

A Comparative Study of Traditional and Contemporary Houses in Ghadames from a Sustainability Perspective

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الملخص

دراسة مقارنة بين المنازل التقليدية والمعاصرة في مدينة غدامس من منظور الاستدامة

سالمة جمعة القبائلي

عواطف فرج بوجلدين

تهدف هذه الدراسة إلى إجراء مقارنة تحليلية بين المساكن التقليدية والمساكن الحديثة في مدينة غدامس بليبيا، من منظور الاستدامة المعمارية في البيئات الحارة الجافة. وتعتمد الدراسة على منهجية تحليلية مقارنة لتقييم الاستجابة المناخية، والتنظيم الفراغي، والأداء الحراري، وكفاءة الطاقة، ومواد البناء المستخدمة في كلا النمطين السكنيين. وظهرت نتائج التحليل أن المساكن التقليدية في غدامس ذات كفاءة بيئية عالية بفضل اعتمادها على استراتيجيات التصميم السلبي، مثل الأفنية الداخلية، والجدران ذات الكتلة الحرارية المرتفعة، والنسيج العمراني المتضام، واستخدام المواد المحلية منخفضة الطاقة الكامنة، مما يساهم في تعزيز الراحة الحرارية وتقليل الاعتماد على أنظمة التكييف الميكانيكية. في المقابل، تعاني المساكن الحديثة من ضعف في التكييف مع الخصائص المناخية المحلية وارتفاع في استهلاك الطاقة نتيجة الاعتماد على المواد الصناعية وأنظمة التبريد الميكانيكية. وقد

خلصت الدراسة إلى أن المساكن التقليدية في غدامس تمثل أنموذجًا مستدامًا يمكن الاستفادة من مبادئه التصميمية في تطوير المساكن المعاصرة، بما يسهم في تحسين الأداء البيئي وتعزيز الاستدامة العمرانية في المناطق الصحراوية.

الكلمات المفتاحية: الاستدامة المعمارية، المساكن التقليدية، المساكن الحديثة، العمارة المناخية، البيئات الحارة الجافة، غدامس.

Abstract

This study examines and compares traditional and contemporary residential architecture in Ghadames, Libya, from the perspective of architectural sustainability. A comparative analytical methodology is employed, focusing on architectural layouts, building sections, urban fabric, climatic responsiveness, thermal performance, energy consumption, and construction materials. The findings reveal that traditional houses in Ghadames achieve high levels of environmental sustainability through the use of passive design strategies, including internal courtyards, thick walls, compact urban form, and natural ventilation. These strategies significantly enhance thermal comfort while minimizing energy consumption. In contrast, contemporary houses exhibit weak climatic adaptation and higher operational energy demand due to their reliance on mechanical cooling systems and industrial materials with high embodied energy. The study concludes that traditional architecture in Ghadames represents a sustainable residential model for hot-arid environments. It emphasizes the importance of integrating climate-responsive traditional design principles into contemporary housing to improve environmental performance and promote sustainable urban development in Libya.

Keywords: Architectural sustainability; traditional housing; contemporary housing; Ghadames; hot-arid climate.

1. Introduction

Architectural sustainability is crucial in light of global environmental issues, particularly in the construction industry dealing with climate change and limited resources. Buildings in harsh climates depend greatly on mechanical cooling, greatly affecting energy usage. In North Africa and the Middle East, swift urban growth and uniform housing designs overlook local environmental considerations, resulting in higher energy consumption. Ghadames, Libya, showcases conventional desert architecture, well-suited to its harsh climate. Its passive design characteristics improve thermal comfort and energy efficiency, whereas contemporary designs exhibit low adaptability. This study investigates the sustainability divide between conventional and contemporary housing, seeking to uncover design ideas for eco-friendly homes in hot, dry areas.

Architectural sustainability focuses on reducing ecological footprints and enhancing social, cultural, and economic value. It emphasizes resource efficiency, climate adaptation, energy utilization, and environmental harmony, especially in hot-arid climates, promoting long-term sustainability and human well-being through suitable designs and materials.

Traditional houses in Ghadames are designed with internal courtyards, thick walls, and narrow streets to ensure thermal comfort and reduce mechanical reliance. In contrast, modern developments often adopt external designs, neglecting local climate concerns, resulting in higher energy consumption and environmental impact. Ghadames is a UNESCO World Heritage Site for its historical significance.

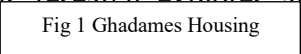


1.1 Problem Statement

Fig 1 Ghadames Housing

Modern house in Ghadames face sustainability challenges due to poor climate adaptation, improper use of local materials, and neglect of passive design, leading to high energy consumption and low thermal comfort. In contrast, traditional houses effectively utilize resources and techniques for better energy efficiency and sustainability.

1.2 Research Objectives

The main aim of this ~~research explores~~ research explores architectural sustainability through a comparative  and modern houses in Ghadames, Libya. It defines sustainability concepts, examines traditional housing adaptability and materials, evaluates modern approaches' shortcomings, and extracts insights to enhance contemporary residential architecture sustainability.

1.3 Research Significance

This study enhances sustainable architecture in hot-arid regions by promoting traditional housing designs for environmental efficiency and indoor comfort, aiming to inform architects and policymakers about sustainable, energy-efficient housing strategies.

1.4 Methodology

This research employs qualitative comparative analysis using secondary data from academic sources. It involves examining Ghadames' geography and climate, analyzing architectural sustainability in hot-arid climates, comparing traditional and contemporary houses, and integrating findings to inform design recommendations.

1.5-Research Limitations

This study focuses on sustainable residential buildings in Ghadames, excluding quantitative assessments and other typologies or climates.

2. Literature Review

Literature review establishes theoretical foundation, highlighting architecture, climate-responsive design, and sustainability in hot-arid regions.

2.1 Traditional Architecture and Environmental Sustainability

Traditional architecture has long been celebrated for its natural sustainability, arising from its ability to adapt to local climates, utilize indigenous materials, and implement passive environmental management techniques. Oliver (2006) underscores that traditional buildings embody generations of regional knowledge where climatic responsiveness and resource efficiency are seamlessly integrated into spatial layouts and construction methods. He contends that these age-old practices hold valuable insights for advancing sustainable design today, particularly in areas facing extreme climatic conditions

Fathy's analysis highlights traditional design's use of courtyards and wind towers for thermal comfort in hot climates, promoting energy efficiency and reducing reliance on mechanical systems.

Edwards (2010) emphasizes sustainable design needs context-specific solutions, unlike modern architecture's disconnect from climate and culture.

2.2 Climate-Responsive Design in Hot-Arid Regions

Research highlights traditional architecture's role in mitigating heat in hot-arid environments. Bahadori (1985) discussed passive cooling methods such as courtyards and thick walls, while Al-Sayyad and

Guernica (1996) emphasized urban morphology's impact on community climate regulation.

Investigations in the Middle East and North Africa highlight that building orientation, solar shading, and courtyard layouts are vital for thermal comfort without heavy energy use. This research establishes a link between sustainable design in hot climates and cultural practices.

Edwards (2010) emphasizes integrating context-responsive strategies in architecture, noting traditional methods' success in aligning with climate, cultural values, and available resources, often neglected in modern designs.

.2.3 Contemporary Housing and Sustainability Challenges

Recent studies highlight challenges in achieving sustainability in arid region housing. Khoshnood et al. (2014) note that modern designs overlook local climates, increasing energy consumption, while Attia (2018) points out that global architectural trends compromise climatic efficiency. Both emphasize the need for design practices that prioritize passive strategies and climate-responsive solutions to create environmentally sustainable buildings in hot climates.

2.4 Research on Libyan Traditional Architecture

Scholars have studied traditional housing in North Africa, notably Libya. Ben Mubarak (2012) noted that oasis homes achieve thermal comfort through thick walls and limited exposure. Hammami (2015) found that Tunisian courtyard homes also employ spatial and material strategies to reduce energy consumption.

Abdelli and Moustapha (2019) analyzed traditional housing in Fezzan, highlighting local materials and passive design strategies for sustainability, providing a foundational framework for the comparative study.

Ghadames Geographical Location

Ghadames, a historic desert oasis town in northwestern Libya near Tunisia and Algeria, is about 543 kilometers southwest of Tripoli. It's known for its beautiful architecture and scenic oasis.



Fig 2 Ghadames location

1. Traditional Housing in Ghadames

Traditional Ghadames houses are made from adobe and stone, offering thermal mass and insulation. Features like internal courtyards, thick walls, and narrow streets reduce solar heat gain and enhance ventilation, promoting thermal comfort sustainably with minimal mechanical reliance.



Fig 3 Traditional Housing in Ghadames

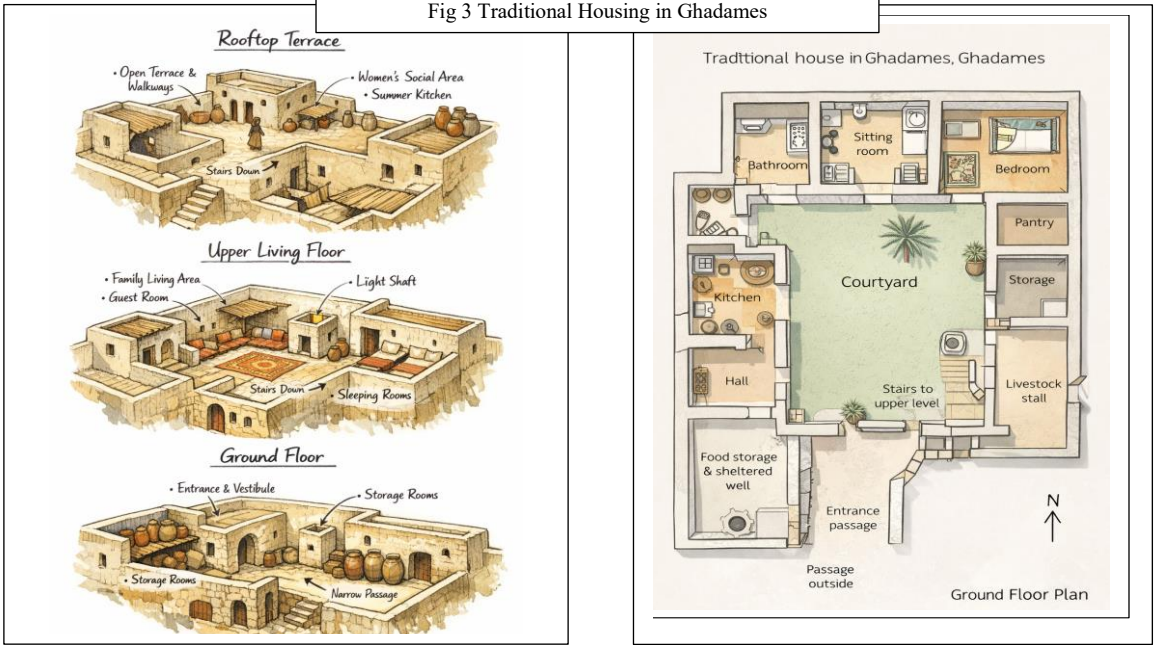


Fig 4 Traditional Housing in Ghadames

2. Contemporary Housing in Ghadames

Modern Ghadames residential buildings use reinforced concrete and steel, ensuring structural stability but lacking thermal regulation without climate adaptation. Designs often overlook passive principles, causing increased solar heat gain and indoor temperatures, leading to heavy reliance on air conditioning and higher energy consumption and environmental impacts.

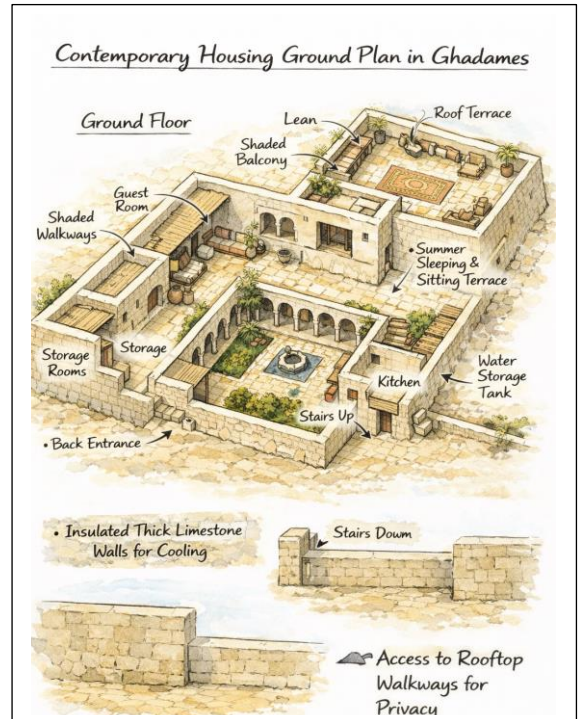
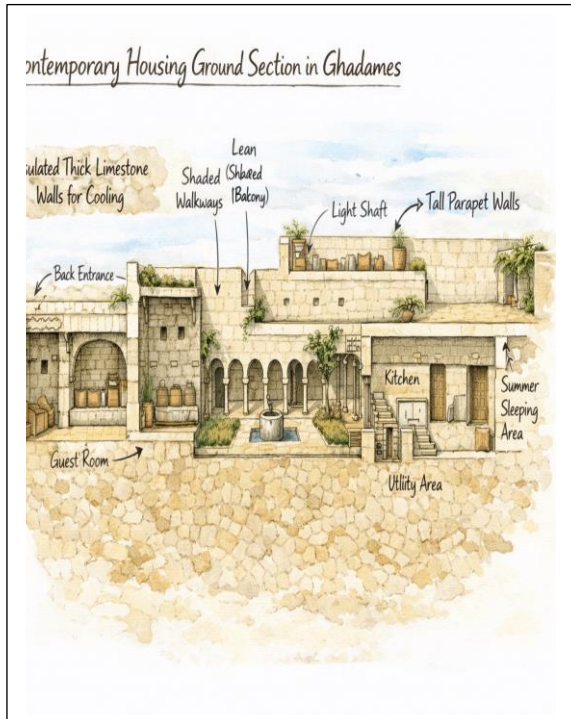


Fig 5 Contemporary Housing in Ghadames

3.Comparative Analysis and Discussion between Traditional and

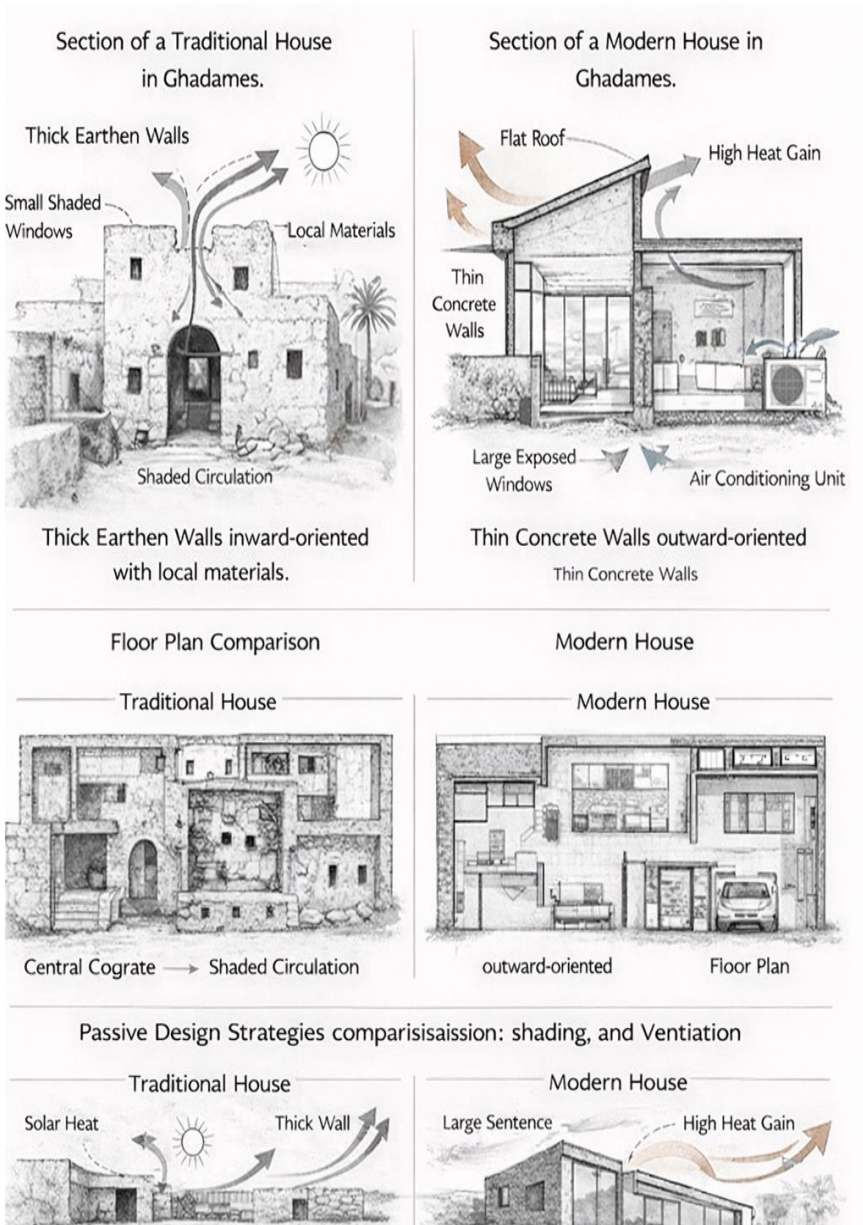


Fig 6 Comparative Analysis

Modern Houses in Ghadames

Traditional and modern Ghadames buildings differ significantly in environmental performance, energy efficiency, sustainability, and climate responsiveness.

3.1 Climatic Responsiveness and Thermal Performance

Traditional houses in Ghadames showcase effective climatic adaptation via passive design. The compact layout limits heat gain, while thick earthen and stone walls provide thermal mass for temperature stabilization. Internal courtyards enhance ventilation and support nocturnal heat release, improving indoor climate control.

Modern houses often neglect climate-responsive design, using reinforced concrete and large windows, leading to high solar heat gain and inadequate insulation, which, combined with poor shading and orientation, causes reliance on mechanical cooling.

Traditional houses are energy-efficient, relying on passive cooling and natural ventilation, with low operational energy demand. In contrast, modern houses utilize excessive energy, especially for air-conditioning, due to poor envelope performance, resulting in increased peak electricity loads and higher carbon emissions.

3.2 Material Sustainability and Environmental Impact

Traditional houses utilize locally sourced materials like mud brick and palm wood, promoting environmental sustainability with low embodied energy and recyclability. In contrast, modern houses mainly use industrial materials such as reinforced concrete and steel, which entail high embodied energy and emissions, necessitating specialized maintenance, thus increasing their overall environmental costs throughout their life cycle.

3.3 Urban Form and Environmental Integration

Ghadames' urban fabric consists of narrow shaded streets and covered walkways, enhancing thermal comfort and mitigating heat islands. In contrast, modern developments feature dispersed layouts and wide streets, increasing solar exposure, surface temperatures, and heat accumulation, ultimately compromising environmental sustainability at the building and neighborhood scales.

Spatially, traditional houses are organized to accommodate social and cultural requirements, including privacy hierarchies, gender segregation, and shared communal spaces. These spatial arrangements strengthen cultural identity and social cohesion, which are integral to sustainable development.

Modern houses, however, often adopt standardized layouts with limited sensitivity to local socio-cultural patterns, resulting in reduced functional efficiency and diminished cultural sustainability.

3.4 Comparative Evaluation

Traditional houses in Ghadames outperform modern ones in sustainability aspects like thermal comfort and energy efficiency.

Contemporary houses' failures arise from neglecting passive design and climate-responsive strategies.

Combining traditional architecture with modern technology offers a feasible solution for sustainable housing in hot arid areas.

Table 1. Comparison between Traditional and Contemporary Houses in Ghadames in Terms of Sustainability

Comparison Criteria	Traditional Houses (Vernacular)	Contemporary Houses
Climatic Responsiveness	Highly adapted to hot-arid climate	Poor adaptation to local climate
Spatial Organization	Inward-oriented layout with central courtyard	Outward-oriented layout with exposed façades
Thermal Comfort	Achieved through passive strategies	Achieved mainly through mechanical systems
Energy Consumption	Very low operational energy demand	High energy consumption, especially for cooling
Building Materials	Local materials (mud brick, stone, palm wood)	Industrial materials (concrete, steel, aluminum)
Embodied Energy	Low embodied energy	High embodied energy
Wall Thickness	Thick walls providing effective thermal insulation	Thin walls with limited thermal performance
Natural Ventilation	Efficient (courtyard effect, small openings)	Limited or inefficient
Shading Systems	Integrated natural shading (narrow streets, overhangs)	Limited or absent shading devices
Urban Fabric	Compact and dense, reducing solar exposure	Dispersed layout, increasing solar exposure
Environmental Impact	Low environmental impact	Relatively high environmental impact
Cultural Sustainability	Strong reflection of local identity and social values	Weak connection to local cultural context
Maintenance	Simple, low-cost, locally manageable	Costly, technology-dependent maintenance
Overall Sustainability Performance	High	Low to moderate

Summary of Table

Table 1 highlights the differences between traditional and contemporary houses in Ghadames regarding architectural sustainability. Traditional houses excel in climatic responsiveness,

thermal comfort, energy efficiency, and material sustainability due to features like inward-oriented layouts, thick walls, and local materials, leading to reduced heat gain and energy demands. In contrast, contemporary houses struggle with climate adaptation, rely on mechanical cooling, and utilize high-embodied-energy materials, resulting in lower environmental performance, confirming traditional housing as a more sustainable model for desert settings.

4. Results

Traditional houses exhibit superior architectural sustainability, demonstrating adaptability to climate, enhanced thermal comfort via passive designs, lower operational energy use, and reduced environmental impact. In contrast, contemporary houses show high energy consumption and poor environmental performance due to mechanical cooling systems and energy-intensive materials.

5. Discussion of Results

Traditional houses showcase sustainability through climate-responsive designs and compact forms, while contemporary homes rely heavily on mechanical cooling. This shift indicates a move away from context-sensitive practices, revealing that modern housing's sustainability issues arise from overlooking traditional climate-adaptive principles, not from construction technologies.

6. Recommendations

Recommendations for sustainable housing in hot-arid environments like Ghadames include energy efficiency measures.

1. Context-Sensitive Housing Design

Housing design must directly address local climate, environment, and culture, avoiding generic architectural models.

2. Reinterpretation of Vernacular Architecture

Traditional architecture's key elements can improve modern designs by enhancing thermal performance and meeting functional requirements.

3. Climate-Responsive Planning Policies

Housing design guidelines in hot-arid regions must prioritize passive climatic strategies by local planning authorities.

4. Sustainable Material Selection

Prioritize low embodied energy and high thermal mass materials, especially local ones, to enhance indoor performance and minimize environmental impact.

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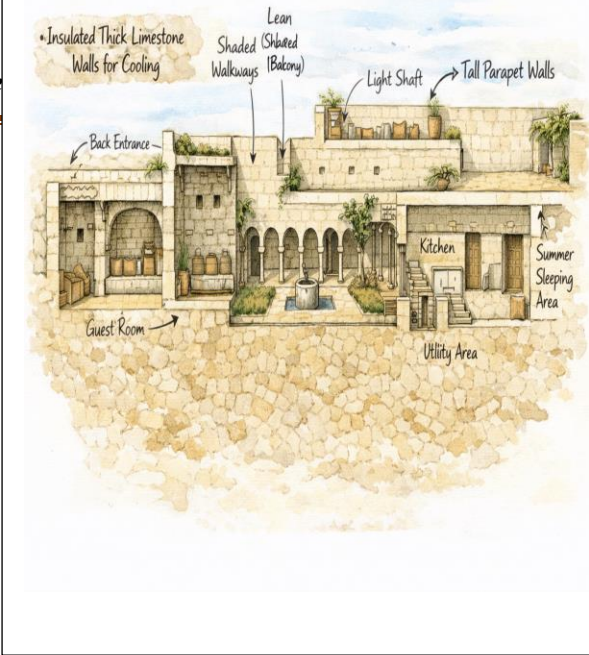
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**Traditional and Contemporary Houses in
Inability Perspective**

Temporary Housing Ground Plan in Ghadames

