type of Roshan. These parts can be seen in one Roshan, or the same Roshan which is generally divided into three parts in detail, from bottom to top, the base, the structure, the crown, or the head of the Roshan shown (Fig. 4 and 5) [23].

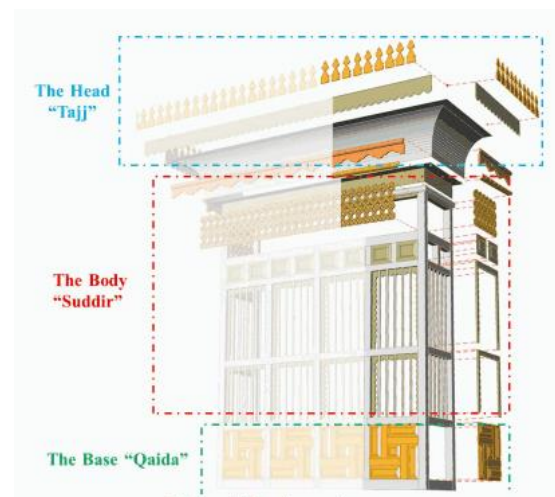


Fig. 4. Infrastrucutre of roshan. [22]



Fig. 5. Roshan in Old Jeddah.

3.3 Qamaria (Circular opening)

Qamaria is openings above the regular openings, and the main doors are circular in most cases. They are visually characterized by their small size and are treated with wood. They are specialized in the exit of hot air. The hot air rises, and it helps the movement of air by replacing the cold air with the hot air coming out of those openings. It is considered one of the sources of natural lighting in the historical houses of Jeddah shown in (Fig. 6).

3.4 Cross Ventilation

Cross-ventilation is the methodology for the cooling that is specifically used in Baeshen House. There are several openings on the façade, as well as in the interior walls to permit the flow of air. Air is highly valued as it cools down the interior and in-house walls or spaces substantially during summer hot days. The sheer effect to conduct cross ventilation at the height of the house is the main factor to control the effect of wind patterns and breezes in Jeddah city. The division of the house and rooms are done as shown in Fig. 7, where the bedrooms were placed on the top floors, to easily produce on-shore and off-shore winds blowing at high altitudes. The Staircase shaft in Jeddah's typical houses, allows the hot air to rise and escape out of the building ^[24].



Fig. 6. Roshan, Qamaria, and Al Kharja in old Jeddah, Source UNICCO World Heritage website.

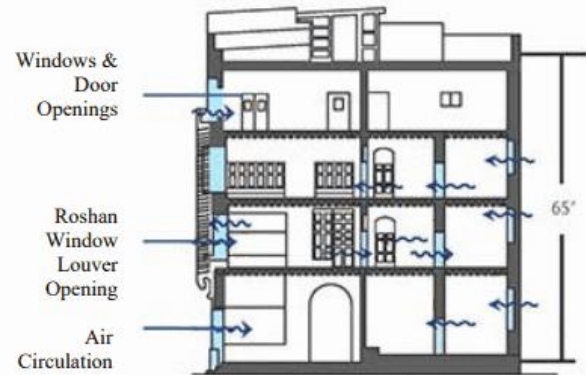


Fig. 7. Cross Ventilation system in Jeddah Heritage Buildings. ^[24]

3.5 Urban Fabric and Natural Lighting Patterns in Historic Jeddah and Social and Environmental Sustainability

The urban fabric in the historical area of Jeddah is considered one of the most important factors and components of social, economic, and urban sustainability. The density of buildings increases in the middle of the historical area to form shaded pedestrian paths to the streets of old Jeddah, which contributes to reducing the temperature and shading the facades of buildings in the area. Some of these paths end in small squares surrounded by a group of houses. These spaces contribute to the formation of the planning parts of the historical city of Jeddah, which is divided into four main areas, which are Harat Al-Sham, Haret Al-Mazloun, Harat Al-Yaman, and Hart Al-Bahr. The planning relationship of the urban fabric to the formation of markets and shops and its relationship to the sites of the main mosques directly affects the social sustainability of the region's residents and merchants. In environmental sustainability, it is observable that the urban planning of the historic houses of Jeddah is shaped so that most of the houses are surrounded by streets on all four sides, which produces shaded corridors and allows natural ventilation through the Roshan openings.

The inner courtyard of the mosque is one of the most important sustainable architectural elements to create shadows and natural lighting and contribute to reducing temperatures, by reducing areas exposed to direct sunlight. In addition, the inner courtyards in the buildings make improvements to the internal climate of the spaces and the surrounding environment [25]. The harmony of design between houses and narrow streets in the urban fabric in the historical area of Jeddah is an exemplary solution for an effective response to the climate to represent environmental sustainability. The urban fabric allows the movement of winds between the spaces in the squares and streets. Moreover, the height of the houses allows to catch the sea breeze and wind inside the historical houses through the high staircase situated in the center of the house and facilitates the flow of air movement inside the house and into the spaces and rooms of the house.

3.6 The Impacts of Light on the Interior Facades

Sunlight reflects changes in color states of the sky to the interior and enters into rooms through windows and openings. Natural lighting passes through the surfaces of the walls in the rooms and has a lively impact on the wall and their texture. Consequently, there is a need to deliberate on daylight, its degree, visibility, and dazzling at the time of crafting the interior and installing opening areas inside a building. The daylight varies in rate and intensity following the function and usage of space. Al-Kharja allows a high amount of natural sunlight into the interior spaces alternative to the open courtyard in the traditional Tabeyat Museum in Jeddah shown in (Fig. 8) and many Arabic houses, with more privacy.

Furthermore, Roshan conserved to be the next level of natural lighting pattern, used to deliver a sufficient amount of natural lighting

for the interior spaces in historical Jeddah houses (Fig. 9 and Fig. 10).



Fig. 8. Al-Kharja in Tabeyat Museum Jeddah



Fig. 9. Natural light from Roshan Sharbtly House.

Jokhdar House in Jeddah historical area is one of the most recently developed projects to be a boutique historical hotel where lighting patterns are well-designed aesthetically and functionally. Figure 11 shows Jokhdar's house before and after restoration. Jokhdar house restoration is a serious challenge, particularly for such a building with relatively small windows and a highly decorated façade. Natural lighting patterns in the house were redesigned through the Raoshan and Qamaria in the front façade. Kharga was added to the top floor as a coffee shape for the hotel which will be an enormous upgrade of natural lighting pattern for the hotel spaces on the same floor.



Fig. 10. Light pattern (Qamaria) Jokhdar House before restoration



Fig. 11. Jokhdar House after restoration and enhancing lighting pattern.

4. Results and Discussion

The heat source of Jeddah is mostly the sun. As unwanted heat is gained and absorbed in interior areas of the house from the walls and doors, shading helps in retaining daylight without the heat. By shading, the exterior walls of the façade Roshans help to reduce the heat gain. In addition, is also the descent of the indirect source of lights from the openings into the interior spaces. The interior spaces of the heritage building contain many thin wooden strips intricately jigsawed together. The pattern is different for the allocated spaces by the indication of the function of that particular

space. For example, horizontal louvers are for bedrooms to maximize privacy, and a more Islamic decorative pattern is assigned for guest reception Roshan (Fig. 12). Through the various stages of research and the extensive study of the three natural lighting patterns and open ventilation infrastructure, a set of results was extracted from the study case for the rehabilitation of interior spaces. The pattern of the infrastructure and their examples are elaborated on in Table 1. The design of the interior of historic buildings in Jeddah is harmonized with the right balance of light and thermal comfort for the occupants. The lighting patterns are according to aesthetic laws and principles of visual movement i.e., balance, continuity, and architectural rhythm [26].



Fig. 12. Shading in the Hijazi Architecture of Jeddah. [24]

Demir *et al.* [27] stated that visual design comprises basic elements and principles that must be taken into consideration at the time of creating ventilation ad openings in the interior of a house. Another study by Metwally [28] has advocated using the gestalt principles which reflect the visual language and patterns to better reflect the objectives and construction materials in the field of architecture. Architectural designers employ Gestalt principles to identify the visual stimulus, aiming to shape interfaces that enlarge the understanding of the reflection of light and visual perception. Ali and Mustafa

[29] have indicated that Islamic architecture is archetypical of aesthetic architectural values such as the Sultan Hassan Mosque in Cairo where lighting patterns beget transparency in the view lessens the raw material cost.

Hertwich *et al.* [30] highlighted that to significantly reduce energy consumption and emission, there is a need to replace or retrofit energy-intensive buildings while replacing the heavy-weighted material with light-weight materials is necessary. In addition, substituting concrete and metals with wooden structures can cause a considerable reduction in emissions.

The lightweight materials give passage to light and allow it to fill the idle spaces of raw material increasing visual impact, color reflection, and transparency. Regarding retrofitting the vernacular architecture, Also, the study by Hussein [31] has already reported the effectiveness of using light-weight concrete for lowering thermal conductivity as the concentration of light increased in the interior spaces where walls were built of light-weight materials and high openings were installed [32].

Berardi and Anaraki [32] further stated that the shelves of light add up illuminance from the windows at a distance of 6 meters and divide the reflection of light homogeneously with Window-to-wall ratios of more than 35% that unfold visibility.

Based on the findings of this study, strategic and economic plans are recommended to develop for preserving the heritage in the historical Jeddah area specifically by forming and developing a group of historical houses. The houses must be developed in a comprehensive sustainable manner consisting of 25 to 30 ancient houses and placing them under immediate protection. Afterward, two to three houses must be developed biennially, according to the available budget. One potential source of the budget is the developed sites, where they have been operated to generate income, and over time, the material returns increase to form a basic solution for financing the development of the following houses and sites, which constitutes sustainability.

Table 1. Vernacular architectures in Jeddah.

Type of Infrastructure	Architectural Adaption in Old Buildings of Jeddah	Benefits
Al-Kharja	Tayebat Museum and Makkah Masjid and Jokhdar House	Open spaces like courtyards, considered to be the largest natural lighting source in historical Jeddah houses
Roshan	Al Balad region of Jeddah, Sharbtly House, and Jokhdar House	Provides a vital source of light and a continuous flow of winds.
Qamaria	Jokhdar House	En route the exit of hot air from its structure of circular shape doors.
Cross Ventilation	Baehsen House	Control the steady flow of air in day to night time

5. Conclusion

This research has investigated the natural lighting light patterns and strategies in the historical buildings of Jeddah. It has been reviewed that Roshans, Qamaria (Circular

openings) cross ventilation and Al Kharja were the most commonly-adopted ways to allow passage of light in the interior of the houses. Also, natural lighting has been found a useful tool for ensuring thermal comfort, color

reflection, and transparency of the houses. The study has recommended using lightweight material for greater visualization and reflection of light which is an economically sustainable strategy. The three said techniques of natural lights have been validated for social sustainability as high openings ensure the privacy of traditional houses. Classification and preservation of the urban heritage of historical buildings in the old Jeddah area preserve the architectural and economic value of those buildings. It represents the architectural value (style, character, form, function, privacy, and method of construction). Raising awareness and educating the community about the importance of the Hijazi and Saudi urban heritage, by organizing lectures for all segments of society can benefit to increase social and economic sustainability. The field of research is sustainable urban development by studying and analyzing the patterns of natural lighting to employ the interior spaces in the Al-Balad region in Historic Jeddah. This experience will be useful for the students, researchers, architects, environmentalists, and the government for sustainable urbanization. Geographically, the research field for comprehensive sustainability is the re-employment of buildings in the historical area of Jeddah in particular.

5.1 Study Limitations and Future Directions

The present study contributes to the existing body of knowledge by consolidating and contextualizing the sustainable aspects of natural lighting in historical Hijazi buildings while considering the vision of the Kingdom of Saudi Arabia 2030 regarding heritage preservation and sustainability. While not providing a comprehensive architectural analysis of every house in the Old Jeddah districts, it offers valuable insights into the significance of natural lighting in shaping and influencing interior spaces, which can inform future research and architectural design

practices in the field of sustainability and heritage conservation. Future studies may conduct an extensive analysis of individual houses in the Old Jeddah districts and compare their architectural elements by taking insights from this study.

It is crucial to understand that the study's scope and case selection was limited to a specific context and may not represent the entirety of Hejazi Architectural buildings in Jeddah or other regions. The availability of these architectural elements, such as Al-Kharja, Roshan, and Qamaria, might vary across different historical structures within the broader Hejazi architectural style.

To provide a more comprehensive understanding of the availability of these architectural elements, further research or studies with a larger sample size encompassing a broader range of Hejazi Architectural buildings would be necessary. This expanded research would enable a more detailed examination of the prevalence and variation of these elements in different historical structures.

While the study's findings are valuable within the specific context of the selected case studies, it is essential to approach the generalization of these findings to the broader Hejazi Architectural buildings with caution. Future studies can build upon this research by investigating a wider range of structures to enhance our understanding of the prevalence and impact of natural lighting and cross-ventilation in different Hejazi Architectural contexts.

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استدامة العمارة الداخلية في المباني التراثية في جدة التاريخية: تحليل أنماط الإضاءة الطبيعية

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المستخلص. ينطرق البحث إلى جوانب الاستدامة من خلال تحليل الإضاءة الطبيعية والمساحات الداخلية للمباني الحجازية التاريخية في جدة. يكمن نطاق الدراسة هذا في رؤية المملكة العربية السعودية ٢٠٣٠ حول الحفاظ على التراث والاستدامة في البناء والحفظ. يستعرض البحث أنماط الإضاءة الطبيعية والتهوية المتقاطعة، ويقيم مدى انسجامها مع مفاهيم الاستدامة في إعادة تأهيل المساحات الداخلية التي تتكامل معها. تم تحديد ثلاثة أنماط إضاءة طبيعية للدراسة. شملت دراسة الحالة الخرجة والروشان والقمرية. وتم اختيار الأنماط بناءً على الحجم، حيث كانت الخارجة تعتبر المصدر الكبير للإضاءة الطبيعية. والروشان مصدراً متوسطاً والقمرية مصدراً صغيراً للإضاءة الطبيعية في منازل جدة القديمة. علاوة على ذلك، تسلط الدراسة الضوء على الدور الحاسم لنظام التهوية المتقاطعة في التنظيم الفعال لدورة تدفق الهواء الساخن وتعزيز النسائم الباردة داخل المنازل والمباني. وتجدر الإشارة إلى أن الإضاءة الطبيعية تبرز باعتبارها جانباً أساسياً من جوانب استدامة المساحات الداخلية، وتتأثر بشدة باستخدام المساحة ومساعي إعادة التأهيل المستمرة. تقدم النتائج رؤى قيمة للباحثين والمهندسين المعماريين والهيئات الحكومية، وتوجه تصميم قوانين البناء المستدام، وتدعو إلى اعتماد مواد خفيفة الوزن ولكنها مستدامة في ممارسات البناء الحديثة.

الكلمات المفتاحية: الاستدامة، التراث، جدة، الهندسة المعمارية.

