

Sustainability Implications of Utilizing Islamic Geometric Patterns in Contemporary Designs, a Systematic Analysis

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Abstract: Recently, scholars have embraced sustainability as a crucial concept deeply ingrained in architectural designs, particularly Islamic geometric patterns (IGP). These patterns hold significance in reflecting Islamic history, identity, and culture. This systematic review explores how scholars have integrated IGPs into modern design, considering the sustainability aspect. The Preferred Reporting Items for Systematic Reviews (PRISMA) reporting checklist was used due to its organized structure as a guide to conduct this review (2012–2022). Data was collected through recognized databases (i.e., Scopus and ProQuest) that house a wide array of journals and publications. Selected journals were categorized based on sustainability pillars—environmental, economic, social, and cultural. In addition, case studies from the region are discussed, as studies didn't explicitly explore the connection between sustainability and the use of Islamic geometric patterns in modern design. Findings indicate that papers predominantly discuss the positive effects on environmental and economic sustainability through IGP implementation. Conversely, social sustainability received comparatively less attention from scholars. Case studies showed that most building designs in the Middle East use IGP to conserve Islamic history and identity, especially in the United Arab Emirates (UAE). This review sheds light on the potential of geometric patterns as a vehicle for sustainable design and contributes to the broader discourse on sustainable architecture.

Keywords: Islamic geometric patterns (IGP); sustainable design; PRISMA; Islamic architecture



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1. Introduction

Throughout history, Islamic Architecture (IA) has been a tool Muslim architects used to preserve their religion, identity, and values against the cultural invasion of foreign countries. Islamic countries were able to impose their religion and history with the use of Islamic architecture. Art and Architecture play an important role in enriching culture and people's identity. Therefore, as Islam was widely revealed in the pre-modern period of time, between 800 to 1500 CE, Islamic geometric patterns (IGPs) emerged [1].

Geometry, as a branch of mathematics, played a vital role in the creation of IGPs. IGPs are decorative elements that mainly styled the exteriors and interiors of Islamic buildings (i.e., mosques) and palaces. Albert et al. [2] defined IGPs as “basic decorative elements of Islamic architecture consisting of a pattern formed by a set of small pieces with simple shapes (straight lines and arcs”. IGPs show four recognizable characteristics: symmetry, interlacing, unboundedness, and flow [3]. IGPs consist of a repeated unit, a polygon that holds the base geometry, and a repetition structure that is the product of systematically repeating the seed unit to fill the space [4]. The main elements of Islamic patterns include geometric, calligraphic, and floral patterns [5]. The floral design represents nature, and its motifs are inspired by the shapes and colors of flowers and trees. The calligraphic

pattern is an essential part of Islam because it uses Quran writings. Geometric pattern relies heavily on the repetition and symmetry of basic geometric shapes to generate a unique pattern. It can be applied in a simple form as well as in a richly complicated design. In fact, Dabbour [6] claimed that Islamic designs heavily rely on geometry; it has a central role and great importance to Islamic designs.

Westerns invaded most aspects of Muslims' lives through technology, modes of living, and economic and political systems. This has led to the fall of Islamic values and, through the years, the fall of the Islamic empire and the triumph of colonization. As a result, Islamic architecture has been influenced as well. To reemphasize the significance of Islamic architecture nowadays, Ben-Hamouche [7] claimed that Islamization is the only way to bridge the gap between Islamic architecture and the modern environment. Islamization is defined as the reuse of early pre-Islamic architectures. Therefore, it is important to constantly embed the concepts and characteristics of Islamic patterns in all local and international modern designs. An example is the United Arab Emirates (UAE). It is an outstanding example of Islamic architecture. Ibn Battuta Mall, Louvre Museum, the Central Market, Souk Medinet Jumeirah, etc., are tourist destinations where the UAE has succeeded in reflecting the Islamic architecture of the Muslims [8].

As the world's vision has shifted towards sustainability. This paper has shed light on the sustainability aspect and its involvement in the IGPs. Sustainability, by definition, is a linked or paired buzzword to all environmental, economic, and social problems that we face in our society. One of the most agreed concepts of sustainability or sustainable development is the integration of the environmental, economic, social, and cultural dimensions (or pillars).

Integrating Islamic geometric patterns into sustainable design practices can create harmonious and environmentally conscious solutions for a more sustainable future. The following are aspects that illustrate the connection between sustainability and IGPs:

1. Resource efficiency: IGPs utilizes repetitive and symmetrical pattern, which can lead to efficient use of material, minimize waste, and promote sustainable construction practices (i.e., 3D printing).
2. Natural inspiration: IGP architects reflect the beauty of nature and harmony found in the natural world (i.e., using the biomimicry principles), which can possibly result in more environmentally friendly solutions.
3. Cultural preservation: IGPs are strongly adopted by Arab cultures as an approach to preserve their Islamic culture that can contribute to the conservation of cultural heritage, promote sustainable tourism, and foster a sense of identity among Arabs.
4. Passive Design Strategies: This includes passive cooling, use of daylight, shading, natural ventilation, etc. Integrating such strategies in a building can highly promote sustainability to meet the sustainability development goals.
5. Social sustainability: Incorporating Islamic patterns in contemporary urban design encourages social interactions, well-being, and inclusivity.

Geometric patterns are a hallmark of Islamic art and architecture. They are found in mosques, palaces, and various forms of decorative arts, even in furniture [9]. These patterns have become a defining feature of Islamic visual culture. Therefore, it is worth to determine their extent of sustainability. A systematic literature review is conducted based on the PRISMA to study the application of sustainability in modern Islamic geometric patterns for the last decade (2012–2022). In other words, the major research objective of this systematic literature review is to elaborate on the application of Islamic geometric patterns in contemporary design. However, this study will focus more deeply on the research objective from a sustainability perspective. Case studies from the Islamic region will be discussed to reflect and support the aim of the paper. Primarily, up to this date, no research papers have clearly discussed the sustainability pillar relation with the application of Islamic geometric patterns in modern design, which merits the added value of this paper to the IGPs research field.

2. Literature Review

2.1. Evolution of IGPs throughout the Years

All Islamic geometric patterns originated from circles, as it is claimed to express the unity of Islam. Most of the patterns are based on hexagons and octagons. Figure 1 shows the evolution of the IGPs and the most outstanding examples through the years. The great Mosque of Kairouan (Figure 1a) is designed primarily with vegetal and floral motifs, but some geometrical patterns were noticed. This is an example of the earliest attempts to apply geometrical ornaments in Islamic architecture. Ibn-Tulun Mosque (Figure 1b) welcomed the geometrical patterns where application shifted from fully using vegetal and floral motifs to squares and circles. Six-point geometrical patterns, hexagons, and eight-point geometrical patterns were introduced [10].

Al-Aqmar Mosque (Figure 1c) is considered an outstanding application of GP in the Fatimid architecture, where six-point stars have also been very popular. The facades were filled with a mix of vegetal, floral, and a few calligraphic decorations. Since this mosque and Al-Salih-Tala'I in Cairo, the use of six and eight-point stars is used in the bas-relief sculptural ornamentation on the walls [10]. Later on, the GP started to spread all over Muslim countries, such as Iran, Turkey, and Egypt. Not only mosques, but Ali-Qapu is also a palace in Isfahan. It is characterized by its extensive use of geometrical patterns, as shown in Figure 1d. This palace shows extensive use of 8 and 10-point geometrical patterns on balconies and ceilings, along with decorated muqarnas, carved stuccos, and paintings with floral and figural motifs [10]. This evolution through time shows the capability of using complex geometric patterns, and artisans had mastered the art in domes, walls, ceilings, windows, etc.

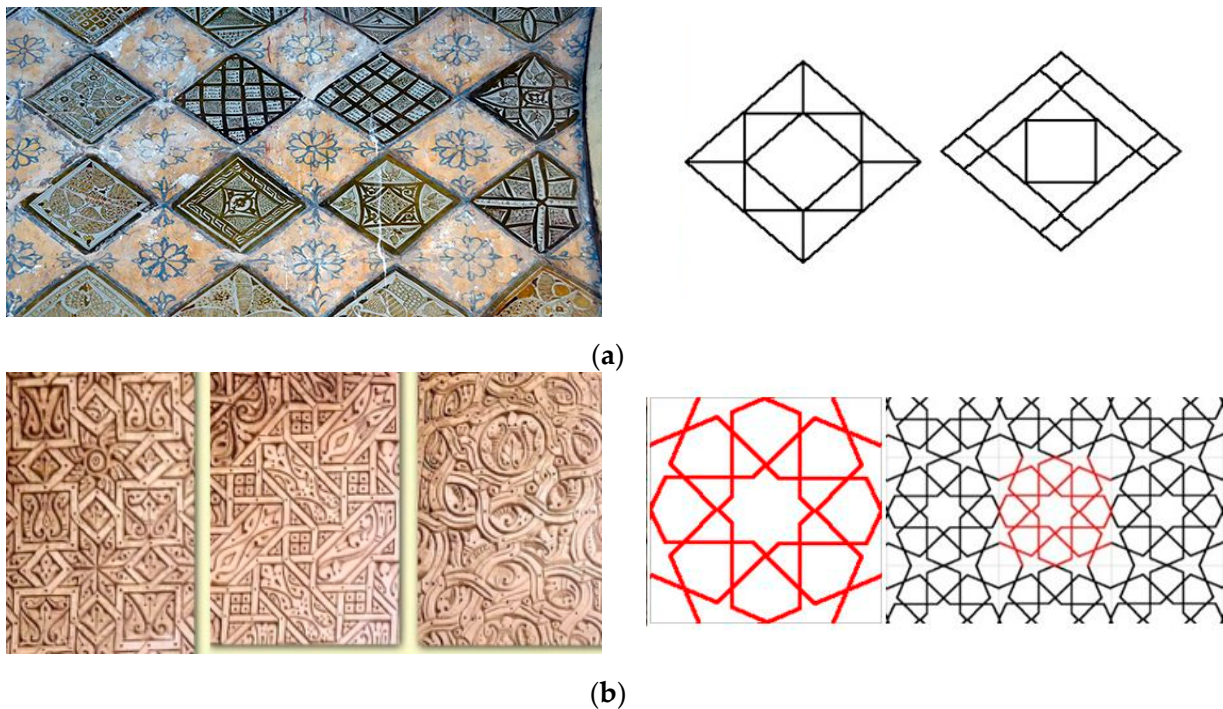


Figure 1. Cont.

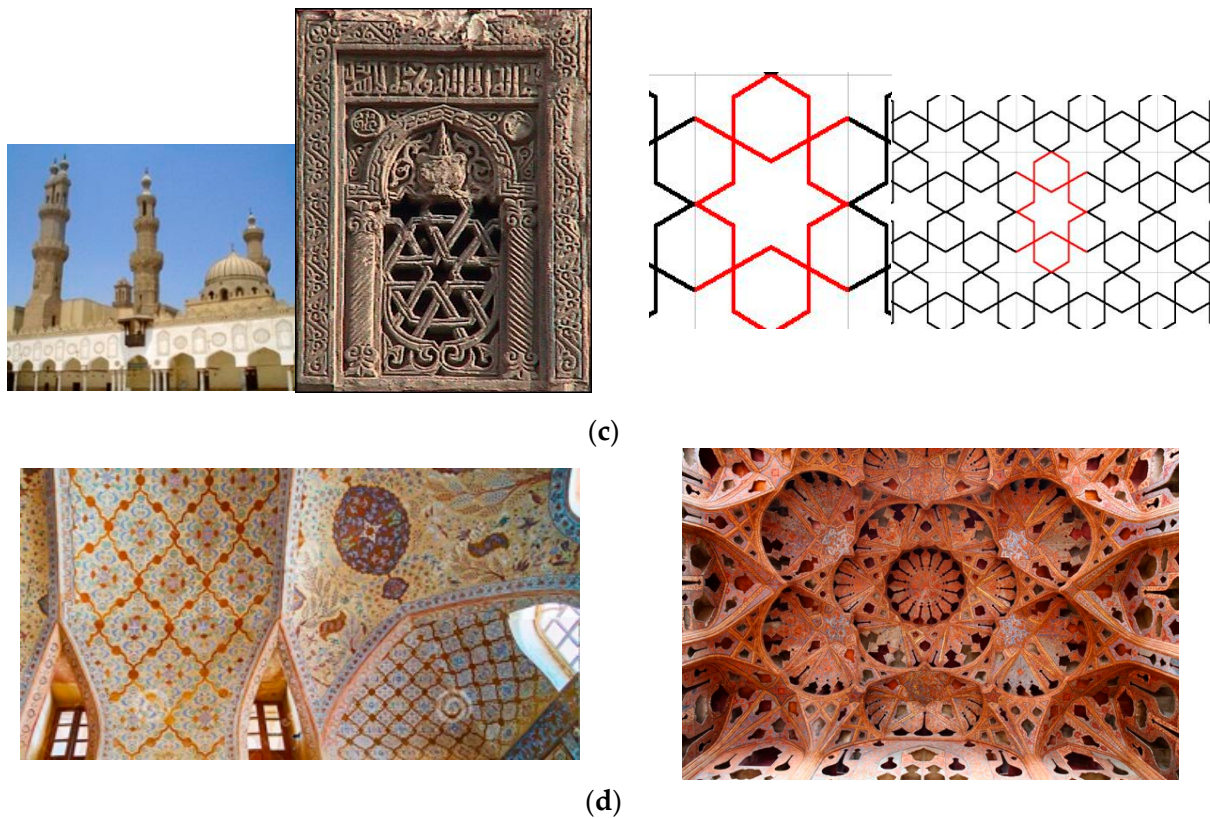


Figure 1. Evolution of IGPs providing most iconic and outstanding examples: (a) The Great Mosque of Kairouan (670 CE)—Iran—Solitary geometric shapes—Earliest attempt to apply IGPs, elementary geometric patterns; (b) Ibn-Tulun Mosque (876–879 CE)—Egypt—Extensive use of geometric patterns; (c) Al-Aqmar Mosque (1125 CE)—Egypt—Mixed use of geometric, vegetal and calligraphic patterns; (d) Ali-Qapu Palace (1598 CE)—Isfahan—Decorative patterns with extensive use of geometrical ornamentation (8 and 10-point geometrical patterns) and floral motifs. (Sources: [10]).

2.2. Contemporary Application Examples

Nowadays, western and non-Muslim environments have adopted Islamic patterns with contemporary thoughts. Samy and Sobh [11] agreed that Islamic patterns can use modern techniques and systems in a new and creative way to be suitable for modern societies and buildings. In fact, architects are taking advantage of new materials and mass production techniques to enrich Islamic art in modern building technology. In other words, Islamic geometric patterns are nowadays developed and represented to suit modern designs. For instance, the Louvre Museum in Abu Dhabi, designed by Jean Nouvel, is amongst the outstanding recent projects that used Islamic patterns in designing the building envelope. This project features eight layers with a triangular pattern as a floating dome structure simulating the filtering of light through the giant mantric Mashrabiya, a traditional Islamic lattice typically used to enclose large second-story openings in houses and buildings [11]. This is presented in Figure 2.

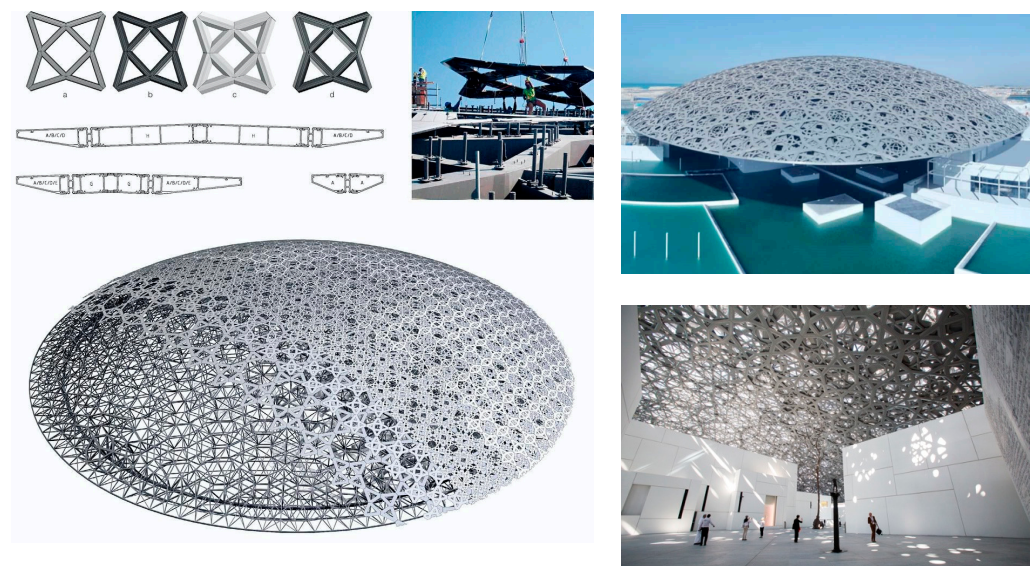


Figure 2. Louvre Abu Dhabi Islamic patterns application (Sources: [11]).

Designers have generated the Girih tiles forms using digital techniques. Samy and Sobh demonstrated that Islamic architecture has the ability to develop and evolve through digitalization. To support their claim, the Alpha Project in Qatar (2010) (Figure 3) was presented as an example to show that designers used Girih tiles digitally to generate the structure skin of the building.

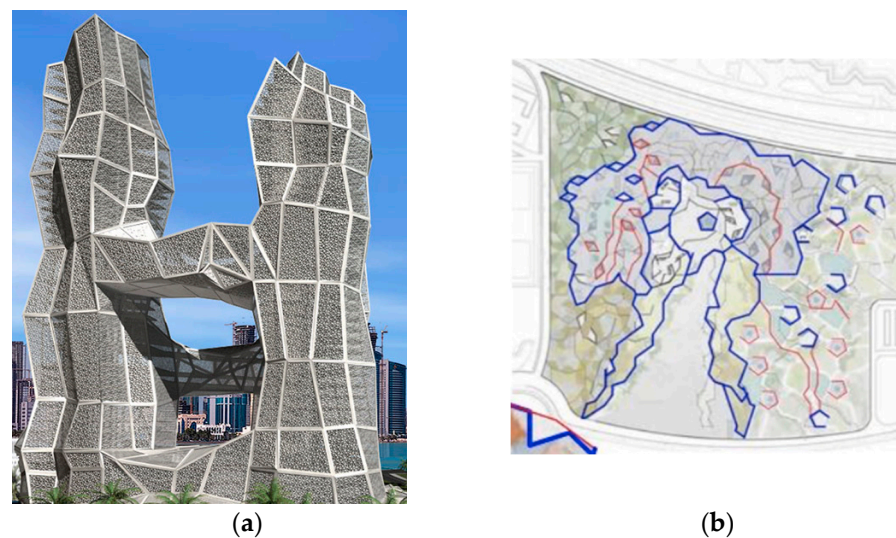


Figure 3. The Alpha Project in Qatar (2010): (a) Exterior design of the building, (b) Layout, (Sources: [11]).

Shafiq [12] explained that Islamic ornamentation is not a traditional heritage art. It is actually a dynamic art that can vary based on variable effects of the era indicated by the human vision in place and time. In other words, to reach a contemporary Islamic ornament, human vision in different places through time can only be varied using fixed Islamic architectural principles (e.g., the use of circles manifests unity).

The United Arab Emirates was, and still is, one of the pioneer Middle East countries to adapt and blend Islamic architecture into the modern community. Patterns of the city, spatial configurations, architectural elements, and decorative ornamentation were noticeably, in many cases, inherited from ancient Mesopotamian and other pre-Islamic patterns [8]. One of the iconic examples is the Louvre Museum in Abu Dhabi, as discussed

earlier, as well as the Masdar Institute. The interior of Ibn Battuta Mall in Dubai displayed ornamentation and figurative Islamic motifs that have significantly attracted a large number of tourists and residents to the UAE. Similarly, conserved projects across Dubai, such as the Gold and Spice market, Bastakiya district, Textiles market, and Souq Medinet Jumeirah, were all exteriors designed with Islamic geometric patterns. This has improved atheism and has helped the government to conserve its history. Accordingly, Dubai has maintained its global scene position, and tourists from worldwide visit the city to enjoy the Islamic architecture. As a result, the government has improved its economy and trade position compared to other countries [8].

The Emirates of Sharjah hosts the Sharjah Light Festival Show annually, where architectural aesthetics are displayed at Sharjah’s landmarks (Table 1). This show highlights the elegance and balance of timeless Islamic motifs while incorporating rapid digital designs, creating a captivating contrast of evolution and speed. Such gestures are considered a universal language and powerful tool for communication throughout history [13]. This is considered as an economic sustainability due to the use of technology. Also, The Chedi Al Bait have used local materials (i.e., wood) to design the patterns and have engraved the patterns on walls. It is interesting to mention that Al Bait has been built upon the foundations of very old heritage houses.

Furthermore, the Sharjah Museums department, in collaboration with the Sharjah Museum of Islamic Civilizations, has initiated a booklet for families and their children to enjoy the collections in the Islamic Art Galleries and learn about them closely [14]. Integrating the teaching of Islamic geometric patterns into educational programs helps future generations to respect and value their identity. Not to mention, Sharjah has unique examples of modern Islamic art mixed with conserved cultural Islamic architecture; examples of such landmarks are the Central Market (1979), Sharjah Museum of Islamic Civilization (1996), University of Sharjah (1997), etc. Nasir Al-Mulk Mosque has applied colorful geometric patterns to attract tourists, where colors bring joy and relief to people’s minds. Bayt Al-Syhaymi has used patterns that can provide privacy for residents.

Table 1. Summary of real-life examples that reflect sustainability aspects.

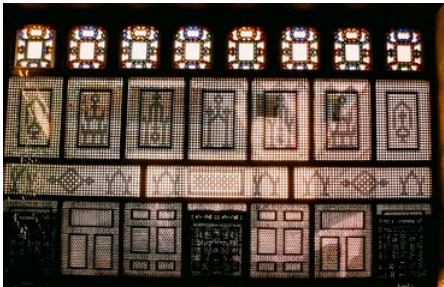
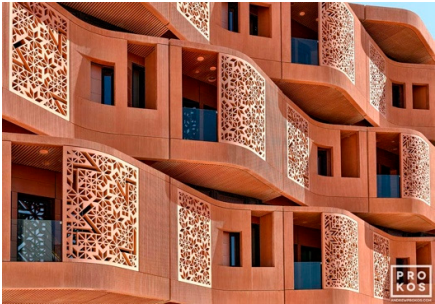
Sustainability Aspect	Examples of Real-Life Cases	
Environmental sustainability: Daylight		
	Louvre museum	Arab world institute
Social sustainability: mental health, privacy		
	Nasir Al-Mulk Mosque	Bayt Al-Suhaymi

Table 1. Cont.

Sustainability Aspect	Examples of Real-Life Cases	
Culture sustainability: Culture preservation		
	Ibn Batuta Mall	Central Market
		
Economic sustainability: Digital technology		
		
	Al Noor Mosque	The Chedi Al Bait

Louvre Museum and the Arab World Institute could be examples of applying environmental sustainability aspects as they both use patterns to reduce the heat of the sunlight and provide suitable daylight for visitors. This will indeed significantly impact the reliance on electricity, which leads to emission reduction.

3. Methodology

A systematic review of papers on Islamic geometric patterns and sustainability was performed to identify how scholars in this field are on the way to fulfilling the sustainability perspectives with the aid of Islamic art and architecture. This systematic review was conducted using the reporting checklist of the Preferred Reporting Items for Systematic Reviews (PRISMA). Scopus and ProQuest were the main online databases used in this research as they are recognized as the most widely utilized online databases for journals and publications searches.

The literature search Ided various keywords such as: “Islamic geometric patterns”, “modern designs”, and “sustainability”. Because these keywords are very wide and commonly used, the results of the initial search were only limited to the titles of the papers. The selection criteria included all English language open-access journals that were published in the last 10 years (2012–2022); 2023 was excluded. Duplicated articles, literature reviews, and irrelevant articles were excluded. A manual screening was conducted by the author to exclude irrelevant articles based on skimming through the abstracts of each paper. A total of 40 publications were assessed and categorized based on their relevance to the sustainability pillars. All 40 articles were carefully read, and information on the research objectives was extracted and recorded on a separate Excel sheet. After comprehensively reviewing the articles, another 12 articles were excluded as the sustainability perspective was not part of their IGP study. This has limited our research to 28 articles only, as presented in the outlined box in Figure 4. Figure 5 is the PRISMA flow diagram.

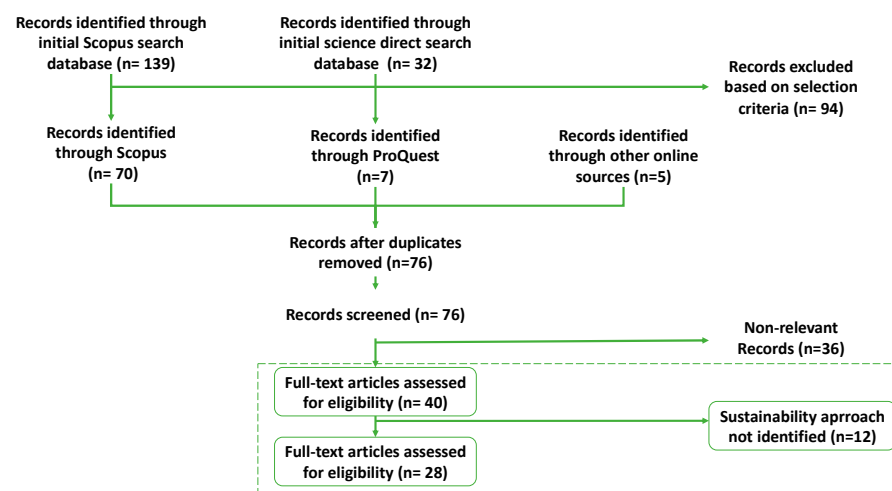


Figure 4. Methodology Approach.

Based on our research, no papers have clearly discussed the sustainability of the IGP application. Therefore, this study will conduct a comprehensive analysis of selected papers as an attempt to identify the environmental, social, or economic aspects based on the results of each selected paper. Table 2 will be used to classify the 28 papers and whether any of the sustainability approaches are met.

Table 2. Criteria of sustainability pillars.

Sustainability Pillar	Criteria
Environmental	- Resource efficiency: Efficient use of resources, such as energy, water, and materials, to reduce waste, minimize pollution, and decrease the ecological footprint. - Use of renewable resources and adopting sustainable land-use practices. - Waste Management: Implementing waste reduction, recycling, and proper disposal practices to minimize waste
Economic	- Promoting sustainable building materials, reducing waste generation - Economic Resilience: create employment opportunities, foster innovation, and support local businesses and industries.
Social and Culture	- Cultural preservation - Aesthetics - Inclusivity of cultures

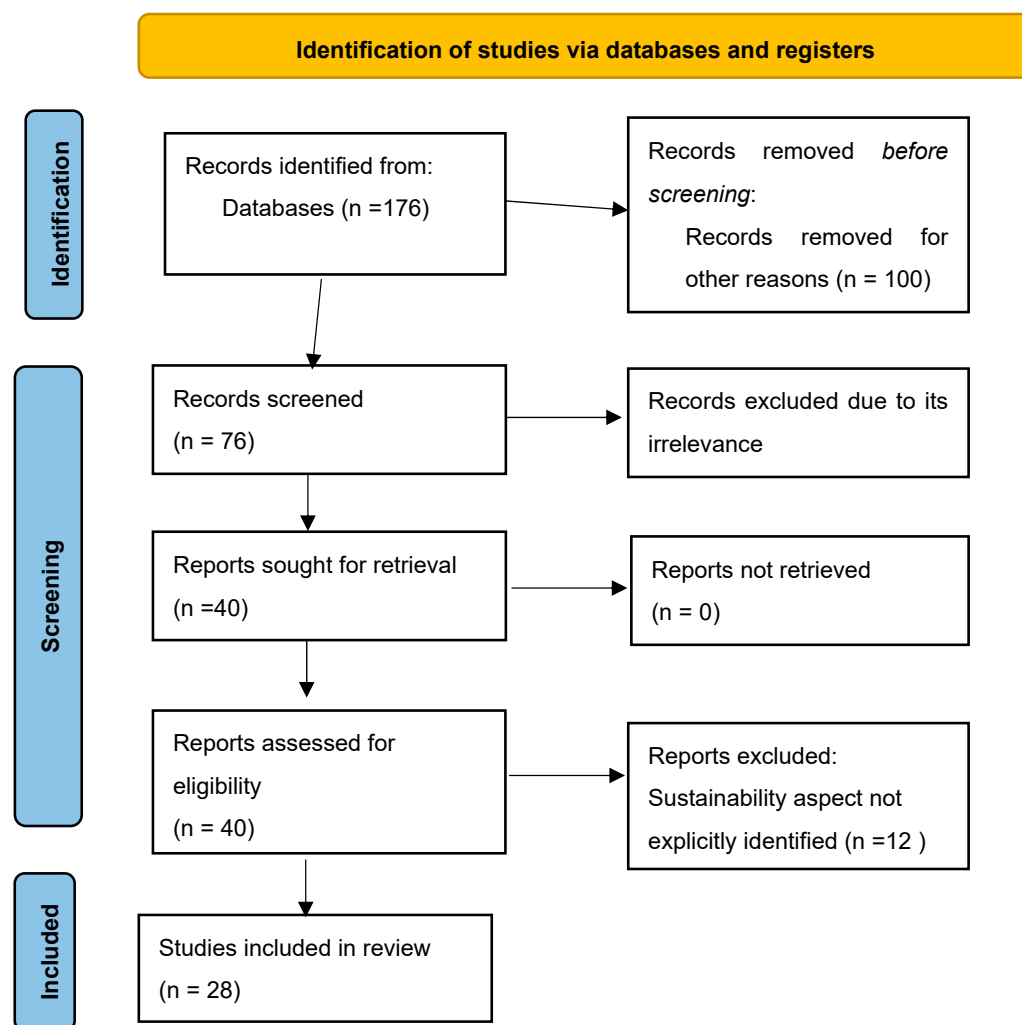


Figure 5. PRISMA flow diagram.

This review paper has explicitly followed the PRISMA guidelines and implemented all steps to obtain significant results.

4. Discussion and Result

4.1. Application of IGPs in the Modern Design

A total of 40 papers were relevant to the application of IGPs in modern design. Authors have carefully analyzed the objectives of each paper and noticed that all papers commonly discuss either the analysis of IGPs in various empires/dynasties or the application/development of IGPs. Analysis of IGPs involves papers discussing the analysis of case studies, evolution, and assessment of IGPs in various eras (e.g., Fatimids and Mamluk dynasties) for different purposes. The application and development of IGPs involve computational models and modern digital technologies utilized to generate or develop Islamic patterns, as well as new approaches proposed to generate new patterns.

The distribution of articles by year of publication in Figure 6 indicates that 2018 was an active year for scholars to publish on the analysis of Islamic geometric patterns. Alani [15] analyzed hexagonal-based Islamic geometric patterns found in historical designs using mathematical simulation models. Nasri [16] used computer software to analyze geometric ornaments to recreate traditional designs or generate new patterns. Similarly, Agirbas [17] used a visual programming language to analyze 2D and 3D Islamic patterns. Mohammadi et al. [18] study analyzed IGPs in Persian architecture to be able to apply complex and

irregular patterns to meet the modern design requirements in generating new patterns or recreating traditional designs.

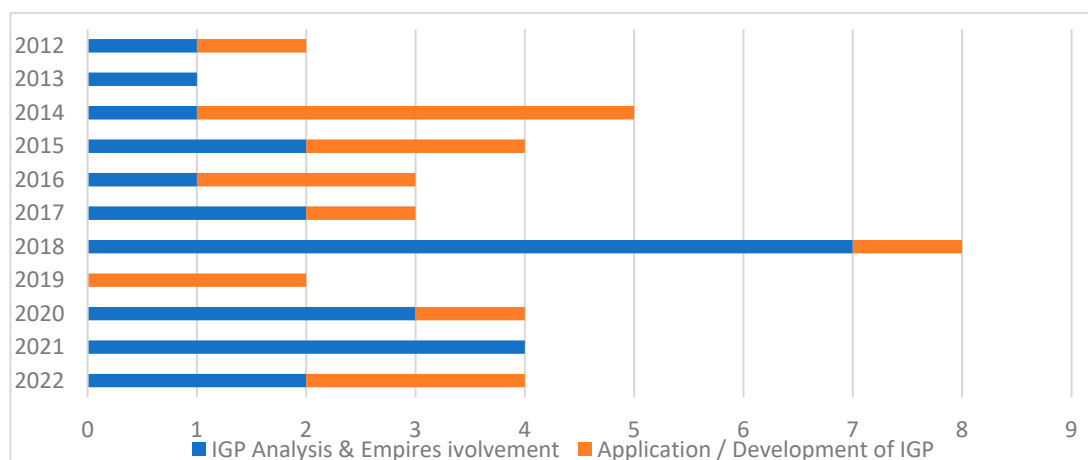


Figure 6. Distribution of articles by year of publication.

The most recent 2022 had in total four publications; two were about the effective role of IGPs in achieving significant reductions in energy consumption (i.e., [19,20]), and two about the aesthetic phenomenology of Islamic geometry within the context of interior design [21] and use of computational aided technology to classify IGPs [5].

Disregarding the year 2018, scholars and researchers have focused evenly on analyzing IGPs in different eras and proposing digital approaches to develop IGPs.

It is difficult to observe a trend. However, it is expected that a positive increasing trend appear in the upcoming years, and more focus will be given to the Islamic geometric pattern as there are many gaps to be covered.

4.2. Sustainability Involvement in Islamic Geometric Patterns (IGPs)

Out of the 40 papers, no papers have clearly discussed the sustainability aspect regarding the application of IGPs. However, we were able to extract and relate 28 papers to different aspects of sustainability.

Table 3 is an overview that shows studies, and the sustainability aspect of the research could belong to. It is observed that the dominant aspect is the combination of environmental and economic aspects of sustainability. This is because of the use of computer-aided technologies and computational methods to either perform analysis or develop new patterns. Alaçam [22] discussed the emergence of digital design approaches and computational thinking to explore the unvisited potentials of muqarnas. Albert et al. [2] developed a new computational method that could possibly create pattern designs and compare patterns between different cultures. Similarly, Zamanigoldeh and Dounas [23] proposed a construction method using a digital strategy, UAV, which will help to create complex shapes. Thalil et al. [24] analyzed patterns encountered in Western Moorish art and used CAD tools to construct new geometric patterns. Barrios and Alani [25] and Nasri [16] used a computational system to study the characteristics of the IGPs and analyze geometric ornaments to recreate traditional designs or generate new patterns. Also, Ajlouni [26] and Aljamali and Fakir [27] utilized a computational model to generate IGPs.

Rashdan and Ashour [21] and Mahmoud [28] have highlighted the three aspects of sustainability. Mahmoud's [28] study aimed to increase awareness about the effective role of geometric patterns as an architectural and artistic capability and to clarify the degree of freedom, flexibility, and functionality as an inherent feature by demonstrating the different practices, styles, and materials. Rashdan and Ashour [21] discuss the aesthetic phenomenology of Islamic geometry within the context of interior design and its purpose and logic in terms of the language of material expression.

Most papers were mutually related to the economic and environmental aspects. For example, Reki and Selçuk [10] mapped the Islamic geometric patterns evolution through different dynasties. Along with that, a special tension was given to the use of different materials, such as wood, bricks, and clay, along with the significance of applying geometric patterns. These materials are environmentally friendly in terms of global warming potential and carbon emission [29]. Also, the paper discussed Jalis (perforated screens), a decorative architectural element that played a major role in tackling the natural conditions of ventilation and lighting in buildings. This can reduce the ecological footprint and efficient use of resources as less air conditions will be used, leading to less waste of energy. Most of the regions with hot climatic conditions have been using the screens efficiently, and this has been a part of their building practices for years. Those finely designed and crafted screens had a positive significance on the natural conditions of the building. Similarly, Sakkal [30] discussed the use of bricks and different building techniques to generate Islamic geometric designs. An example in the Middle East is the Chedi Al Bait in Sharjah. Building techniques, materials used, and crafted screens are all aspects considered to conserve that heritage landmark (Table 3). Using such a technique with the aid of 3D printing can indeed play a major role in reducing construction waste and emissions as well as building and labor costs. In addition, Hosseine et al. [31] investigated the daylight performance of different Islamic geometric patterns (IGPs) used in Orosies with different thicknesses on the West and south facade. Emami et al. [32] employed geometric patterns in ornaments of shading screens to be used as a daylight control system. Mohamed and Bande [19] formulated a repertoire of IGPs that can be used in façade cladding systems that achieve significant reductions in energy consumption while also providing sufficient daylighting and quality views. Selim [20] designed a shading device based on the Girih fractal geometry inspired by tree concepts and then employed the Islamic Girih fractal geometric patterns through their repeated units in a contemporary design with advanced tools, thus achieving significant contrast of solids and shapes against light and shade in contemporary designs. Sabry and Dwidar [33] aimed to display the most important aesthetic values and creative concepts in Islamic Architecture, which expresses the adaptation of Islamic Architecture concepts, environmental treatments, and Islamic ornaments in a creative contemporary way using modern technology. Lim [34] designed a metamaterial that is adapted depending on the external environment. This is listed as environmental as it will help to optimize pressure, thermal, and moisture coefficients. Accordingly, this will significantly reduce the use of different materials to achieve the same results. It was proposed that such an area should be overlooked by practitioners for future purposes.

Lee et al. [35] analyzed geometric patterns by digital technology to lay out a foundation for efficiency and flexibility in developing future designs and material fabrication. Digital technology is the key to optimization, replacement of workers, creativity, and innovation, which all fall under the economic aspects.

Alani [15] overviewed studies that have established a categorization system to classify the IGPs. In fact, this is important for designers and architects as this will help to create and evolve new geometric patterns. Consequently, designers and architects will be more creative. Moradzadeh and Ebrahimi [36] developed Islamic geometric patterns from planar coordinates to three or higher dimensions through their repeat units.

Ahmed et al. [37] shed light on the aesthetic values within the Fatimid architectural heritage to preserve and protect it from the effects of cultural invasion. Kharazmi and Sarhangi [38] proposed approaches for depicting geometric constructions of the Friday Mosque architectural ornaments in order for architects to creatively construct exclusive geometric patterns. This is a social aspect as this improves their vision, leading to a better-looking building and improving social life. Looking at historical heritage, examples will indeed be reflected in the modern vision of buildings. Ajlouni [39] understands mathematical principles to construct complex patterns (i.e., Dodecagonal quasiperiodic patterns). This helps architects to generate aesthetic modern designs.

Table 3. Summary of most relevant review papers.

Publication	IGPs Analysis and Empires Involvement			Application/Development of IGPs		
	Environmental	Economic	Social/Culture	Environmental	Economic	Social/Culture
Reki and Selçuk [10]	✓	✓				
Sakkal [30]	✓	✓				
Alaçam [22]					✓	
Albert et al. [2]					✓	
Alani [15]					✓	
Moradzadeh and Ebrahimi [35]					✓	
Thalal et. al. [24]	✓	✓				
Barrios and Alani [25]				✓	✓	
Cromwell [4]	✓	✓				
Selim [20]				✓		
Nasri [16]		✓				
Ajlouni [26]					✓	
Agirbas [17]		✓				
Mohamed and Bande [17]				✓	✓	
Rashdan and Ashour [21]	✓	✓	✓			
Lim [34]		✓	✓			
Aljamali and Fakir [27]		✓				
Ajlouni [39]			✓			
Lee et al. [35]		✓				
Ahmed et al. [37]			✓			
Hosseini et al. [31]	✓	✓				
Emami et al. [32]				✓	✓	
Kharazmi and Sarhangi [38]						✓
Zamanigoldeh and Dounas [23]					✓	✓
Mahmoud [28]	✓	✓	✓			
Sabry and Dwidar [33]		✓	✓			

It is clearly seen how Islamic geometric patterns have a strong presence in the modern design of buildings in all sustainability pillars. Accordingly, rating systems to assess the sustainability of such buildings have been of interest to scholars, such as Al Sakkaf et al. [40] study. This study contradicts Tabasi and Ban’hashemi’s [41] study, where they analyzed the sources of inspiration. Results showed that only a few designs were inspired by historical patterns, such as Islamic patterns.

5. Conclusions

In conclusion, this comprehensive literature review delves into the use of sustainability in geometric patterns (IGPs) within contemporary architectural designs. The research aims to explore the connection between patterns and sustainability, focusing on publications from 2012 to 2022. By following the PRISMA reporting checklist tool and using Scopus and ProQuest databases, we carefully analyzed 28 articles to understand how sustainability perspectives were incorporated into IGPs.

The findings of this study highlight a gap in the research. While Islamic geometric patterns have long been celebrated for their aesthetic value, there has been little exploration of explicitly integrating sustainability principles into contemporary designs. The analysis

reveals that despite the recognized historical importance of IGPs, there is a lack of research specifically addressing their role in promoting architectural practices.

Nevertheless, insightful case studies from the region have demonstrated a growing awareness of the potential of IGPs in fostering sustainable design approaches. These case studies showcase how the inherent repetition and symmetry found in IGPs contribute to resource efficiency by minimizing waste and encouraging construction practices.

Results showed that most researchers had applied the environmental aspect when designing the IGPs by reducing the daylight, creating shades, and optimizing thermal and pressure coefficients. Examples could be the Louvre Museum and the Arab World Institute. There has been limited research that applied IGPs to meet the economic sustainability aspect, although IGPs in contemporary design will lead to utilizing low-cost materials and less reliance on electricity that, eventually reduces the water and electricity bills for consumers. Several papers and applications were designed using the IGPs to reflect the history and identity of Muslims as applied in The Chedi Al Bait and Noor Mosque in Sharjah. By merging the heritage of Islamic geometric patterns with contemporary sustainability objectives, architects and designers have a unique opportunity to have buildings that are harmonious, culturally significant, and environmentally aware. This will increase their sustainability rating.

This research brings value to the field of IGPs by shedding light on their potential for architecture and opening new avenues for inquiry. It also contributes to the discussion on architecture and lays a foundation for future research to delve deeper into the possibilities offered by IGPs as a viable pathway towards a more sustainable built environment.

As our world progresses towards a responsible future, comprehending and harnessing the inherent sustainable qualities of Islamic geometric patterns becomes not only vital for preserving cultural identity but also transformative in addressing contemporary environmental challenges.

By reinventing the design aspects while prioritizing sustainability, we have the opportunity to establish a mutually beneficial relationship between the past and the future. This approach paves the way for practices that are both environmentally conscious and culturally significant.

6. Limitations

This paper has focused on a very limited scope, which is journals that have integrated sustainability and IGPs in the past ten years (2012–2022). Conference papers, book chapters, and reports were excluded. Accordingly, the papers collected were very limited (28 papers), and our results may not be accurate. However, this paper sheds light on the importance of IGPs in modern designs and could be used as a tool to reflect sustainability.

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