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Adopting Vernacular Building Design Strategies for Contemporary Green Building

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Abstract. The demand for more energy-efficient buildings has increased, driven by the need to reduce energy consumption and mitigate climate change. Recently, the use of vernacular building strategies has gained increasing attention because such strategies are often based on local knowledge and practices developed over time to respond to specific environmental conditions and cultural contexts. In Jordan, there is a rising interest in integrating vernacular design strategies into contemporary buildings, aiming to enhance indoor environmental quality and minimize energy consumption. This study employs a case study approach to investigate the adoption of vernacular design techniques in contemporary green buildings in Jordan, while also exploring the underlying factors influencing their selection and implementation. The findings reveal that contemporary green buildings employ diverse vernacular design strategies including the use of stone as a building material, incorporation of thermal mass, implementation of shading features, and careful positioning of windows to optimize natural lighting, ventilation, and energy efficiency. These design strategies have the potential to contribute to sustainable development goals, preserve cultural heritage, and serve as a guiding model for future modern building designs in Jordan.

Keywords: Vernacular design, energy efficiency, contemporary buildings, Jordan

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INTRODUCTION

Energy-efficient buildings are becoming increasingly important as the world faces challenges related to climate change and sustainable development (1,2). In regions such as Jordan, where the climate is very hot during the summer and cold in the winter (3), buildings are a significant source of energy consumption (4,5). According to a report by the Ministry of Energy and Mineral Resources in Jordan, the energy consumption for cooling in the residential sector was approximately 2,600 GWh in 2019, whereas the energy consumption for heating was approximately 1,300 GWh (6). Hence, the use of energy-saving techniques in buildings is particularly important to reduce the demand for cooling and heating (7) and improve the thermal performance of buildings (8). One approach to achieving energy efficiency in buildings is to use vernacular building strategies (9), which are traditional building techniques that have been adapted to local conditions over time (10). Climatic conditions in Jordan greatly influence building practices. Vernacular building strategies have been used in Jordan for centuries owing to their significant benefits in terms of

energy efficiency and increased occupant comfort (11). One of the most notable features of traditional Jordanian architecture is the use of courtyards that provide natural ventilation, cooling, and privacy. The courtyard is typically surrounded by open rooms, with shaded arcades providing additional protection from the sun (12). The thick walls of these rooms are made from local materials such as stone and mud, which provide excellent insulation and help keep the interior cool. Recently, there has been growing interest in incorporating vernacular design strategies into contemporary green buildings. For example, incorporating courtyards in building design, both for their functional benefits and cultural significance. In addition, the use of local materials such as stone and mud is notable because they are readily available and sustainable. However, the implementation of vernacular building strategies in contemporary buildings in Jordan is hindered by four significant challenges. First, there is a lack of awareness among architects, engineers, and builders about the benefits of incorporating vernacular design strategies. Consequently, these strategies may not be considered during the design or construction of buildings (13). The second challenge is the limited research on the actual performance of vernacular design strategies in contemporary buildings. Third, there is a lack of standardization in the use of these strategies, making it difficult to apply them consistently across different building types. Finally, resistance to change may also impede the adoption of vernacular design strategies in modern buildings owing to a preference for modern architectural styles and a desire to use the latest technology (14). These challenges and knowledge gaps must be addressed to promote the wider implementation of vernacular design strategies in modern buildings and achieve greater energy efficiency and sustainability. Hence, this study aims to investigate vernacular design strategies implemented in green-certified Jordanian buildings, that may enhance indoor environmental quality and energy efficiency. We focused our study on certified green buildings as examples of contemporary buildings because this can provide valuable insights into how we can create more sustainable and contextually responsive buildings that are better suited to the local environment and culture.

RESEARCH METHODS

The qualitative research methodology approach was applied to achieve the research aim outlined in Section 1, as it allows for an in-depth understanding of vernacular design strategies that could be applied to green-certified buildings in Jordan (15, 16). The study encompassed two distinct research methods: (i) the architectural case study approach was employed to comprehensively understand the study's context and collect data on both vernacular and contemporary design strategies (17, 18). (ii) Qualitative observations, including photographic documentation and architectural surveys, were used to collect data about the analysed case studies. For analysis, three buildings located in Amman, Jordan, were selected. Three site visits were conducted to collect the required information and observations regarding the selected case-study buildings. The site visits provided detailed insights into the physical attributes, architectural features, and contextual factors of the buildings under investigation. During site visits, the research team visited each of the selected buildings and closely examined the buildings' exterior, interior, and surrounding environments. Detailed documentation was carried out, including photographic surveys, to capture the building's overall design, materials, construction techniques, and specific architectural elements related to energy-efficient strategies. Additionally, precise measurements were taken to document the wall thickness dimensions, window sizes and placements, shading devices, and other relevant architectural details.

Building Selection

As mentioned in section 2, three buildings were selected for analysis as case studies (Figure 1). The key design attributes of the selected buildings are listed in Table 1. The first case study represents most of the vernacular buildings in Jordan that include various energy-efficient strategies, we refer to this building in this research as “VB”. This building was selected for its typical instance, and it enhances our understanding of the characteristics of vernacular buildings in Jordan. The second case study has been selected because of its uniqueness. This was the first LEED-certified residential building in Jordan. In addition, the building won several national and international prizes. It symbolises archetypal contemporary residential buildings in terms of design and construction methods. This building includes several applications of energy-efficient techniques; therefore, it assists in exploring modern energy-saving features. The third case study is also a LEED-certified building and was selected because of its intrinsic interest. This provides an opportunity for an in-depth understanding of the technical process of the application of environmental modifiers. It also includes modern strategies for energy saving that have been applied for the first time in Jordan, we refer to green-certified buildings in this study as “GB”.

RESULTS AND DISCUSSION

This section presents the results of our analysed data and illustrates the vernacular design strategies adopted in GBs.

Vernacular Design Strategies

Our results show that the analysed VB includes several design strategies that are used to enhance the energy efficiency of the building. For example, the courtyard was used to reduce the energy required for cooling in summer and heating in winter by providing natural ventilation and shading (Figure 2. a). During the cooling season, the courtyard acts as a cool-air reservoir, specifically when it includes a water feature, reducing the need for air conditioning (Figure 2. b). During the heating season, the courtyard provides shelter from the wind, reducing the heat loss from the building (19). In addition, courtyards can provide natural light to interior spaces, reducing the need for artificial lighting (20). Overall, courtyards play an important role in improving the energy efficiency of buildings. Moreover, the domed and barrel-vaulted roofs were used in the VB to reduce the amount of energy needed for heating and cooling (Figure 2. c). The roof involved a series of arches organized in a parallel to generate a half-cylinder form. Such roofs can improve the natural ventilation and air circulation inside the building, reducing the need for mechanical ventilation or air conditioning (21). It also assists in the uniform distribution of natural light, thereby reducing the need for artificial lighting. These types of roofs are usually constructed with insulating materials (i.e., hays, mud, and animal fibers) to enhance their thermal performance (22). Furthermore, the size and position of the windows in the VB are usually used to control the circulation of air through the building and sun accessibility (23). For example, tall and narrow windows have been used to reduce the negative impacts of outdoor climatic conditions. Typically, such windows are located on the wall facing the courtyard to allow cross-ventilation. In contrast, smaller windows are distributed on the East, West and North facades to avoid summer sun heat and protect building occupants from cold winter winds.

Table 1. Comparison of the main building attributes of vernacular (VB) and contemporary buildings (CB) analysed in this study.

Aspect	Building type	
	VB (n=1)	GB (n=2)
Total area (m2)	410	350
Floor (n)	One	Two
Building orientation	South	South
Cooling	The wind flow, courtyard with water features and shading elements help to cool the interior spaces.	The geothermal cooling system
Heating	Solar energy is used for heating in winter by designing the southern courtyard and south large windows to collect solar radiation. The massive thickness of walls includes a time - lag of several hours in the transfer of heat from internal to external spaces and vice versa	Solar photovoltaic panels, windows' design
Ventilation	Small openings above the door level to allow natural ventilation	Natural and mechanical ventilation
Insulation material	Hay, mud, and animal fibres are used to insulate the building	Foam concrete is used for roofs and floors Polystyrene and rock wool are used for walls
Green-certified	No	Yes

FIGURE 1. The vernacular buildings selected in this study, (b) and (c) the green-certified buildings are analysed in this study.

FIGURE 2. (a) the courtyard in the vernacular building, (b) the water feature positioned in the middle of the courtyard in the vernacular building, and (c) the domed and barrel-vaulted roofs in the vernacular buildings.

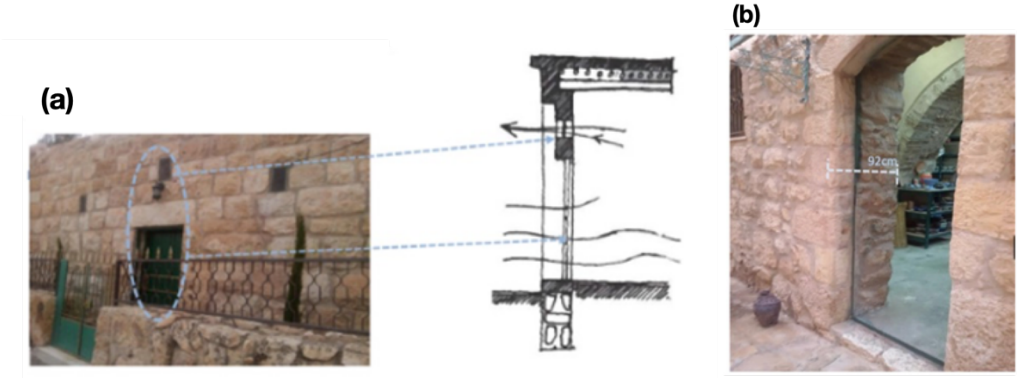

FIGURE 3. (a) The small vents above the door level to allow natural ventilation, (b) the massive thickness of external walls in the vernacular building.

Another design technique is to use high-level small rectangular openings (i.e., 30*30 cm) above the door level to allow natural ventilation and release warm air as shown in (Figure 3. a). The use of thermal mass is another effective strategy for improving the energy efficiency in the VB, particularly in climates with significant temperature fluctuations (24). Thermal mass is provided by using massive stone walls, with an approximate thickness of 92 cm (Figure 3. b). These walls capture and store solar heat during the day, which is then released at night to maintain a comfortable indoor temperature. However, it is important to note that the effectiveness of thermal mass depends on various variables, including the type and location of the material, building design, and local climate.

Implementing Vernacular Design Strategies in Green Buildings

Our analysis of the vernacular design strategies implemented in the analysed GBs showed that there are several adopted design strategies, both for their cultural significance and energy efficiency benefits. For example, the design of windows in GBs is influenced by vernacular architecture. Windows are strategically designed to exploit natural ventilation, daylight, and solar heat gain. This also involves incorporating modern shading techniques, such as overhangs or louvres, to reduce solar heat gain (Figure 4) or using double-paned or low-emissivity glass to improve insulation and reduce heat loss. In addition, in GBs, stone is often used as a cladding material rather than a load-bearing structural element. Stone cladding can provide an attractive and durable finish for the building exterior while also providing thermal insulation and protection from the elements. The use of stone can help create a sense of tradition and cultural identity while also providing a modern and sophisticated aesthetic. In contrast, currently, the use of massive wall thickness in CB construction is less common in Jordan than it used to be, as builders and architects increasingly turn to alternative materials, such as concrete blocks, lightweight concrete, and insulated panels, that can provide similar thermal insulation and structural performance with less material usage and low cost. Overall, although the GBs analysed in this study apply modern design strategies and technologies to improve energy efficiency and indoor environmental quality, such as photovoltaic cells, energy-efficient lighting, and smart building management systems, they often incorporate vernacular techniques and materials to enhance building energy saving.

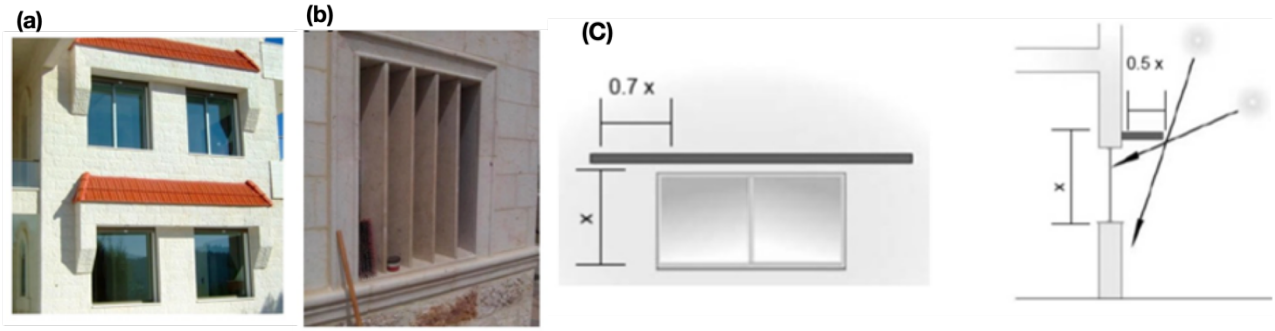

FIGURE 4. (a) The overhang shading elements, (b)vertical sun breakers, and (c) the recommended length and depth of shading features.

CONCLUSIONS

This study was designed to investigate vernacular design strategies implemented in green-certified buildings in Jordan. The findings have revealed that the adoption of vernacular techniques can be influenced by a variety of factors, including cultural, social, economic, and environmental considerations. Several vernacular design strategies have been adopted in the analysed green buildings, such as using stone as the building material, shading devices, and passive solar design principles. These strategies can assist in reducing the energy consumption and harmful impacts of buildings on the environment. However, the success of implementing vernacular design strategies in contemporary buildings in Jordan relies on various factors, including the availability of suitable materials, the design and orientation of the building, and the local climate. Therefore, further research is necessary to develop effective and practical solutions for implementing vernacular energy-efficiency strategies in modern buildings. Overall, the investigation highlights the importance of balancing modern building practices with traditional knowledge and techniques to create sustainable and energy-efficient buildings that are well-adapted to their local environment and culture.

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