

Integration of Qamariyah in Modern Architecture in Yemen: A Systematic Literature Review

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Abstract

For over 4,000 years, Qamariyah, traditional stained-glass windows, have been a defining feature of Yemeni architecture. It strikes a balance between aesthetics and privacy while symbolizing cultural identity. However, the rapid modernization and adoption of industrial materials have led to its decline in contemporary architecture. This study provides a systematic literature review of peer-reviewed journal articles published between 2004 and 2024, retrieved from Scopus, ScienceDirect, and Google Scholar. A total of 10 full-text articles were analyzed using qualitative content descriptive analysis into three major themes: (1) concept and definition of Qamariyah and its role in Yemeni architecture, (2) approaches to integrating Qamariyah into Yemeni modern architecture, and (3) key considerations of Qamariyah. The findings reveal that the Qamariyah is primarily valued for seven key considerations: privacy, cultural and social identity, symbolic meaning, use of local materials, economic local design, and contributing to sustainability. Despite its recognized value for enhancing cultural continuity and environmental performance in modern buildings, extant literature lacks empirical studies on its economic feasibility and construction techniques. This review concludes that the successful integration of Qamariyah into contemporary design necessitates a hybrid approach, innovatively combining traditional considerations and modern design techniques to bridge Yemen's rich architectural heritage with future sustainable development.

Keywords: Architectural heritage, modern architecture, Qamariyah, Sana'a, stained glass window, sustainability, traditional architecture, Yemen.

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Introduction

Recently, due to globalization and the homogenization of the built environment, there is a growing international reappraisal of vernacular architecture as a vital source of sustainable and culturally relevant design principles (Asquith & Vellinga, 2006). Traditional building practices are recognized not as relics of the past but as invaluable repositories of knowledge, demonstrating a profound connection to local climate, materials, and socio-cultural norms (Oliver, 2006). This global shift towards valuing indigenous knowledge highlights the urgent need to document and adapt these practices to address contemporary challenges.

Sana'a, the capital of Yemen, is one of the world's oldest continuously inhabited cities and is designated as a UNESCO World Heritage Site. Its architectural identity is distinguished by multi-story tower houses, intricate facades, and the incorporation of Qamariyah decorative stained-glass windows framed in gypsum or marble (Attia, 2022; UNESCO, 2021). These windows, whose name derives from the Arabic word Qamar (moon), have for centuries embodied both aesthetic beauty and functional performance by enhancing privacy, diffusing daylight, and reducing reliance on artificial lighting (Abdelwahab et al., 2023; Radwan et al.,

2021), see Figure 1. Historically, the Qamariyah has been revered for its dual role, providing functional benefits in daylighting and thermal comfort while serving as a powerful symbol of aesthetic sophistication and cultural identity (Akalin et al., 2019).

Historically, Qamariyah represented not only an architectural element but also a marker of cultural identity, social prestige, and spiritual symbolism (Akalin et al., 2019). Their geometric and floral patterns often reflected religious and cultural values, while their design responded effectively to local climatic conditions by promoting ventilation and thermal comfort (Alamri et al., 2022). However, contemporary construction trends in Sana'a increasingly prioritize minimalist and cost-efficient materials such as aluminum and plain glass, often at the expense of traditional craft (Al-Sallal, 2022; Attia, 2022). This transition has accelerated the decline of Qamariyah, creating concerns about cultural continuity and architectural sustainability. Although several studies acknowledge the cultural and environmental significance of Qamariyah (de Macedo et al., 2023; Al-Harbi et al., 2023), few have systematically synthesized how these features can be adapted to modern residential contexts.



Figure 1: Traditional *Qamariyah* Windows in the Old City of Sana'a, Showcasing Intricate Gypsum Frames and Colored Glass Patterns. (Source: Author records, 2025).

As noted by Al-Harbi et al. (2023), the current literature often describes these features in isolation, celebrating their historical value but failing to provide a comprehensive and practical framework for integrating them into modern architectural practice. There is a distinct lack of synthesized research focused on the methods and practical challenges, such as material adaptation, thermal performance upgrades, and economic viability, of adapting such traditional elements to meet contemporary needs (Pardo, 2023; Attia, 2022). This gap between theoretical appreciation and practical application leaves a void for architects and policymakers seeking to preserve cultural identity without sacrificing modern comforts and standards. Therefore, this study aims to bridge this gap by systematically investigating the role of the Qamariyah and the key considerations for integrating Qamariyah into Yemeni modern architecture. Within this context, this paper will examine factors such as cultural aspects, privacy, material choice, and environmental sustainability, and how these impact the adoption of Qamariyah in current residential designs. Specifically, this systematic review seeks to answer two research questions:

What is the Qamariyah, and what is its role in Yemeni architecture?

How does the body of knowledge indicate the integration of Qamariyah into Yemeni modern architecture?

Literature Review

Historical Context of Qamariyah in Yemeni Architecture

Qamariyah windows, integral to Yemeni architecture for more than four millennia, reflect a tradition that combines craftsmanship, cultural symbolism, and functional performance. Typically constructed from gypsum or marble frames embedded with intricately patterned stained glass (Abdelwahab et al., 2023; Ayssa, 1996). Their placement on the upper walls of tower houses in Sana'a optimized natural light while safeguarding modesty and social norms deeply embedded in Islamic culture (Akalın et al., 2019). Moreover, Qamariyah carried profound cultural and spiritual meaning. Beyond their decorative role, these windows symbolize a bridge between the sacred interior space and the external environment, reinforcing both privacy and connectivity. This dual function made Qamariyah not only an architectural feature but also a cultural marker of identity and social status (Al-Harbi et al., 2023).

Furthermore, Qamariyah embodied early principles of sustainability. By reducing the need for artificial lighting and moderating indoor temperatures through passive climate control, they offered environmentally responsive design solutions long before the emergence of contemporary energy-efficiency discourses (Attia, 2022). Such attributes underline their significance as precursors of sustainable architecture within arid environments. However, socio-political instability and rapid urbanization have significantly undermined the continuity of this tradition. Modern housing in Sana'a increasingly relies on industrial materials such as aluminum and plain glass, which, although cost-effective, fail to preserve the cultural depth and environmental performance of Qamariyah (de Macedo et al., 2023). Consequently, the marginalization of these traditional windows poses a threat to Yemen's architectural identity, underscoring the urgency of documenting, reviving, and integrating Qamariyah craftsmanship into contemporary practice. Preservation efforts should therefore combine innovative material solutions with policy support to sustain this unique architectural heritage in the face of modernization pressures (Al-Harbi et al., 2023).

Figure 2 illustrates the key factors contributing to the cultural significance of Qamariyah in Yemeni architecture by emphasizing four interconnected aspects. The historical context highlights the long-standing tradition and evolution of Qamariyah, underscoring its significance in Yemen's architectural heritage. Artistic craftsmanship underscores the intricate skills and techniques of Yemeni artisans in creating these unique stained-glass designs. Cultural themes reflect the representation of religious and cultural motifs, symbolizing harmony and spiritual transcendence. Finally, modern challenges address the impact of urbanization and the adoption of modern materials, which pose a threat to the preservation of Qamariyah as a vital cultural and architectural element.

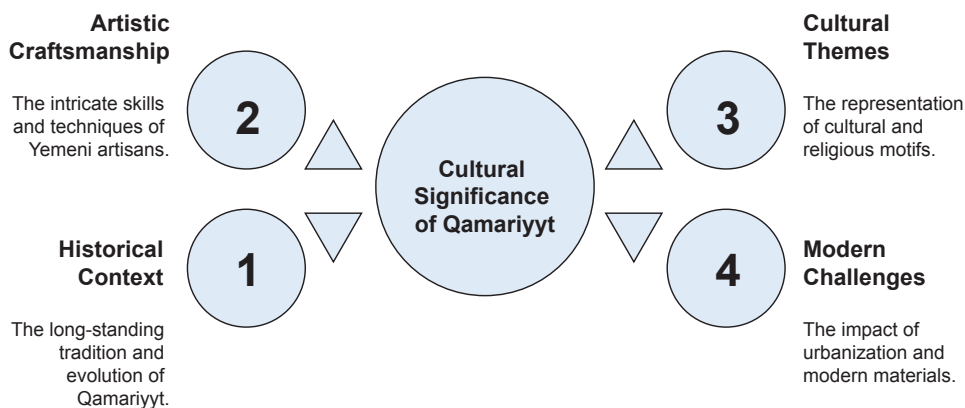


Figure 2: Factors Contributing to Qamariyah's Cultural Significance. (Source: Author records, 2025).

Modern Architectural Trends and Challenges in Sana’a

The architectural landscape of Sana’a has undergone significant changes in recent decades, driven by urbanization, globalization, and economic shifts. Modern construction in the city has increasingly embraced minimalist design principles, characterized by simplicity, functionality, and the use of industrial materials such as concrete, aluminum, and plain glass. This transition marks a departure from the ornate and culturally rich designs that defined traditional Yemeni architecture, particularly the intricate Qamariyah windows (Mazzetto, 2018). Minimalist designs prioritize efficiency and affordability, often at the expense of cultural heritage and aesthetic continuity.

According to Ali and Al-Hashimi (2018), modern architectural styles in Sana’a often conflict with the city’s historic identity. Traditional elements like Qamariyah, which once played a central role in defining the cultural and visual character of homes, are being replaced with generic design elements that lack cultural resonance. This shift is partly driven by the economic appeal of modern materials, which are cheaper and easier to source than the gypsum and colored glass traditionally used in Qamariyah construction (Attia, 2020). However, this trend has led to a loss of the sensory richness and historical continuity that traditional designs once offered.

The impact of minimalist architecture extends beyond aesthetics. Attia (2022) highlights that traditional Yemeni designs, including Qamariyah, were inherently sustainable, utilizing local materials and responding to the region’s climate. Modern designs, by contrast, often overlook these environmental considerations, relying on energy-intensive solutions like artificial lighting and cooling systems. This not only diminishes the ecological benefits of traditional architecture but also undermines the cultural identity embedded in Yemen’s built environment. The rise of minimalist architecture in Sana’a underscores the challenges of balancing modernization with cultural preservation (Alalouch et al., 2019). While modern designs cater to contemporary needs, they risk erasing the architectural heritage that has long defined the city’s identity. Addressing this requires innovative approaches to integrate traditional elements like Qamariyah into modern construction.

Regardless of these integration factors, Qamariyah is not widely integrated into modern architecture, both from an economic viability perspective and in terms of building techniques that adapt to a contemporary lifestyle. These challenges underscore a need for creative means to maintain this architectural legacy amidst contemporary urban revitalization. The primary obstacle to the extensive use of Qamariyah in modern residences is the maintenance and crafting cost, see Table 1. These traditional Qamariyah windows, crafted from materials such as gypsum and colored glass, require a significant amount of labor and skilled artisans to produce. According to Alqalami et al. (2020), the average cost of making a conventional Qamariyah window is 40% higher than that of a commercial aluminum-framed glass window; thus, this type of window is less accessible for homeowners with limited budgets. In addition, a 2023 market survey revealed that 62% of new homeowners in the capital, Sana’a, seek cost-effective solutions compared to traditional materials, reflecting the increasing costs of construction. The increased inclination towards more economical substitutes, including plain glass and aluminum, has massively affected the consumption of traditional Qamariyah, putting them at risk of extinction (de Macedo et al., 2023).

Table 1: Comparative Costs of Window Materials in Sana’a. (Source: Al-Shawesh, 2022).

Material Type	Cost (SAR per unit)	Skilled Labor Required	Production Time (hours)
Traditional Qamariyah	800–1,000	High	15–20
Aluminum-Framed Glass	400–600	Moderate	5–8
Polymer-Based Qamariyah	600–750	Low	8–12

Furthermore, adapting Qamariyah's unique design features to modern construction methods is even more difficult. Contemporary architectural practice has become dependent on prefabricated components and industrial materials. According to Soltanzadeh and Moghaddam (2015), integrating the intricate designs and artisanal craftsmanship of Qamariyah into such frameworks requires significant adjustments in design and production processes. For example, incorporating Qamariyah into prefabricated facades may necessitate the use of custom molds or hybrid materials, thereby increasing both complexity and cost. Despite these challenges, opportunities exist to overcome them. Yet, there is a need to investigate the methods of integration of these local traditional features into modern architecture, see Figure 3. Therefore, this study will explore the role of Qamariyah and its integration in modern architecture in Yemen.



Figure 3: Modern Residential Building in Sana'a Attempting to Incorporate Qamariyah-Inspired Features (Author, 2024)

Comparative of Traditional and Modern Materials

A detailed comparison of traditional Qamariyah features and modern building materials reveals significant differences in terms of material composition, cost, functionality, and overall impact on architectural design. Traditional Qamariyah windows are made from locally sourced gypsum and colored glass, offering both aesthetic and functional benefits. In contrast, modern building materials, such as aluminum and simple glass, prioritize efficiency, affordability, and mass production, see Figure 4.

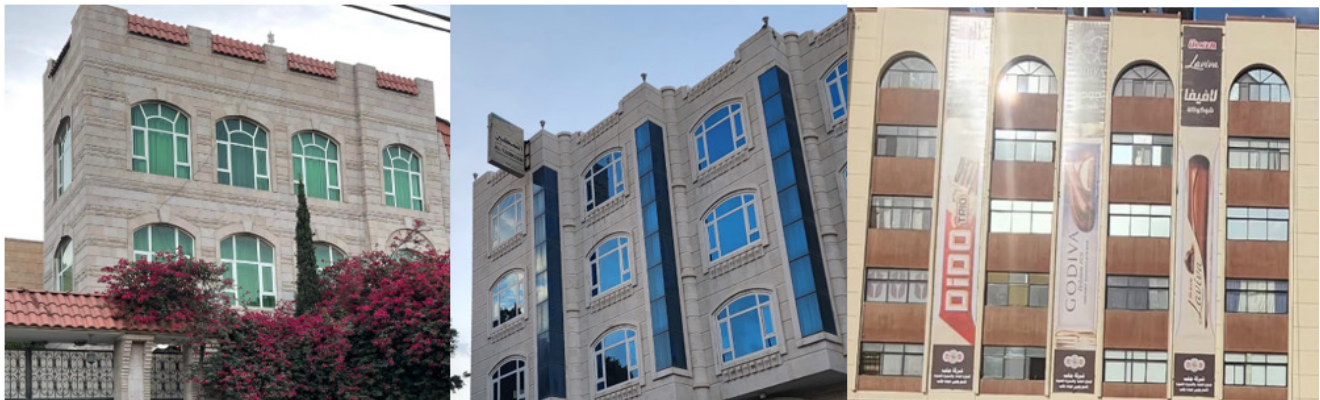


Figure 4: Modern Aluminum and Plain Glass Windows in Sana'a, Reflecting Simplicity and Cost-Efficiency (Source: Author, 2024).

The material composition of traditional Qamariyah consists of gypsum frames, often intricately carved, which hold colored glass panes in geometric or floral patterns. These materials are locally sourced, contributing to the preservation of local craftsmanship and reducing the environmental impact associated with transportation and manufacturing (Abd Hamid et al., 2023). On the other hand, modern materials like aluminum and simple glass are more cost-effective but are often perceived as less culturally significant and less environmentally friendly. The use of aluminum, while lightweight and durable, lacks the visual appeal and functional benefits of traditional materials, such as gypsum (Abd Hamid et al., 2023).

The shift from traditional to modern materials in Sana'a is particularly evident in the design of windows. Traditional Qamariyah, as shown in Figure 4, prioritizes privacy through intricate designs that diffuse light while maintaining a sense of seclusion. By contrast, modern windows, as shown in Figure 5, utilize aluminum and plain glass, reflecting a focus on simplicity and cost efficiency. The differences in material and design highlight the challenges of preserving cultural heritage in contemporary construction.

Traditional Qamariyahs offer better privacy conditions due to the compound geometries, which provide some opacity to the outdoor view while still allowing for natural light to penetrate the space (Mazurek, 2022). However, modern windows, designed with larger panes of clear glass, don't offer as much privacy. Therefore, using modern windows with larger panes of clear glass may not suffice for privacy, as it will be easy to see through.



Figure 5: Traditional Qamariyah Windows in Sana'a, Emphasizing Privacy and Cultural Aesthetics (Author, 2024).

Lastly, traditional Qamariyah windows also excel in energy efficiency. They provide ventilation, sustaining natural light and thermal insulation, and minimizing reliance on artificial lighting and heating efforts, which is particularly significant in hot environments (de Macedo et al., 2023). Modern windows can be energy-efficient, primarily due to their double-glazed panes or the use of specialized materials. However, they are more focused on maximizing light use and insulation in terms of space rather than energy, which can lead to higher energy consumption in certain situations (Memari, 2021).

However, as mentioned, there is an architectural transition from using the traditional Qamariyah windows to modern aluminum and plain glass alternatives. This shift results in a loss of cultural identity, diminished aesthetic value, and a potential decline in environmental performance, particularly in terms of privacy and passive energy efficiency. Therefore, this review study aims to provide an

evidence-based understanding of the unique considerations associated with these traditional features, informing strategies for their potential integration or adaptation in modern construction. Table 2 presents a comparative analysis that highlights the challenges and trade-offs associated with integrating traditional Qamariyah features into modern architectural designs, particularly in terms of cost, privacy, and energy efficiency.

Table 2: Comparison of Traditional and Modern Building Materials in Sana'a.

Source	Considerations	Traditional Qamariyah Features	Modern Building Materials
Alnehmi (2024)	Window Materials	Gypsum, Colored Glass	Aluminium, Simple Glass
Mazurek (2022)	Privacy Consideration	High (Through intricate designs).	Low (Larger glass windows).
Abd Hamid et al., (2023)	Cost	Lower (Local materials).	Higher (Imported materials).
de Macedo et al., (2023)	Energy Efficiency	High (Natural light and insulation).	Moderate (Less focus on energy-saving).

Conceptual Framework of Considerations of Qamariyah Integration

The conceptual framework of this review was established based on an extensive review and analysis of previous studies, which primarily focused on the Qamariyah feature and its key considerations. Multiple factors, including privacy, cultural preferences, environmental benefits, and compatibility with contemporary architectural styles, shape the integration of Qamariyah into modern architecture in Sana'a. These considerations underscore the importance of striking a balance between tradition and innovation in urban development. Privacy and cultural norms are deeply embedded in Yemeni society, significantly influencing architectural choices. As noted by Abdelwahab et al. (2023), Arab cultures place a strong emphasis on privacy within the domestic sphere, particularly in urban areas. Qamariyah, with its intricate designs and semi-transparent materials, allows natural light to penetrate while shielding interiors from external views. This makes them ideal for addressing privacy concerns, especially in densely populated neighborhoods. According to a 2022 survey conducted in Sana'a, 75% of residents expressed a preference for maintaining traditional privacy features in their homes, indicating a strong cultural inclination toward elements like Qamariyah (Abd Hamid, 2023). However, the shift toward larger, minimalist glass windows in modern homes often compromises these values, underscoring the need for thoughtful integration of traditional designs.

The environmental and energy efficiency benefits of Qamariyah also advocate for their continued use. Attia (2022) emphasizes that traditional Yemeni architecture is inherently sustainable, relying on local materials and passive design techniques to minimize energy consumption. Qamariyah windows, for instance, provide natural illumination and ventilation, reducing the reliance on artificial lighting and air conditioning. Research shows that homes equipped with Qamariyah windows consume up to 30% less electricity for lighting compared to those with plain glass windows. This highlights the potential of Qamariyah to contribute to environmentally friendly construction in a region facing rising energy demands. Construction materials and their compatibility with Qamariyah represent another critical factor. Al-Sayyed (2012) argue that modern minimalist designs, characterized by simplicity and industrial materials, often clash with the ornate and organic nature of Qamariyah. While traditional regionalist styles seamlessly incorporate Qamariyah, adapting these features to modern construction requires innovative solutions. For example, hybrid approaches that combine traditional and modern materials could bridge the gap between heritage preservation and contemporary design.

Abd Hamid (2023) confirmed that 75% of Sanaa residents advocate for privacy-oriented elements, such as Qamariyah, in contemporary homes. Additionally, its environmental benefits are critical in an era of increasing energy demands. Attia

(2022) highlights that Qamariyah promotes passive cooling and lighting, reducing energy consumption by up to 30% compared to conventional glass windows, thereby aligning with sustainable construction practices. However, integrating these features into modern architectural styles poses challenges. Traditional Yemeni designs inherently harmonize with Qamariyah, but minimalist trends, favoring industrial and streamlined materials, often clash with its intricate aesthetics (Abd Al-Razik, 2024; Al-Sayyed, 2012). This necessitates innovative approaches, such as using hybrid designs that blend modern materials with traditional Qamariyah patterns, preserving cultural identity while meeting contemporary demands.

The successful integration of Qamariyah requires a balanced approach that respects cultural heritage, maximizes environmental efficiency, and adapts to evolving architectural trends, ensuring its relevance in Yemen's rapidly urbanizing landscape. Therefore, several sociocultural, environmental, and local design considerations influence the integration of Qamariyah into modern Yemeni architecture. Figure 6 illustrates the conceptual framework of integrating Qamariyah into modern Yemeni architecture. It highlights three main aspects: the local traditional architecture of Yemen, its considerations, and integration into modern architecture.

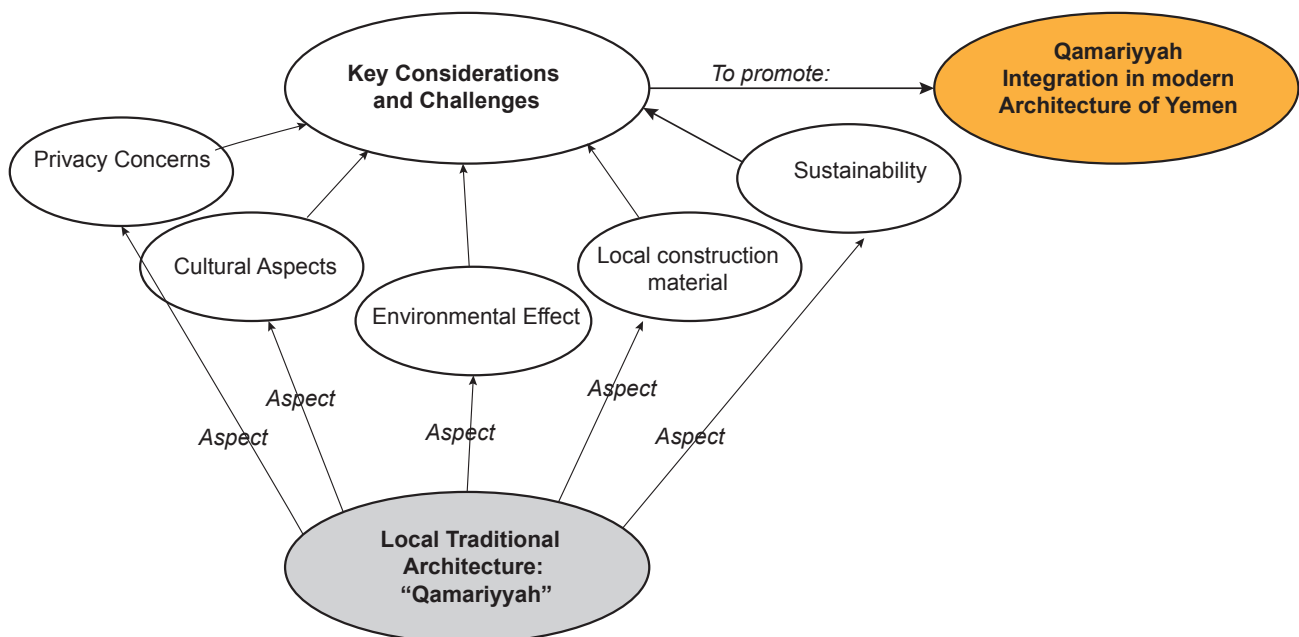


Figure 6: Conceptual Framework of Qamariyah Integration in Yemen (Sana'a) Architecture. (Source: Author Records, 2024).

Material and Method

The primary objective of this review is to examine the considerations and challenges that influence the integration of Qamariyah in modern homes in Sana'a, with a specific emphasis on cultural, economic, and environmental aspects. This study employed a systematic literature search and review methodology, following the PRISMA guidelines (Page et al., 2021) and the systematic literature review process outlined by Grant and Booth's (2009) and Salih et al. (2024). Additionally, it utilized Mayring's (2014) qualitative content data analysis approach and Salih et al.'s (2024) simple descriptive analysis to analyze the synthesized data. The review specifically addressed two questions: (1) What is the Qamariyah, and what is its role in Yemeni architecture? (2) How does the body of knowledge indicate the integration of Qamariyah into Yemeni modern architecture? The methodology employed a few systematic steps of literature search following PRISMA guideline, including (1) identification through electronic database searches, (2) screening for duplicate papers, initial screening based on language and type of publication,

and title and abstract screening based on study relevance and type of publication, (3) eligibility assessment for the full text of selected papers based on predefined criteria, and (4) final inclusion of relevant studies, see Figure 6. Analytical processes were supported by specialized software, including Mendeley Desktop v1.19.8 for reference management, and Microsoft Excel 365 (Version 2405) for data organization and visualization, ensuring methodological rigor throughout the review process. This method enables the identification, categorization, and synthesis of relevant literature, providing both transparency and reproducibility. The following PRISMA flow diagram shows the key steps of the current systematic search and review (Figure 7).

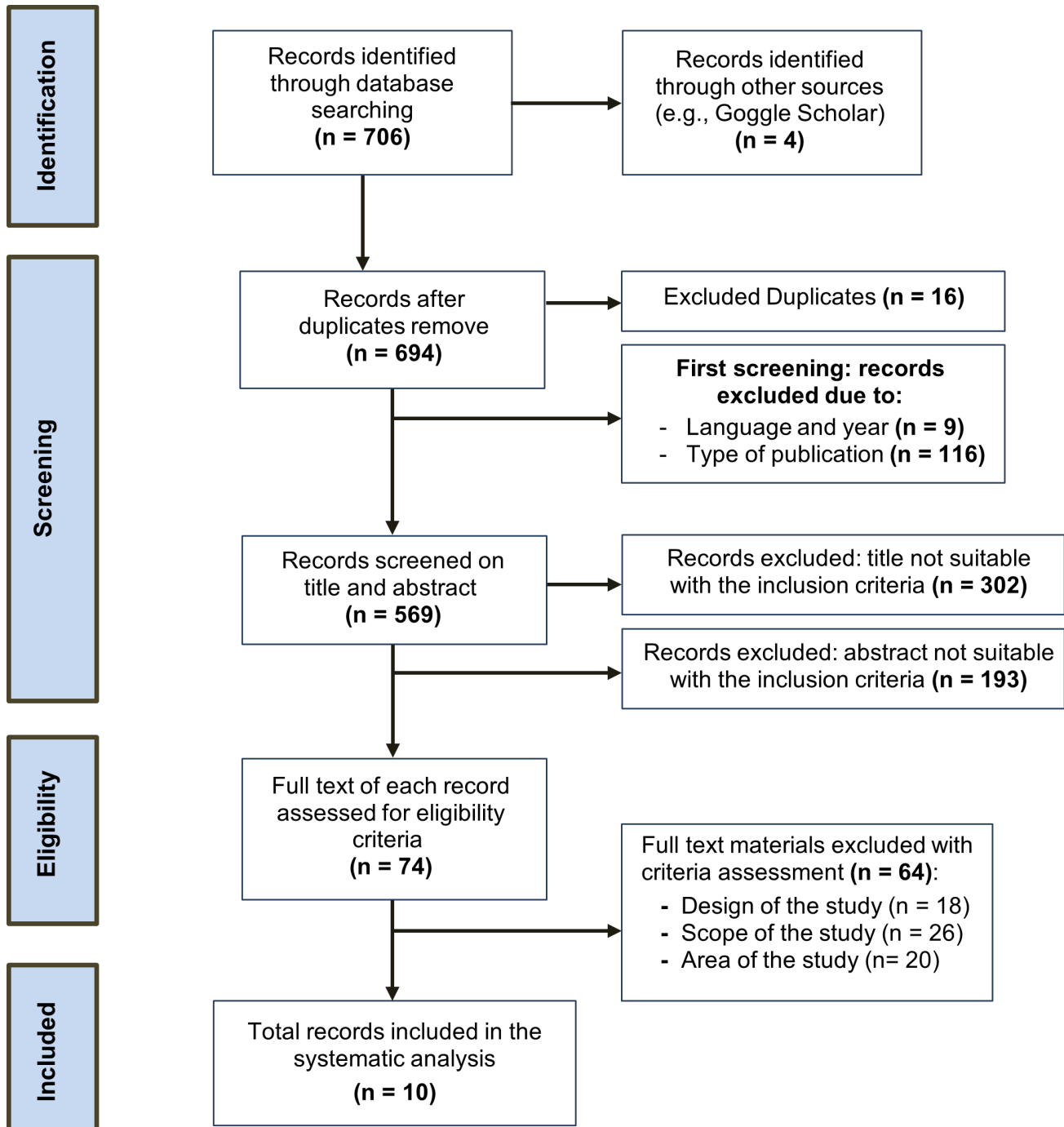


Figure 7: PRISMA Flow Diagram for the Selected Study. (Adapted From Page Et Al., 2021; Salih Et Al., 2024).

Data Sources and Search Strategy

The electronic search was conducted in August and September 2024 for studies published in the English language within the last 20 years (between 2004 and 2024). Relevant studies were retrieved from two major academic databases, including Scopus and ScienceDirect. A manual search was also conducted on additional established papers using Google Scholar. Three key variables, using the PEO framework (P = population, E = exposure, and O = outcome), were employed to generate keywords from the database (Salih et al., 2024). Therefore, the following keywords were used in various combinations: P: (Yemeni OR Yemen OR Islamic OR Sana'a OR Sanaa OR Aden OR Shibam OR Hadramout OR Taiz OR Marib) AND E: (modern OR vernacular OR historical OR traditional OR history) AND/OR (architecture architectural OR urban OR planning OR housing OR house OR tower) AND O: (Qamariyah OR Qamariyyah OR Qamariyah OR Qamariya OR Ghamaryeh OR moon-shaped windows OR stained-glass windows). Whenever necessary, search terms, MeSH terms, and operators were applied in the main search.

Inclusion and Exclusion Criteria

To ensure quality and relevance, specific inclusion and exclusion criteria were applied: (1) Language and year of publication: include only studies published in English within the last 20 years to maintain linguistic accessibility and contemporary relevance. (2) Type of publication: include only peer-reviewed journal articles to ensure academic quality; thus, exclude books, book chapters, reports, and non-indexed sources. (3) Design of the study: include only primary studies employing empirical methods (quantitative, qualitative, or mixed methods), to ensure the quality of included evidence; and exclude pure review, conceptual papers, or conference proceedings. (4) Scope of the study: include studies that directly address the review topic and provide findings directly or indirectly relevant to the main keyword: Qamariyah feature; and exclude studies outside the identified scope. (5) Area of the study: include studies focusing on Yemeni traditional architecture and especially those that indicate facade or window design in Yemen; and exclude studies that do not involve the targeted area. These criteria were systematically applied during the screening and eligibility steps using Mendeley Desktop v1.19.8 in conjunction with a PRISMA flow diagram.

Study Selection and Data Extraction

As mentioned, the current systematic review process followed the PRISMA framework, comprising four steps: identification, screening, eligibility assessment, and inclusion. Two independent reviewers performed a systematic search of chosen electronic databases pertinent to the study's scope during the identification phase. All retrieved papers were imported into Mendeley Desktop for organization and management, and all duplicate papers were excluded to ensure accuracy. At the screening stage, the same two reviewers independently assessed the titles and abstracts of all retrieved records against predefined eligibility criteria, which pertained to publication type and language. Studies meeting these basic criteria were further screened based on their titles and abstracts for topic relevance to the review's scope. Articles identified by either or both reviewers were retained for the next step. In the eligibility step, full-text versions of the selected articles were assessed using more detailed inclusion criteria, such as the study design, area, and scope, as detailed in the previous section. A supplementary manual search of the reference lists from included studies was subsequently conducted using Google Scholar to identify any further eligible articles that the initial database searches may have missed. Finally, the full text of the selected studies from the previous steps was included in the inclusion step for the content and descriptive analysis of this review. A summary table was prepared to document key data from the

selected studies using Microsoft Excel 365 (Version 2405). Both authors provided formal consent to the procedures detailed in the review protocol, thereby ensuring methodological integrity and transparency.

The extracted data from the selected studies were analyzed using simple descriptive statistics and content analysis, which systematically codes and condenses textual data into key categories, utilizes frequency statistics, and provides qualitative content descriptions to describe the synthesized data in each theme based on the review questions, based on Salih et al. (2024) and Mayring (2014) approaches. In line with review questions and objectives, this process revealed three main themes. The first theme indicated the concept and definition of Qamariyah and its role in Yemeni architecture. The second theme highlights the approaches to adapting Qamariyah into Yemeni modern architecture. The final theme addresses key considerations of Qamariyah features in Yemeni architecture, such as environmental and sustainability benefits, aesthetic advantages, and economic challenges. Together, these themes provide a coherent framework for understanding both the opportunities and constraints of integrating Qamariyah in modern and traditional Yemeni architecture.

Results

The current systematic review yielded a total of (n=706) studies, identified through the search using the specified databases. Furthermore, a manual review through Google Scholar yielded (n=4) additional studies for inclusion. Following the removal of duplicate entries and the application of filters for peer-reviewed journal articles published in English within the last 20 years, a total of (n=569) papers were retained. Subsequently, (n=495) studies were excluded after title and abstract screening determined they did not meet eligibility requirements. In the eligibility step, the two reviewers independently evaluated (n=74) full-text articles for eligibility. Of these, (n=10) studies were included in the final content analysis, while (n=64) were excluded based on the predefined inclusion and exclusion criteria. Overall, seven studies (n=7) were published in Scopus, one study (n=1) in ScienceDirect, and two studies (n=2) in Google Scholar; see Table 3.

Table 3: Sources of Data for Literature Review

Journal	Source	Year(s)	No.
Journal of Palestine Ahliya University for research and studies	Palestine Ahliya University: Google Scholar	2024	1
International Journal of Sustainable Development and Planning	IIETA: Scopus	2024, 2022	2
International Journal of Innovation and Industrial Revolution	GAE: Google Scholar	2023	1
Journal of Islamic Architecture	National Journal Accreditation: Scopus	2022	1
Alexandria Engineering Journal	Elsevier: ScienceDirect	2020	1
International Journal of Engineering Research and Technology	International Research Publication House: Scopus	2020	1
International Journal of Civil and Environmental Engineering	IJENS: Scopus	2019	1
Archnet-IJAR: International Journal of Architectural Research	ARCHNET: Scopus	2018	1
Civil Engineering and Architecture	Horizon Research Publishing: Scopus	2015	1

As indicated in Table 3, the annual distribution of publications reveals a recent concentration of studies on the topic of the current review, with the highest frequency occurring in 2024, 2022, and 2020 (n=2 per year). This was followed by 2023, 2019, and 2018 (n=1 per year). The data suggest a gradual rise in scholarly attention to this topic starting from approximately 2022. The studies were distributed homogeneously across journals, with most journals publishing only a single study (n=1); a notable exception is the International Journal of Sustainable Development and Planning (a Scopus-indexed journal at the time), which published two (n=2 studies).

Regarding the design of the selected studies, eight (n=8) studies employed qualitative methods, including six (n=6) studies that used case study and document analysis, one (n=1) study that used case study analysis, and one (n=1) study that used case study and interviews. Meanwhile, the other two studies (n=2) employed mixed methods, including case studies, observation, questionnaire surveys, and space syntax modelling. All studies were conducted either fully or partially in Yemen; specifically, nine (n=9) studies were carried out entirely within Yemen, and one (n=1) study included contexts from both Yemen and Egypt. The majority of studies (n=7) focused explicitly on the Sana'a context, whereas the remaining three (n=3) encompassed various historical cities, including Sana'a. For further details, refer to Table 4, which provides a summary of the selected studies.

The following sections show the findings of the reviewed studies in three themes based on the review questions and objectives: (1) concept and definition of Qamariyah and its role in Yemeni architecture; (2) approaches to adapting Qamariyah into Yemeni modern architecture; (3) key considerations of Qamariyah features in Yemeni architecture. The content analysis provides a comparative synthesis across studies, highlighting convergences, differences, and implications for integrating Qamariyah in Yemeni architecture.

Table 4: Summary of the Selected Study.

No.	Source	Title	Journal	Objective	Methodology	Definition	Findings	Limitations	Future work
1	Soltanzadeh and Moghadam (2015)	Sana'a, Structure, Historical Form, Architecture and Culture	Civil Engineering and Architecture	To analyze the structure and form of the ancient city of Sana'a, with a specific focus on the influence of Islamic culture, and to investigate the principal role Islamic culture played in shaping the city's urban form.	Method: Qualitative method: case study and descriptive-analytical method, utilizing documentation and library research. Area: Urban spaces of Sana'a, Yemen. Sample: Case study of Old Sana'a, analyzing various documents, drawings, and photographs.	Qamariyah is a special design wooden window usually used in the traditional houses in Sana'a, consisting of skylights plastered with colored glass.	Qamariyah (or Ghamaryeh) added a unique architectural style to Sana'a city and its traditional houses, reflecting the religious values of the Islamic community. The study also found that the city's markets and mosques are essential features of its urban development. Thus, it contributes to the city's architectural aesthetic and urban and community cultural values. This study highlights the importance of maintaining, protecting, and preserving the city to safeguard its cultural heritage.	Limitation of study area: The study is limited to the city of Sana'a and does not provide a comprehensive comparison with other cities in Yemen. Limitation of results: The study also does not give a detailed analysis of the city's modern urban development and its impact on the city's traditional features.	This study suggested that future studies can examine the city's modern urban development and its impact on its traditional features. It also recommended that future research should focus on motivating citizens and informing them about the importance of protecting and repairing Sana'a.
2	Ali et al. (2018)	INVESTIGATING THE APPLICABILITY OF SUSTAINABLE URBAN FORM AND DESIGN TO TRADITIONAL CITIES, CASE STUDY: THE OLD CITY OF SANA'A	International Journal of Architectural Research Archnet-IJAR	To investigate the sustainability potential of urban form and design in the traditional architecture of the ancient town of Sana'a and their applicability on three basic principles ranked as the leading principles of sustainability form and urban design theorized in the New-Urbanism movement.	Method: Mixed methods: field observation, archival data, and simulation using GIS, ECOTECT, and Space Syntax modelling, as well as the analysis of documents. Area: urban spaces of Sana'a, Yemen. Sample: (n=5) cases from Haddah and Sawan in Sana'a.	The traditional urban and architectural form of Yemeni architecture better controls urban solar energy, wind flow patterns, shade and shadow patterns, and air temperature than the new layouts, contributing to overall sustainability.	This study contributes to the understanding of the sustainability and environmental impacts of traditional architecture in Sana'a. The results indicate that the traditional urban layout and architecture of buildings is more sustainable in terms of form and density, walkability, connectivity, and urban solar energy than the new layouts. Therefore, it demonstrates that traditional architectural forms are a more effective model in terms of sustainable principles than new layouts. The results showed differences in the arrangement of traditional settlements and urban subdivision layouts in modern settlements, which might affect the urban fabric of the city's development.	Limitation of study area: The study is limited to the city of Sana'a and does not provide a comprehensive comparison with other cities in Yemen. Limitation of results: The study does not provide a detailed analysis of the economic and social factors that influence urban development in Sana'a.	The study suggests that future research should focus on examining the built form typologies and detailed features. It highlighted that the principles and characteristics of traditional urban forms can be applied to enhance modern urban development. The study also highlights the importance of compactness and connectivity in achieving sustainable urban forms.

No.	Source	Title	Journal	Objective	Methodology	Definition	Findings	Limitations	Future work
3	Attia (2019)	Traditional Sustainable Architecture Techniques and Its Applications in Contemporary Architecture: Case Studies of the Islamic House in Fatimid Cairo and Sana'a, Cities in Egypt and Yemen	Zenodo (CERN European Organization for Nuclear Research)	To analyze traditional sustainable architecture techniques in the Arab region and to explore their applications in contemporary architecture.	Method: Qualitative method: analytical research and case studies. Area: Islamic houses in Cairo and Sana'a in Egypt and Yemen. Sample: Various case studies of Islamic houses and buildings from Cairo and Sana'a, analyzing documents and drawings.	Qamariyah (or Qamariya) is a mounting of semi-circular slots made of white gypsum and stained colored glass in geometric shapes. The main window openings are covered from the outside by Mashrabiya, which are composed of stone or wood to provide ventilation, block out sunlight, and provide privacy for the people inside the house.	The results include the identification of traditional sustainable architecture elements, such as courtyards, Mashrabiya, and Qamariyah, and their applications in contemporary architecture to achieve sustainable designs. This traditional architecture is shaped by the local climate and environment, as well as local traditions, social, and economic factors. Besides their sustainable and environmental effect, these traditional sustainable architecture elements contribute to the people's privacy inside the house. Therefore, the results suggest that it is effective to incorporate traditional sustainable architecture elements into contemporary architecture to achieve sustainable designs.	Limitations of methodology: This study is limited to specific case studies analyzed. Limitations of study area: limited to the Arab region.	The future work suggested by the study includes further research on the applications of traditional sustainable architecture elements in contemporary architecture and the development of new sustainable architecture techniques.
4	Abdallah et al. (2020)	Traditional Yemeni Architecture and Its Impact on Energy Efficiency	International Journal of Engineering Research and Technology	To analyze the techniques, methods, and architectural elements of traditional Yemeni buildings and their impact on energy efficiency, and to understand the environmental components of traditional Sana'ani buildings.	Method: Qualitative method: case study and document analysis. Area: Sana'a, Shibam Hadramout, and Tehama in Yemen. Sample: (n=3) cases (n=2 tower buildings and n=1 house).	Qamariyah (or Qamariyah) is the upper part of the traditional Yemeni building's window, used for lighting. The lower part is the windows, while the third part is a small opening beside (Qamariyah) used for ventilation. This type of window takes advantage of temperature differences, thus working to expel hot air by the effect of pressure differences.	The study found that traditional Yemeni architecture is sustainable and energy-efficient, with its design and materials adapted to the local climate and environment. The study also found that the use of local materials, such as mud bricks and stone, provides thermal insulation and reduces energy consumption. The study recommends that modern buildings should be designed and constructed using local materials and techniques to reduce energy consumption and promote sustainability.	Limitations of methodology: This study is limited to specific case study analyses. Limitations of study area: limited to three regions of Yemen. Limitation of results: The study does not provide a comprehensive analysis of the energy efficiency of traditional Yemeni buildings.	Future work could involve applying the principles of traditional Yemeni architecture to contemporary building codes and testing the effectiveness of these designs in different contexts and regions.
5	Attia (2020)	Traditional multi-story house (Tower House) in Sana'a City, Yemen. An example of sustainable architecture	Alexandria Engineering Journal	To provide an overview of traditional houses and conduct an analytical study of the traditional multi-story house in Sana'a City, focusing on its components, building materials, construction systems, and spatial organization.	Method: Qualitative method: case study and analytical approach. Area: traditional multi-story house in Sana'a City, Yemen. Sample: (n=1) case study (traditional multi-story house), examining the components, building materials, construction systems, and spatial organization.	Qamariyah (or Qamariya) is the top window part, which is placed in gypsum frames in colored stained glass (yellow, red, and blue), allowing sunlight to paint a beautiful shape on the other wall of the room, forming double contracts inside and outside. It contributes to providing natural lighting and cross ventilation (from the lower part of the window), as well as privacy for the house users.	The study finds that the traditional multi-story house in Sana'a City, designed with traditional features, such as Qamariyah, is an example of sustainable architecture, providing natural lighting and ventilation, and fulfilling socio-economic needs.	Limitations of methodology: This study is limited to specific case study analyses. Limitations of study area: limited to multi-story house in Sana'a City, Yemen.	Further research could also investigate the potential for incorporating traditional sustainable architectural elements into contemporary building designs.

No.	Source	Title	Journal	Objective	Methodology	Definition	Findings	Limitations	Future work
6	Alamri et al. (2022)	AN APPROACH FOR PRESERVING OTTOMAN CULTURAL HERITAGE UNDER THREAT IN YEMEN: A CASE STUDY "THE OLD CITY OF SANA'A"	Journal of Islamic Architecture	To evaluate the condition of Ottoman buildings in Sana'a, determine the level of intervention needed for preservation, and provide a methodology for assessing the cultural heritage of historical and cultural value.	Method: Qualitative method: case study and descriptive and analytical approach. Area: Sana'a City, Yemen. Sample: (n=28) case studies (various types of buildings).	The traditional heritage buildings in Yemen have the richest cultural heritage in the Middle East. Therefore, the traditional heritage architectural form of Yemeni architecture possesses a rich cultural heritage and significant historical value.	The study identified the damage to Ottoman cultural heritage buildings in Sana'a as a result of the conflict, and made suggestions for preserving and pursuing the threatened heritage. It concludes that cultural heritage in Yemen is in danger due to internal wars and external aggression, and that it is essential to raise awareness of the risks and establish measures to preserve cultural heritage.	Limitations of study area: limited to Sana'a city in Yemen. Limitation of results: The study does not provide detailed data on the traditional elements, such as Qamariyah; it focuses on a comprehensive condition analysis of traditional Ottoman Yemeni buildings.	The study suggests that future research should focus on preserving and pursuing the threatened Ottoman cultural heritage in Sana'a, and that international organizations, such as UNESCO, should be involved in the preservation efforts. Future studies could focus on the historical and cultural significance of the Ottoman buildings and their elements in Sana'a, and the development of more comprehensive methodologies for evaluating and preserving cultural heritage.
7	Attia (2022)	Learned Lessons from Traditional Architecture in Yemen -Towards Sustainable Architecture	International Journal of Sustainable Development and Planning	To explore the lessons from traditional architecture in Yemen, analyzing the city's urban form and traditional house design, and identifying the aspects of sustainability in traditional Yemeni architecture.	Method: Qualitative method: case study. Area: Sana'a City, Yemen. Sample: Various case studies (various types of buildings from Sana'a).	Qamariyah (or Qamariya) is the top window part, which is surrounded by white stucco and decorated with colored stained glass. It contributes to providing natural lighting and cross ventilation (from the lower part of the window), as well as privacy for the house users.	The results demonstrate that traditional Yemeni architecture and its traditional elements, particularly in the city of Sana'a, have the potential to contribute to sustainable development, highlighting the crucial role of the local context, climate, culture, and indigenous knowledge in designing sustainable architecture. It highlights the need to incorporate traditional elements into contemporary architecture to create sustainable and environmentally friendly buildings. It also concludes that local context and indigenous traditional knowledge have significantly influenced traditional Yemeni architecture.	Limitations of methodology: This study is limited to specific case study analyses. Limitations of study area: limited to Sana'a city in Yemen and may not be generalizable to other regions.	To apply the lessons from traditional Yemeni architecture to modern architectural design, and further explore the potential of traditional architecture to contribute to sustainable development.
8	Abd Hamid et al. (2023)	THE YEMENI ARCHITECTURE INFLUENCED THE CULTURE IN THE TOWER HOUSE IN BAB AL YEMEN, SANA'A	International Journal of Innovation and Industrial Revolution	To identify the building architecture characteristics in Yemeni tower houses design, with a focus on on-site measurements, building observation, building spatial measurements, and secondary data collection from various sources.	Method: Qualitative method: case study: on-site observation, building spatial measurements, and interviews with local authorities and Yemeni residents. Area: Sana'a City, Yemen. Sample: (n=1) case study of the Abuoluhum Tower House.	Qamariyah (or Qamariyyah) is the top window part, which has a curving decoration with colourful glass. Generally, the carvings at the top of windows are natural formations or wall panels in Arabic script.	The study found that the traditional tower house in Bab al Yemen has a unique design and layout, with its elements (e.g., Qamariyah) and design satisfying the lifestyle and culture aspects, including the application of traditional design, traditional building materials, and Islamic values. These unique architectural characteristics provide a sustainable and comfortable living environment, featuring natural ventilation, thermal comfort, and privacy.	Limitations of methodology: This study is limited to specific case study analyses. Limitations of study area: limited to a single tower house in Sana'a city, Yemen and may not be generalizable to other regions.	Future studies could explore the application of traditional Yemeni tower house design principles in modern building design, with a focus on sustainability and environmental comfort. They could continue to explore the culture and lifestyle of the Yemeni people in relation to architecture and design.

No.	Source	Title	Journal	Objective	Methodology	Definition	Findings	Limitations	Future work
9	Al-Afari et al. (2024)	Form and Content in Yemeni Architecture: Exploring Continuity Mechanisms of Heritage - A Case Study of Sana'a City	International Journal of Sustainable Development and Planning	To address the issue of the form and content of Yemeni architecture and the mechanisms of communication with heritage and examine the intellectual and cultural transformations accompanying rapid urban development, which were characterized by subjective tendencies that abandoned traditional architectural forms.	Method: Mixed methods: case study and quantitative and qualitative surveys, including site observation, photographs, and in-depth interviews. Area: Sana'a City, Yemen. Sample: observation and the site visit to Old Sana'a City (one case study), and several interviews with architects and academic researchers.	Qamariyah (or Qamariyah), a term derived from the word "moon," a symbol of divinity in ancient Yemeni religion, is a circular aperture crafted from polished, translucent marble. Positioned above windows, it is illuminated from within at night, projecting an appearance akin to a full moon. This architectural element evolved over time, adopting a semi-circular form made of gypsum and inlaid with colored glass, ultimately becoming a crucial feature in Sana'a's architectural identity. The incorporation of peacock colors and various decorative motifs into the Qamariyah creates a harmonious relationship among architectural components. This transforms building facades into dynamic, painting-like compositions that energize viewers, alleviate monotony, and engage with local environmental and social traditions. Thus, the aesthetic principles embedded in the city's architecture express a deep material and intellectual culture, forming a cohesive interplay between form and meaning within its urban heritage. This enduring and adaptable system demonstrates a sustained commitment to preserving Sana'a's cultural and architectural legacy.	The study shows that the old city of Sana'a stands out for its historical significance and distinctive urban and architectural formation, guided by aesthetic values, and that the modern architecture of Sana'a has deviated from its inherent character and local identity. The study finds that the architecture of Old Sana'a serves as a prime example of a harmonious equilibrium between material requirements and emotional/spiritual needs. The modern architecture in Sana'a, however, has prioritized material aspects over spiritual and human considerations.	Limitations of study area: limited to Sana'a city in Yemen and may not be generalizable to other regions.	Future work may include devising creative measures to preserve the historical privacy features of Old Sana'a's architecture and harmonize it with contemporary developments, as well as promoting a comprehensive understanding of heritage and its values. The study also recommends that architects employ communicative design mechanisms to foster harmony between heritage architecture and modern developments.

No.	Source	Title	Journal	Objective	Methodology	Definition	Findings	Limitations	Future work
10	Alnehmi (2024)	Investigating Permanence Principles of Sustainability in the Sabaeen-Himyaritic Yemeni Architecture	Vol	To identify a set of standards and innovations that achieve sustainability in ancient Yemeni architecture, and to understand the experiences and skills of the ancient Yemeni people in architecture.	Method: Qualitative method: case study: an analytical and inductive approach. Area: Yemen (including Sana'a and other mountain cities). Sample: Several case studies of tower buildings from traditional Yemeni architecture.	Traditional windows are typically small openings that usually block direct sunlight. Therefore, they control solar radiation and airflow.	The study found that the ancient Yemeni people utilized local materials, prioritizing resource efficiency, climate responsiveness, social and cultural compatibility, flexibility, and adaptability to future expansion, thereby achieving sustainability in their architecture. The buildings were designed to harness natural ventilation, utilize solar radiation, and provide shading, while minimizing environmental impact.	Limitations of methodology: This study is limited to specific case study analyses. Limitations of study area: limited to the pre-Islamic period, specifically the Himyarite-Sabaeen architecture. It focuses on the geographical location of Yemeni lands, extending from the city of Ma'rib to the city of Taiz.	The study recommends that both official and private experts utilize the solutions from ancient Yemeni architecture and apply them to modern architecture. The study concludes that traditional Yemeni architecture is worth preserving and that its principles can be used in modern buildings to create more sustainable and culturally relevant designs.

The Concept of Qamariyah

Overall, the traditional Yemeni features and elements, particularly the façade elements, were mentioned in all of the selected studies (n=10). The Qamariyah features were described and highlighted directly in most of the reviewed studies (n=7). They were mentioned in different terms, such as Qamariyah (Al-Afari et al., 2024), Qamariyyah (Abd Hamid et al., 2023), Qamariah (Abdallah et al., 2020), Qamariya (Attia, 2022; Attia, 2020; Attia, 2019), Ghamaryeh (Soltanzadeh and Moghadam, 2015). Meanwhile, other studies (n=3) highlighted the Qamariyah indirectly as traditional windows (Alnehmi, 2024), traditional heritage architectural buildings and forms (Alamri et al., 2022), and traditional urban and architectural forms (Ali et al., 2018), see Table 4 and Table 5.

Table 5: Integration of Qamariyah Feature and its Considerations and Challenges.

No.	Source	Context	Qamariyah Identification	Integration of Qamariyah in Modern Architecture	Consideration
1	Soltanzadeh and Moghadam (2015)	Urban spaces of Sana'a, Yemen.	Directly mentioned as Ghamaryeh	NA	Key factors: Cultural element. Local materials and resistant to climate changes. Symbolic and identity.
2	Ali et al. (2018)		Indirectly mentioned as a traditional urban and architectural form of Yemeni architecture.	Yes, through the application of design principles and characteristics of traditional urban forms to enhance modern urban development.	Key factors: Privacy. Social cultural demands. Cultural values. Environment and energy efficacy. Sustainability. Local materials and environment.
3	Attia (2019)	Urban spaces of Sana'a, Yemen.	Directly mentioned as Qamariya.	Yes: recommended to apply sustainable design through traditional architecture and low technology.	Key factors: Privacy. Environmental element. Sustainability. Local materials and resistant to climate change. Local economic material. Challenges: Challenges in construction techniques and skills

No.	Source	Context	Qamariyah Identification	Integration of Qamariyah in Modern Architecture	Consideration
4	Abdallah et al. (2020)		Directly mentioned as Qamariah.	Yes: recommended to apply the principles of traditional Yemeni architecture to contemporary building codes.	Key factors: Environmental element. Sustainability. Local materials and environment
5	Attia (2020)	Traditional house in Sana'a City, Yemen.	Directly mentioned as Qamariya.	Yes: recommended to apply traditional sustainable architectural elements to contemporary building designs.	Key factors: Privacy. Environmental element. Sustainability. Local materials and environment (recyclable). Local economic design and materials
6	Alamri et al. (2022)	Traditional heritage buildings in Sana'a City, Yemen.	Indirectly mentioned as traditional heritage buildings.	NA	Key factor: Cultural Heritage.
7	Attia (2022)	Traditional Yemeni architecture, Sana'a City, Yemen.	Directly mentioned as Qamariya.	Yes, through the application of traditional architectural elements and principles to sustainable design and modern techniques.	Key factors: Privacy. Culture and tradition. Environmental element. Sustainability. Local materials and environment. Local economic design and materials.
8	Abd Hamid et al. (2023)	Traditional tower house, Sana'a City, Yemen.	Directly mentioned as Qamariyyah.	Yes: through sustainability and environmental comfort the traditional Yemeni tower house design principles can be applied into modern building design.	Key factors: Privacy. Social cultural demands. Environmental element. Sustainability. Local materials and environment (recyclable). Symbolic and identity.
9	Al-Afari et al. (2024)	Old City of Sana'a, Yemen	Directly mentioned as Qamariyah.	Yes: through design aesthetics and identity the traditional local design principles can be applied into modern Yemeni architecture.	Key factors: Privacy. Cultural and social identity. Environmental element. Sustainability. Local materials and environment (recyclable). Local economic design and materials. Symbolic and identity. Challenges: Challenges in construction techniques and skills.
10	Alnehmi (2024)	Traditional tower buildings in Yemen (including Sana'a and other mountain cities).	Indirectly mentioned as a traditional Yemeni window.	Yes: recommended to integrate into modern architecture	Key factors: Cultural sense. Environmental element. Sustainability. Local economic design and materials. Symbolic and identity. Challenges: Challenges in construction techniques and skills.

Qamariyah, a term derived from the word “moon” or “windows of the moon,” is a special design of semi-circular window traditionally made of translucent marble and stained colored glass (yellow, red, and blue) later it evaluated to white gypsum frames and stained colored glass in geometric shapes, allowing sunlight to paint a beautiful shape on the other wall of the room, forming double contracts inside and outside (Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022, 2020, 2019). It is usually used in the traditional houses in Sana'a as the upper part of

the window. It also contributes to filtering sunlight and provides natural lighting, while offering privacy to the people inside the house (Soltanzadeh & Moghadam, 2015; Abdallah et al., 2020). It also contributes to the building facades that energize viewers, alleviate monotony, and engage with local environmental, cultural, and sustainability traditions. Most importantly, it contributes to the historical and cultural identity and heritage of the city of Sana'a (Alnehmi, 2024; Alamri et al., 2022; Ali et al., 2018).

Integration of Qamariyah in Yemeni Modern Architecture

Most of the selected studies (n=8) mentioned the integration of traditional local design elements and principles into modern Yemeni architecture (Alnehmi, 2024; Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022, 2020, 2019; Abdallah et al., 2020; Ali et al., 2018). However, half of these studies (n=4) focused only on recommendations for future study to apply the principles and characteristics of traditional Yemeni architecture and forms to enhance modern urban and architectural developments (Alnehmi, 2024; Attia, 2020, 2019; Abdallah et al., 2020), without a clear conceptual framework on how to integrate these traditional features in the modern architecture. The other four studies (n=4) mentioned that the traditional Yemeni architecture can be incorporated into the modern developments through the traditional local design aesthetics, identity, and principles, including the privacy and cultural identity (Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022; Ali et al., 2018), see Table 5. Nevertheless, they didn't discuss the practical application of this integration and its economic implications.

Consideration and Challenges of Qamariyah Integration

Cultural and Privacy Considerations

Overall, most of the included studies (n=9) have highlighted the privacy and cultural considerations of Qamariyah features in traditional Yemeni architecture, as shown in Table 5. Over half of the selected studies (n=6) have mentioned privacy considerations as one of the Qamariyah aspects (Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022, 2020, 2019; Ali et al., 2018). Besides, seven (n=7) of the selected studies have mentioned the cultural aspects of the Qamariyah feature (Alnehmi, 2024; Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022; Alamri et al., 2022; Ali et al., 2018; Soltanzadeh and Moghadam, 2015). The cultural aspect was highlighted in different terms, such as cultural sense (Alnehmi, 2024); cultural identity (Al-Afari et al., 2024), social cultural demands (Abd Hamid et al., 2023; Ali et al., 2018), cultural heritage (Alamri et al., 2022), culture and tradition (Attia, 2022), and cultural element (Soltanzadeh & Moghadam, 2015), see Table 5.

These studies confirm that Qamariyah remains deeply embedded in Yemen's cultural identity, functioning not only as an aesthetic element but also as a guardian of privacy and a social cultural feature (Abd Hamid et al., 2023; Ali et al., 2018). In terms of privacy, the intricate stained-glass patterns of Qamariyah allow daylight penetration while obstructing direct views into domestic spaces, aligning with cultural norms of modesty and privacy (Alamri et al., 2022). Moreover, the symbolic value of Qamariyah persists in their representation of harmony, divine unity, and spiritual transcendence (Al-Afari et al., 2024).

Along with cultural considerations, the symbolic and identity roles of traditional Yemeni architecture, including Qamariyah and its integration into modern architecture, were discussed in four (n=4) of the reviewed studies (Alnehmi, 2024; Al-Afari et al., 2024; Abd Hamid et al., 2023; Soltanzadeh & Moghadam, 2015).

Environmental and Sustainability Considerations

Most of the included studies ($n = 8$) have highlighted the environmental and sustainable considerations of Qamariyah features in traditional Yemeni architecture (Alnehmi, 2024; Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022, 2020, 2019; Abdallah et al., 2020; Ali et al., 2018), as shown in Table 5. These studies have mentioned the local feature of Qamariyah as a traditional environmental element that can contribute to sustainability in a modern sense (Abd Hamid et al., 2023; Attia, 2020, 2019). Attia (2020) and Abd Hamid et al. (2023) confirmed that the traditional Qamariyah is also a sustainable architectural element that can be incorporated to achieve sustainable modern architecture.

Besides, Qamariyah are consistently highlighted as contributors to passive environmental performance. Their ability to diffuse natural light reduces reliance on artificial lighting, while their placement in upper façades promotes ventilation and enhances indoor comfort (Abdelwahab et al., 2023). Furthermore, Abdallah et al. (2020) found that traditional Yemeni architecture is sustainable and energy-efficient, with its design and materials adapted to the local climate and environment. They also found that the use of local materials provides thermal insulation and reduces energy consumption. Therefore, Qamariyah is considered a critical traditional environmental element that can contribute significantly to the principle of sustainability in modern Yemeni architecture.

Eight ($n=8$) of the selected studies have discussed the use of local materials and their positive environmental and climate impact (Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022, 2020, 2019; Abdallah et al., 2020; Ali et al., 2018; Soltanzadeh & Moghadam, 2015). Six of these studies ($n=6$) highlighted the positive impact of the use of local materials in these traditional Yemeni architectures on the environment (Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022, 2020; Abdallah et al., 2020; Ali et al., 2018), due to natural resources, recyclability, and harnessing renewable energy sources (Al-Afari et al., 2024).

Economic Considerations

The use of these natural sources and recyclable materials in the traditional Yemeni architecture, such as Qamariyah, contributes to reducing economic costs while enhancing human comfort (Al-Afari et al., 2024). Overall, five ($n=5$) studies mentioned the economic aspects of the traditional Yemeni architecture and designs, mainly due to the use of local material in construction, such as mud-break, stone, marble, and wood (Alnehmi, 2024; Al-Afari et al., 2024; Attia, 2022, 2020, 2019), as shown in Table 5. However, the evolution of international modern architecture led to the introduction of cheaper commercial construction materials and modern construction techniques, such as mass-produced aluminum (Attia, 2019); this affected the transformation of traditional architecture in Yemen into a more contemporary international form, leading to the replacement of conventional forms, such as Qamariyah, with easy construction aluminum and glass windows. Three of the reviewed studies ($n = 3$) have discussed the challenges of construction techniques and skills (Al-Afari et al., 2024; Alnehmi, 2024; Attia, 2019). Therefore, the economic difficulties lie in reconciling traditional architecture with scalable, cost-effective production methods suitable for modern housing. Besides, despite the significant financial and environmental advantages of traditional local materials and forms in Yemeni architecture, Qamariyah faces the transformation barriers in contemporary architecture due to challenges in blending modern building techniques, skills, and costs (Al-Afari et al., 2024; Alnehmi, 2024; Attia, 2019).

Discussion

Recently, there has been a significant surge in international interest in the traditional local architecture, such as that in Sana'a, Yemen. Traditional Yemeni architecture is a celebrated exemplar of vernacular design, renowned for its ingenious adaptation to the local environment and scarce resources (UNESCO, 2021). Characterized by ornate mud-brick towering, stained-glass Qamariyah windows, and intricate geometric patterns, this architectural tradition is a profound physical manifestation of Yemeni cultural identity and craftsmanship. However, their position as a World Heritage site is threatened by both conflict and rapid modernization and urbanization (UNESCO, 2021). This transition has accelerated the decline of distinctive features, such as the Qamariyah, creating concerns about local cultural continuity and architectural sustainability. While existing studies, as noted, rightly acknowledge the cultural and environmental significance of these traditional elements, a critical gap remains in the role and methods of integration of these features (Al-Harbi et al., 2023). Therefore, this review investigated the role of Qamariyah in Yemeni architecture, as well as the key factors and challenges in integrating Qamariyah into modern Yemeni architecture. In line with this objective, the current systematic review aimed to answer two research questions: what is the Qamariyah, and what is its role in Yemeni architecture? And how does the body of knowledge indicate the integration of Qamariyah into Yemeni modern architecture?

To answer the research questions, a systematic literature review was conducted on the full-text of 10 peer-reviewed journal articles published between 2004 and 2024. Most of these studies were published in Scopus peer-reviewed journals within the last five years, indicating the increased interest in academic research on this critical topic. In line with the first research question, Qamariyah was directly described in seven of the selected ten studies as a distinct local feature of traditional Yemeni architecture, specifically in Sana'a, characterized by a semi-circular window, whose name derives from the word "moon," with a design that emphasizes both aesthetic appeal and functional benefits; historically crafted from translucent marble and later from white gypsum frames with stained colored glass. The gypsum frame is crafted to hold intricately cut-glass pieces, often in geometric or floral patterns, which are key to the unique visual charm of Qamariyah. The colored glass, typically in shades of red, blue, and yellow, allows natural light to filter through, creating a vibrant, ambient lighting effect inside the home. This composition not only serves decorative purposes but also plays a crucial role in the functionality of Sana'a dwellings, particularly in terms of privacy and environmental adaptation (Attia, 2022, 2020).

Overall, the ten studies have discussed seven key characteristics of Qamariyah in Yemeni architecture, including privacy, cultural and social identity, symbolic and identity, environmental considerations, the use of local materials, economic local design, and their contribution to sustainability. These findings contribute to the findings of previous studies, confirming that Qamariyah remains deeply embedded in Yemen's cultural identity, functioning not only as aesthetic elements but also as symbols of privacy and social cultural identity (Akalin et al., 2019). Privacy is a key cultural concern in Yemen, where the domestic sphere is highly valued, and traditional windows, such as Qamariyah, play a crucial role in safeguarding this aspect of life (Abdelwahab et al., 2023).

Their intricate stained-glass patterns allow daylight penetration while obstructing direct views into domestic spaces, aligning with cultural norms of privacy (Abdelkader, 2020; Alamri et al., 2022). As Attia (2022) notes, traditional Yemeni architecture, including the use of Qamariyah, reduces dependence on artificial lighting by maximizing the penetration of daylight. The diffused light also enhances the aesthetic quality of the interior spaces, adding a layer of warmth and visual depth. Al-Harbi et al. (2023) demonstrate that stained-glass windows can mitigate

glare and solar heat gain, thereby contributing to energy savings in hot climates. Nevertheless, the extent of these benefits varies depending on design and material quality. Attia (2022) demonstrates that traditional gypsum-framed Qamariyah are highly effective in regulating daylight, but less efficient in terms of thermal insulation compared to modern double-glazed alternatives. Their translucent design diffuses daylight effectively while reducing glare and helping to regulate indoor temperature, a form of pre-modern sustainable design (Abdallah et al., 2020). Moreover, the symbolic value of Qamariyah persists in their representation of harmony, divine unity, and spiritual transcendence (Akalin et al., 2019).

In addressing the second research question, only four studies discuss the integration of Qamariyah features in modern architecture in Yemen. Nevertheless, their analysis remains theoretical; a significant gap exists regarding the practical application and economic implications of this design approach. These findings also highlight the scarcity of studies on integrating the traditional features of Qamariyah into modern architecture, particularly in Yemen. In terms of integration, Qamariyah is a unique local design feature in Sana'a architecture, as it combines cultural identity with environmental sustainability, thereby positioning Qamariyah as an invaluable element in modern architectural integration. The current systematic review suggests addressing the mentioned considerations, including privacy, cultural and social identity, symbolic identity, environmental concerns, the use of local materials, local economic design, and sustainability approaches, for Qamariyah integration in modern Yemeni architecture. The integration of these windows into modern architecture could significantly enhance both the environmental efficiency and cultural identity of contemporary Yemeni architecture (Al-Afari et al., 2024; Abd Hamid et al., 2023; Attia, 2022).

From an environmental perspective, Qamariyah demonstrates relevance to modern sustainability goals. Their ability to diffuse daylight and reduce reliance on artificial lighting resonates with passive design strategies widely recommended for energy-efficient housing, as mentioned by Ghosh and Norton (2018). Similarly, Hee et al. (2015) highlighted that the use of stained glass and patterned windows in Islamic and Mediterranean architecture shows measurable reductions in cooling and lighting demands when traditional shading or glazing techniques are applied. However, Attia (2022) stated that these traditional elements require adaptation through material innovations, such as integrating double glazing or thermochromic layers, to meet modern performance standards while preserving their aesthetic character (Waheeb, 2023). In contemporary applications, hybrid designs that incorporate modern materials while maintaining traditional aesthetics can further enhance their relevance. For instance, Al-Shawesh (2022) mentioned that incorporating insulated glass within traditional Qamariyah patterns can provide improved thermal performance, aligning with modern energy-saving standards. de Macedo et al. (2023) suggested integrating construction materials, such as polymer-based stained glass or hybrid composite frames, as a potential strategy to balance traditional aesthetics with contemporary energy standards. Alassaf (2024) mentioned that contemporary glazed window technologies, such as low-emissivity or multi-layer systems, provide superior insulation while still allowing for daylighting, which can be integrated into the Qamariyah feature. This innovative approach ensures that Qamariyah continues to serve as both a cultural symbol and a functional feature, bridging Yemen's architectural legacy with modern demands.

Based on the mentioned literature, Qamariyah remains highly valued for its cultural symbolism and environmental benefits; however, its integration into modern housing is constrained by economic and material limitations. Despite its critical economic role due to the use of local materials and positive environmental and climate effects, some studies highlight its declining presence under modernization pressures (Al-Afari et al., 2024; Attia, 2019), while others emphasize the potential

of hybrid solutions that adapt traditional designs to contemporary technologies. This divergence suggests that cultural preservation efforts may depend increasingly on awareness campaigns and educational initiatives that highlight the architectural and spiritual significance of Qamariyah. The artisanal production process requires specialized craftsmanship, resulting in higher costs compared to mass-produced aluminum or glass windows (Alamri et al., 2022). Moreover, issues of durability and maintenance are frequently highlighted, particularly as traditional materials such as gypsum are prone to weathering in urban environments (Al-Shawesh, 2022; Attia, 2022). Some studies also argue that economic pressures have accelerated the replacement of Qamariyah with cheaper alternatives, especially in middle-income housing (Hinkle et al., 2022). However, other studies suggest that integrating innovative materials such as tempered glass or insulated glazing may reduce costs while retaining aesthetic and cultural integrity (Fanack, 2020). These findings indicate that the future of Qamariyah in Sana'a depends on striking a balance between cultural preservation and innovation, thereby ensuring that its heritage is not lost amid urban transformation.

In conclusion, this systematic review elucidates the multifaceted role of the Qamariyah and its integration in Yemeni architecture, moving beyond its recognition as a mere aesthetic element to position it as a critical nexus of culture, environment, and technology (see Figure 8). Qamariyah continues to serve as a potent symbol of Yemeni cultural identity and religious tradition. Their stained-glass designs and elevated placement in facades support privacy while permitting natural light, an architectural response that aligns with social and cultural norms in Yemen and sustainability principles. Qamariyah have historically communicated social status and identity through their craftsmanship and aesthetic sophistication. These traditional designs reflect cultural identity and environmental adaptability, whereas modern construction trends often prioritize cost efficiency and standardized techniques, creating tensions between heritage preservation and contemporary demands. One significant implication relates to the cultural and social dimension of architecture. Qamariyah embodies privacy, modesty, and symbolic meaning, making them an integral part of Yemeni architecture. Nevertheless, challenges in construction techniques and skills, as well as limited compatibility with contemporary construction methods, remain significant barriers. Yet, it can be integrated into modern Yemeni architecture by applying proper design considerations, such as privacy, cultural and social identity, symbolic significance, environmental concerns, the use of local materials, local economic design, and sustainable approaches. Exploring material innovations and hybrid fabrication techniques could also make Qamariyah more feasible in contemporary practice. This innovative approach ensures that Qamariyah continues to serve as both a cultural symbol and a functional feature, bridging Yemen's architectural legacy with modern demands.

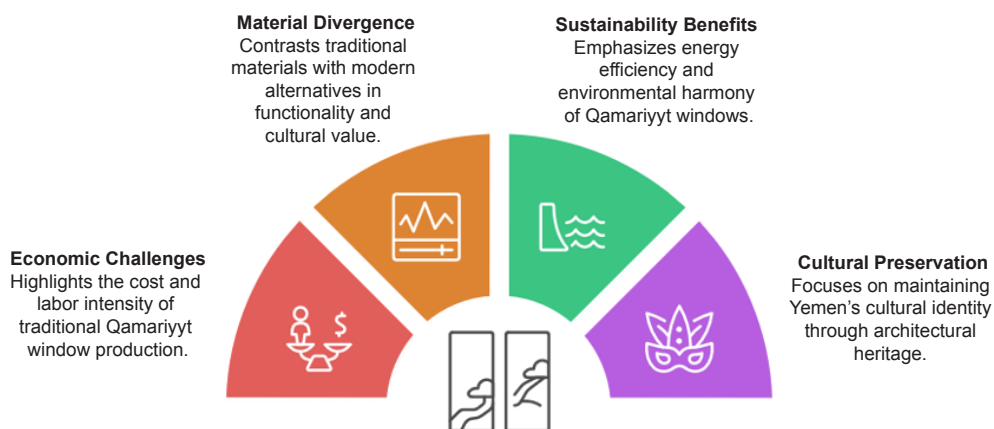


Figure 8: Integration of Qamariyah in Modern Architecture. (Source: Author, 2024).

While this review provides a comprehensive synthesis of recent literature, its limitation lies in its reliance on secondary sources from the two main databases Scopus and SinceDirect. Future studies should complement this approach with empirical fieldwork in Sana'a, including qualitative interviews with architects, builders, and homeowners, as well as quantitative simulations of energy performance in houses with Qamariyah. Combining literature review with empirical methods would strengthen the validity of findings and provide deeper insights into practical applications (Xiao & Watson, 2019). Furthermore, the review's scope was limited to English-language, peer-reviewed journal articles published since 2004. Consequently, relevant studies in other languages, older publications, and grey literature such as industry reports were excluded, potentially introducing a publication bias. Future research should also empirically investigate the feasibility, construction methods, and cost-benefit analysis of integrating these traditional elements to provide a practical framework for architects and developers.

Theoretical and Practical Implications of the Study

The findings of this systematic review carry significant implications for both theoretical discourse and practical application in the fields of architectural heritage, sustainable design, and cultural preservation. From a theoretical perspective, the study's primary theoretical contribution lies in its systematic codification of the Qamariyah's value. It transitions from an anecdotal appreciation to an evidence-based framework, consolidating seven key characteristics: privacy, cultural and social identity, symbolic identity, environmental performance, use of local materials, economic local design, and sustainability, that define its role. This framework provides a structured lens through which scholars can analyze other vernacular architectural elements, both within Yemeni architecture and in global contexts. Furthermore, the review identifies and helps resolve a critical theoretical tension within preservation studies, the perceived dichotomy between tradition and modernity. The analysis demonstrates that the Qamariyah is not a relic to be merely preserved but a dynamic design principle that can be adapted. It challenges the notion that cultural authenticity is contingent solely on the use of historical materials, proposing instead a theory of adaptive cultural sustainability. This theory posits that the essence of a traditional feature (e.g., diffused light for privacy and ambiance, geometric patterning for identity) can be maintained and even enhanced through modern material innovations, thus ensuring its continued relevance.

From a practical perspective, the findings of this review offer actionable guidance for architects, policymakers, and craftsmen, primarily by advocating for a hybrid design approach that innovatively adapts the Qamariyah for contemporary use. Practically, this involves integrating modern materials, such as insulated glazing, low-emissivity coatings, or durable composite frames, within traditional patterns to significantly enhance thermal performance and durability while preserving aesthetic and cultural integrity, thereby making them more viable for modern construction. To support this, policymakers are urged to develop incentives for homeowners and initiatives to sustain artisanal craftsmanship, ensuring these adapted features can counter the economic pressures favoring cheaper, standardized alternatives. Ultimately, these strategies provide a clear blueprint for embedding the Qamariyah's environmental benefits, like passive daylighting and solar heat gain mitigation, and profound cultural significance into modern Yemeni architecture, transforming it from a threatened heritage element into an active and sustainable component of the built environment.

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