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# Responsive Design Approach towards the Sustainable Mosque Architecture

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**Abstract.** This paper's primary purpose is to design a sustainable mosque for communal development that adapts to the surrounding area. The National Mosque and The Mizan Mosque were selected as prominent case studies emphasizing the study of form and space. Thus, this study summarizes new ways of describing mosque design, using structural and semiotic paradigms as a methodological approach to studying the relationship between mosque design and sustainable aspects. The guidelines developed from this study are helpful for designers, builders, developers and relevant authorities to build mosques as sustainable community development in the future.

## 1. Introduction

The architecture of the mosque is an essential existence for Muslims [1]. The mosque is a religious institution that symbolizes the greatness of civilization and sovereignty of Muslims since the days of the prophet PBUH. The mosque function as a religious institution that symbolizes Islamic values since it is the centre for the unification and symbolism of the various Islamic community. In this sense, the mosque serves as a centre for the education and dissemination of Islamic knowledge, covering creed, worship, morals and all aspects of Islamic science [2]. The mosque's aspect as a symbol of unity plays a significant role in attracting the Muslim and the new converts (mualaf) to Islam, including the non-muslim community, to better recognize and deepen Islamic religion through mosques. In this regard, the mosque's design must be built to have sustainable features that meet the needs of all levels of society [2]. In this regard, sustainable architecture is crucial in mosque design as a catalyst that can create a conducive environment towards an eco-friendly mosque, which is technologically comfortable aligned with the UN Sustainability Development Goals (SDG's). This is crucial and affects the design approaches and the planning of the mosque built form. The following section will first elaborate on the role and importance of sustainable architecture, followed by the characteristics that contribute to sustainable mosque design to understand this in-depth [3].

## 2. Definition and Role of Sustainable Architecture

Sustainable architecture aims to reduce the impact on the environment of buildings with a lack of efficiency in the use of materials, energy, expansion space, and ecosystems in general [4]. Sustainable architecture aims at energy and ecological conservation in the design of the built environment. The idea of sustainability, or ecological design, is to reduce our collective well-being or make it impossible to obtain resources for other applications in the long run [5]. According to the definition, there are five



characteristics of sustainable architecture. First, it is important to consider the environment in which it will be carried out through a thorough analysis of the territory, location, climatic conditions of the area, ventilation, trees or surrounding buildings that may block the entry of natural light etc. Second, design and orientation, which is optimal orientation, is a critical aspect to minimize energy consumption. The right direction of incoming light and solar radiation can take advantage of the natural heat source. The design that aligns with the solar orientation allows taking advantage of the sun's position to capture the lightest during the day. Third, determine how energy will be used and conserved. In addition to ensuring excellent insulation, the use of shutters and adjustable shutters contribute to energy efficiency. It is also essential to consider renewable energy such as solar panels and photovoltaic panels, wind power generators, etc [6].

There are currently several 'eco-friendly' options. Forth, use natural, recycled or recycled materials. It is essential to have sustainable materials to minimize the environmental impact of the building, for example, by choosing natural materials such as roof coverings, facades and roofs. Using recycled materials to manufacture louvres systems reduces costs, saves resources, and reduces our environmental footprint by minimizing CO<sub>2</sub> emissions [4]. Furthermore, lastly, reduce, recycle and reuse waste. Related to the previous item, the reduction or removal of waste from the environment is a crucial point of sustainable architecture, which has begun to incorporate cardboard and metal as elements easy to recycle and reuse through the manufacturing process and thereby being able to integrate them back into the chain and reduce their environmental impact. It is also essential to avoid contaminated materials that may pose a health risk to occupants [6].

### **3. The Importance of Sustainable Architecture to Society**

The world community currently faces two significant challenges, namely the issue of climate change and energy security. Both issues must be addressed collectively and effectively. A critical approach is essential. Green technology is to minimize the negative impact on humans in the development of applications of products, equipment and systems to conserve the environment and natural resources. Green technology also helps the development of a knowledge society that pushes towards practising sustainable energy and a better way of life. It is based on four types, namely energy, environment, economy and society [5] [6]. From the energy aspect, green technology is looking for ways to minimize energy intake and, promote employment efficiency. From an environmental aspect, the impact on the environment can be minimized and preserved. From the economic aspect, green technology enhances the economic development of the country using technology. From the society, the essentiality of life of the people can be improved. In this regard, having a built environment comprising various types of building typology, including religious institutions [7].

### **4. The Elements of Sustainability in Mosque Design**

In general terms, scholars outlined that the eco-friendly or for sustainable mosque design typically can be viewed and understood in four general aspects: i) the architecture design form and space-making, ii) building operational and management phase and iii) expansion or extension stage. In fact, more focused on architecture design form and space-making to outline the aspects that can be referential exemplar for reference by future designers and scholars. By understanding this, the empowerment of the mosque as a place of knowledge, brotherhood and fostering cooperation can be established [8]. The purpose is to make the mosque a center of activity and a source of economic development, so that various ethnic, racial and age groups can be coordinated within the mosque complex can be established. This will strengthen the mosque function and its role as the missionary centre, education, development, and humanity's construction. However, for the sake of this study, the focus of the discussion will only involve setting, space and design organizations (facade and details, the structural organization, and material use) to produce a better design of the sustainable mosque in the future [9]. There are two elements of sustainability that make up sustainable architecture in mosque design: form and space-making.

**Table 1.** Elements of Sustainability

Element	Indicator	Explanation
Form	Facade	The idea of sustainability in the design of a mosque that focuses on openings in the arrangement of elements such as doors and windows. Maximizing the entry of sunlight and transparent ventilation in the mosque space is influenced by the arrangement of the openings vertically or horizontally as well as wider
	Detailing, element structure and material usage	Natural building materials are used according to the local climate such as wood, bamboo, nipa palm, stone (brick, stone), plaster, marble, concrete, steel, glass, and composites. Decorative elements that focus more on visual effects in proportion, scale, and facade
	Setting	The location of the mosque is more user -friendly and branched. Access routes are easy to pass, have some number of entrances, walking distance and less fencing elements as well as more open. This is to create a sense of being celebrated and welcomed to the mosque. A mosque scale that responds to a user -friendly surrounding context. If large -scale space requires a lot of energy consumption then, it is necessary to follow the proportions of human scale to help provide a level of comfort to users.
Space making	Space organization	Multi -purpose and large spaces such as walkways, verandas and corridors to maximize the use of the space as a moving or circulation zone. The arrangement of space, orientation, and function of space are designed according to the landscape and contours of the soil. The provision of open space and green space as a space mediation space can create natural ventilation to cool the indoor building while reducing heat. In fact, maximize natural lighting into the interior space

**5. Method of Study**

To analyze the two selected case studies and to understand the design approaches adopted by the designers in producing mosques with sustainable elemental features and characteristics, interpretivism paradigm and hermeneutics are adopted to analyze the case study. Interpretivism is applied as this study involves identifying and collecting evidence concerning the social phenomena, which is the responsiveness towards sustainable aspects [10]. Since the present research focuses on investigating the mosque as a case study, Schleiermacher's concepts are useful in two main ways as a technique of analysis. First, referring to his concept of linguistic interpretation and hermeneutic circle will guide the reading and interpreting of the mosque design and all documentation relating to the mosque projects [11][12]. Second, his concept on psychological interpretation is useful when interpreting designers' intentions and ideas to grasp a clear understanding of the designer's ideology that they are situated in. This is because Schleiermacher's hermeneutical theory took the position that understanding is the objective recognition of the author's intended meaning -in which there is a need to see the world from the author's perspective (*verstehen*) and recognize what the author initially felt or thought [13][14]. In brief, Schleiermacher's hermeneutics approach is appropriate for interpreting written text that relates to the mosque design development involving the end product. This is important to achieve the objective of this study, which is to understand how the sustainable design ideas of architects are implemented in the design of mosques from the aspect of form and space-making. In sum, four generic features can be

referred as determinants or indicators to describe the role of mosque. These generic elements are: i) size; ii) spatial organization and treatment; iii) setting; and iv) structural form and material expression [14]. For the benefit of this study, this paper will focus on the indicators as outlined below since they are seen suitable to explain the representation of sustainability aspects in the mosque design as case study.

**Table 2.** Method of Data Collection and Analysis

Element	Indicator	Explanation
Form	Facade [15]	Using a coating system. The basic structure is described for the articulation of the building facade to see the morphology of the building, the addition of elements to the facade, and the geometry of the facade used.
	Details, element structure and material usage [14]	Observe and describe architectural elements. Building materials used by looking at the three elements of the building, namely the roof, walls and floor.
	Setting [16]	Contextual elements on the building environment and landscape are analyzed by analyzing the orientation and placement of buildings as well as soil contours.
Space	Space organization spatial theory of syntax [17].	Analyze floor plans by identifying entry points and movement patterns in the interior. Passive natural lighting and ventilation

The selection of the sustainable architecture Mosque case study is justified based upon three characteristics: first, the mosque's location and placement is in an urban context within a mixed development context. Second, the status ownership of the mosque under the category of state mosque as a prominent landmark. And third, the period of the mosque was constructed during the early post-independence era and the late post-independence era. These two periods are critical as they reflect the level of awareness and intensity on how the designers of these two mosques approach the issue of sustainability in mosque design. Furthermore, these two case studies are selected due to their architectural style portraying the modernist approach in form-making as these mosques represent a significant departure from the stereotypical eclectic style. Thus, the selected case study methods are The National Mosque (Masjid Negara) and The Mizan Mosque (the avantgarde mosque)

**Table 3.** Data Findings

Indicator	The National Mosque (Masjid Negara)	The Mizan Mosque (the avantgarde mosque)
Facade	-Masjid Negara, Kuala Lumpur has a simple design and is full of passive sustainability features such as the application of ventilation elements and excellent natural lighting. Practicing the three (3) basic elements of nature, namely air, water and light, makes this mosque a sustainable building from current climate change and global warming. The three (3) elements are integrated using several components such as geometric patterned translucent wall panels that can help bring ventilation and lighting into the prayer room in addition to water and courtyard elements that can cool the entire prayer	- The mosque has a more structured facade using stainless steel structures and geometric decorations to reflect elements of Islamic art. The steel structure is also used as a retainer for the roof of the mosque to look like a tree branch. openwork geometric decoration to separate maintaining privacy between the outer and inner spaces. is not only beautifying the mosque but functioning for every facade built.

room. Local finishes such as granite tiles can also help cool the floor surface temperature.



-Conflation of modernist elements of horizontal plates, water and contrasting color and materials in Masjid negara, Kuala Lumpur is the outcome of a 'topicalization' of the language of the International style .

-In terms of construction form, this mosque is divided into several linear zones unlike other iconic mosques that are built bulky and dense. This concept helps improve the quality of ventilation and good lighting. Only a small part of the mosque space, the main prayer hall, has been converted into an air - conditioned space, but most of it still retains the original concept.



- The use of the latest technology, namely gas air conditioning (Gas District Cooling) to replace the fan and air conditioning in the interior of the mosque. To provide a cool, comfortable indoor temperature and calm air, the use of water elements around the mosque prayer room is preferred. In fact, the geometric openwork on the mosque windows also plays a role in the air circulation there is the interior space of the mosque.



Details, element structure and material usage

-Folding umbrella roof, main concrete star corner the roof and the 'covered umbrella' tower are 73 feet high. Umbrellas, synonymous with the tropics, are featured prominently - the main roof is reminiscent instead of open umbrellas, the tower closes with folded umbrellas



- Although the facade and open space are designed but the use of ultrasonic technology to repel the arrival of birds into the mosque space is provided. The dome of the mosque also uses stainless steel, in addition to the use of marshrabiya sails around the prayer space serves as a passage of wind and natural illumination of sunlight.



-The mihrab has been modified from square to curved and inlaid with Quranic verses in Moroccan calligraphy. The mimbar is built of carved wood.

--The glass' mihrab'-the modern idea of transparency applied in the 'Steel' Mosque.





- The National Mosque is also equipped with green trees and several water pools and fountains that aim to balance the air in the environment and beautify the mosque area.

-The concept of the mosque is open, the wind roaring from the direction of the lake creates a cozy atmosphere.

-The garden and open space make the atmosphere at Tuanku Mizan Zainal Abidin Mosque cooler and more comfortable.

Setting



-The 22,500 -square -foot main prayer space can accommodate 3,000 worshippers. There are 3 large doors & a special door for royal use. The ragged roof above it reflected the reddish light during the day.

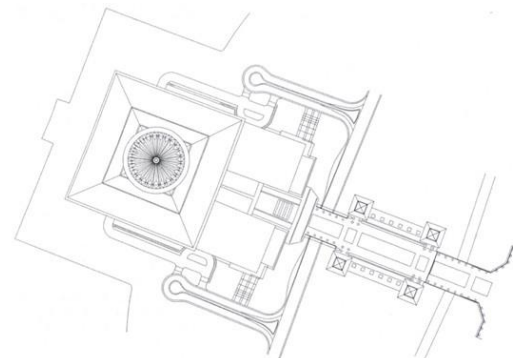
-The Iron Mosque in Putrajaya which focuses more on places of prayer, learning and teaching. It combines traditional and contemporary as well as modern religious elements on the facade. Distinctive design and functional aesthetics. a more systematic and straightforward entrance.

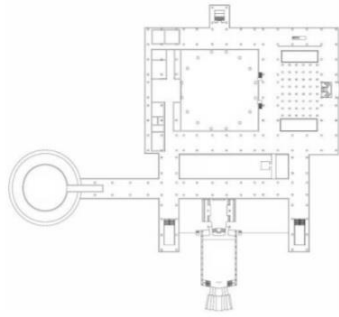
Space organization

- The overflow prayer room which is the veranda/porch of the mosque can accommodate up to 5000 people. This space is protected from the outside by an aluminum lattice curtain.

- Large -scale floor plan with cementitious prayer space according to the function of the mosque space used for prayers and, surrounding community activities.

-The change of plan of the mosque changed from a multi -functional main prayer space to a more complex one with multi -courtyard entrances and arcades.





**Discussion**

The National Mosque and The Mizan Mosque have the potential to have a sustainable design approach tailored to the shape or space of the building in terms of space function organization as well as construction materials.

**Table 4.** Elements and architectural features of a sustainable mosque

Element	Architectural features
Form	<ul style="list-style-type: none"> <li>- A strategic and clear location in the city center is the location of a mosque that has succeeded in becoming a center of worship and a local community surrounded by Muslims and non -Muslims. The closer the distance of the mosque to the community, the stronger the influence of the mosque's function on human life.</li> <li>- Every design and space built has a specific meaning and function. Architecture that provides comfort to its users involves architecture that is simple, practical, non -exclusive and transparent. The design has a local identity and easy access to the community in approaching the mosque. Building materials, structures, and styles using local materials are important to the culture and identity of the local community. this is to further strengthen the function of the mosque as a center for da'wah and the local community.</li> </ul>
Space	<ul style="list-style-type: none"> <li>- To create interaction for mosque users with locals, the use of multi -functional and more universal spaces is designed. The division of space according to the function of the mosque is necessary to involve more optimal use of space, comfort in communal and more organized such as the ground floor is more focused on the public/community while the upper floor is more privacy especially for worship and private.</li> </ul>

**Conclusion**

From the above, designing a mosque as a sustainable community centre involves two essential elements of form and space. First, design that fits into the building placement, multi-functional space. Second, simple design appearance, easy-to-access materials and integrated architecture. This is important because, considering the above architectural strategies, it can build a eco community-friendly mosque in the future even though local values are still maintained. The mosque is nondenominational, inclusive, open and friendly to the outdoors where it is a meeting place and cultural bridge where modernity and innovation meet the sacred principles of eternal life. Nevertheless, sensitivity to sustainable features is significant as it will produce more robust and more durable buildings that can last for centuries.



## References

- [1] Achmad Fanani 2009 *Arsitektur masjid* (Yogyakarta: Penerbit Bentang)
- [2] Othman Mohd Yatim 1989 *Warisan Kesenian dalam Tamadun Islam* (Dewan Bahasa dan Pustaka: Kuala Lumpur).
- [3] Mastor Surat 2008 *Pembangunan Tipologi Masjid Tradisional Melayu Nusantara* (Bangi: UKM).
- [4] Aflaki A, Mahyuddin N, Al-Cheikh Mahmoud Z. and Baharum M R 2015 A review on natural ventilation applications through building facade components and ventilation openings in tropical climates, *Energy and Buildings* **101** 153-162
- [5] Fung Y W and Lee W L 2014 Identifying the most influential parameter affecting natural ventilation performance in high-rise high-density residential buildings, *Indoor and Built Environment* **24**(6) 803–812
- [6] Hussin A, Salleh E, Chan H Y and Mat S 2014 Thermal Comfort during daily prayer times in an Air-Conditioned Mosque in Malaysia *Proceedings of 8th Windsor Conference: Counting the Cost of Comfort in a Changing World*
- [7] M T M Rasdi M and Utaberta N 2010 The Design of Mosque as Community Development Centers from the perspectives of the sunna and wright "s organic architecture, *Journal of islamic architecture*, **1**(1) 1–7
- [8] Mastor Surat 2008 *Pembangunan Tipologi Masjid Tradisional Melayu Nusantara* (Bangi: UKM).
- [9] Movahed K 2014 Mosque as a religious building for community development *Fifth Annual Conference on Information & Religion* 1–8.
- [10] Hays K M 1984 Critical Architecture: Between Culture and Form, *Perspecta* **21** 15-29
- [11] Eco Umberto 2005 *Structuralism*. In Neil Leach *Rethinking Architecture: A Reader In Cultural Theory* (London: Routledge Taylor and Francis Group) pp 173-186.
- [12] Stake R E 2005 *Qualitative Case Studies*. In N. K. Denzin & Y. S. Lincoln (Eds.), *The Sage handbook of qualitative research* (Thousand Oaks, CA : Sage Publications Ltd) pp 443-466.
- [13] Taurens J 2008 *Meaning and Context In The Language of Architecture In: Place And Location: Studies In Environmental Aesthetics and Semiotics* (Tillinn: Institute of Art History, Estonian Academy of Arts) pp 71-82.
- [14] Ramzi Hafsa and Muffeq Maysaa 2012 Structure As A Tool of Achieving Human Scale In The Islamic Architecture *International Conference On Transport, Civil, Architecture and Environment Engineering* (Dubai)
- [15] Shatha Malhis 2004 Local Identity of modern Amman-Jordan: A Perceptual Approach Towards Identifying An Inter-Subjective And Shared Architectural Schemat, *Urban Design International* **9** 119-130
- [16] Ching D K 2010 *Architecture Form, Space And Order 3rd edition* (New Jersey: John Wiley & Sons inc)
- [17] Hillier & Hanson 2006 *The social logic of space* (UK: Cambridge University Press).

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