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Mosque and Environmental Issues: A Research Path Analysis

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Mosques play an important role in the social structure of Muslim communities. Mosque functions are not only limited to religious functions, but also play an important role in addressing various social problems faced by the community as well as environmental issues, such as raising awareness and knowledge related to environmental cleanliness, energy resources, and waste management, where these roles are integrated with Islamic principles. The purpose of this study is to see the development of research on the topic of "Mosque and Environment" and research plans that can be carried out based on journals published on the theme. This research uses a qualitative method with a bibliometric analysis approach. The data used is secondary data derived from the Scopus database with a total of 539 journal articles and the keywords used in data retrieval are "Mosque and Environment". Then, the data is processed and analyzed using the VosViewer application with the aim of knowing the bibliometric map of research development "Mosque and Environment". The results of the study found that in bibliometric author mapping, the authors who published the most research on the theme "Mosque and Environment" were Yüksel A.; Arici M.; Krajčík M.; Mortada H.A.; Baleha M.; Kuppinger P.; Oparin, D.; Sert F.Y.; Karaman Ö. Y.; and Barik R.K.Furthermore, based on bibliometric keyword mapping, there are 4 clusters with dominating words, namely building, system, strategy, use, mosque, person, culture, and element. Furthermore, the topics of research lines related to Mosque and Environment are Energy consumption strategies in mosque buildings, Effects of mosque-based environmental knowledge programs, Societal relations and mosque environmental impact, and Muslim community responses to mosque environmental issues.

Keywords: Mosque; Environment; Research Map; Bibliometric

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INTRODUCTION

The mosque acts as a vital institution in Islamic society, which performs various functions other than just a place of worship, for example playing an important role in education, social engagement, empowerment of Muslim communities, and even plays a role in environmental aspects. For example, in the research of Hasanain & Muslimatusshalihah (2021) and Karumullah (2023), it is explained that the functions of mosques in educational and social aspects include providing religious education, teaching the Quran, Hadith, and Islamic practices to individuals, especially the younger generation, conveying important social values such as ethics, morality, tolerance, and social responsibility. Mosques also contribute to character development, helping to mold individuals with strong personalities, integrity, and responsibility (Karimullah, 2023). On the economic aspect, mosques collect funds from zakat, infaq, shadaqah, and waqf for economic activities and fundraising. Through this, mosques can mobilize the community economy by establishing mosque cooperatives (Hasanain & Muslimatusshalihah, 2021).

Mosques also take an important role in the environmental aspect, where mosques promote environmental sustainability through their architectural design and the activities they organize. By incorporating sustainable design principles, mosques can serve as models for environmentally responsible buildings and educate the public on the importance of green practices. Sobri et al (2021) explained that one of the main aspects of sustainable mosque design is the use of energy-saving technologies. Mosques can be equipped with solar photovoltaic systems to generate renewable energy, reducing their dependence on fossil fuels and lowering carbon emissions. Passive design strategies, such as optimizing natural ventilation and natural light, can also improve the thermal comfort of worshipers while minimizing the need for artificial cooling and lighting (Sobri et al., 2021).

Mosques can also contribute to water conservation through the implementation of water treatment systems and the use of water-saving fixtures. This helps reduce pressure on local water resources and promotes responsible water management (Sobri et al., 2021). Beyond the physical structure, mosques can serve as centers for environmental education and awareness. By organizing workshops, lectures, and campaigns on topics such as waste reduction, energy conservation, and sustainable living, mosques can empower their communities to adopt environmentally friendly practices in their daily lives (Sobri et al., 2021). Thus, it is important to be able to empower mosques, not only limited to religious roles but also social, economic, and especially environmental ones that are integrated with Islamic principles.

However, empowering mosques to adopt environmentally sustainable practices faces several significant challenges that hinder its potential impact. One key issue is the lack of awareness and understanding among mosque leaders and congregants regarding the benefits and methods of sustainable practices. Many mosque administrators do not prioritize environmental issues, considering them secondary to spiritual and community functions. This knowledge gap can lead to resistance to the implementation of green technologies, such as solar energy systems or water conservation measures, despite their potential benefits to the environment and the long-term sustainability of the community (Ummah for Earth, n.d.; Sobri et al., 2021).

Financial constraints are also a considerable barrier. Many mosques operate on a limited budget, which can limit their ability to invest in sustainable infrastructure. The initial costs associated with green building technologies, while often offset by long-term savings, can be daunting for mosque management, especially in communities that may already be struggling economically (Sahid et al., 2024). In addition, there is often a lack of standardized guidelines or frameworks for designing and building eco-friendly mosques. This absence can lead to inconsistencies in how sustainability is approached across different mosques, resulting in varying levels of effectiveness in environmental initiatives. The traditional architectural and design heritage of many mosques can also conflict with modern sustainable design principles, making it difficult to integrate new technologies without compromising aesthetic and cultural values (Azmi & Kandar, 2019; Sahid et al., 2024).

Furthermore, the broader socio-political context can also affect the ability of mosques to engage in sustainability efforts. In areas where environmental issues are not prioritized by local governments or where there are competing social issues, mosques may struggle to secure the support and resources necessary to effectively implement sustainable practices. Overcoming these challenges requires a concerted effort to raise awareness, provide financial support, and develop clear guidelines that align with Islamic values and environmental stewardship (Ummah for Earth, n.d.). Therefore, it is important to see the extent of the current development of *Mosque and Environment* through research, and one method that can be used to see the

development of research is bibliometrics using VosViewer.

Bibliometric methods are able to create and display author journal maps and research paths based on co-citation data or keyword maps based on co-incidence data. Some studies that examine related to *Mosque and Environment* are Ninglasari & Himmawan (2021) examining the extent of the development of mosque library literature using bibliometric tools (RStudio with "biblioshiny" and Vosviewer) based on the Web of Science (WOS) database. Throughout history, mosque libraries have played an important role in the advancement of civilization. From an economic perspective, the progress of civilization in terms of education and welfare cannot be separated from the existence of libraries. The results showed patterns of co-authorship, document citations, keyword co-occurrence, and thematic evolution. The evaluation of research on mosque libraries included 73 documents by 154 authors affiliated with 79 organizations in 20 countries. The most frequently used word in mosque library research was "mosque." The published articles cover the fields of Information Science and Library Science.

Rusdi et al (2023) reviewed the research map of studies that have been conducted on mosque-based economic development. The results showed a significant increase in the number of research articles published from 2013 to 2016. However, in the following years, namely 2017 to 2022 there was a decrease in the number of published research articles. One of the most popular articles is "Assessing the Economic Impact of Cultural Heritage Sites Using a Social Accounting Matrix: The Case of the Mosque-Cathedral of Cordoba" written by Campoy-Munoz, Pilar, Cardenete, M. Alejandro, and Delgado, M. Carmen in 2017 with 32 citations and 5.33 citations per year. Among the researchers, Malik S is the author and journal publication related to mosque empowerment with the highest number of research articles, namely 7 research articles. Some topics that are often discussed are community, zakat, and infaq. Topics that are still rarely discussed include waqf, agency, management, COVID-19, and pesantren.

As-Salafiyah et al (2021) reviewed research around mosque economics in reputable journals. The findings of this research conclude that mosque economics research case studies are still dominated by Indonesia (76 studies), followed by Malaysia (14 studies), and Bangladesh (3 studies). In addition, the average journal publishing time ranges from 9 to 10 years. There are at least 43 journals that publish articles on mosque economics with other study focuses, such as zakat. In addition, the ratio of qualitative research (76%) still outweighs the quantitative approach (14%). The study also found that mosques play an important role in building Islamic socio-economic and political civilization as a basis to support the development of Islamic social funds, halal industries, and microfinance BMT (Baitul Maal wat Tamwil).

Other relevant research includes Sudana et al (2022) examining the development map and trends of Mosque Libraries published by reputable journals, and found that the number of publications on the development of library research roles continues to increase. In general, in Islamic history, mosque libraries have become educational facilities owned by mosques on a waqf basis. Aboul-Enein (2018) examined the phrase "The earth is your mosque" from the perspective of environmental health narratives and education in the Quran, finding that the Quran can serve as an influential medium and educational resource for culturally congruent environmental health interventions in diverse populations, particularly in Muslim communities, and for enhancing and maintaining a healthy environment. Hassanain et al (2021) present an exemplary post-occupancy evaluation of mosque facilities in Saudi Arabia as religious built environments. The results show that worshipers are highly satisfied with the condition of the built environment in mosque facilities, including acoustic comfort, spirituality, and aesthetic performance elements. As-Salafiyah (2020) evaluated the literature on mosque economics published in reputable journals, and found that mosques are crucial in developing Islamic socio-economic civilization.

This research was conducted to complement existing research and fill the gaps of previous research and to expand the literature related to *Mosque and Environment* through research paths. Specifically, the purpose of this research is to see the development of "*Mosque and Environment*" research published by journals on the theme and see future research opportunities by formulating a research agenda.

METHOD

In this study, various scientific journal publications related to the theme "*Mosque and Environment*" around the world were used as data sources. The data is collected by searching for journal publications indexed in the Dimension database using the keywords "*Mosque and Environment*". After that, scientific articles or journals that are relevant to the research theme will be selected based on the publication data that has been collected. Journals equipped with DOI are the criteria in the screening process and data

processing using software. There were 531 journal articles published from within the research theme "*Mosque and Environment*". The development of publication trends related to the research topic was analyzed using VOSviewer software, which can generate bibliometric maps and allow for more detailed analysis.

In order to build the map, VOSviewer uses the abbreviation VOS which refers to Visualizing Similarity (Al-Qital et al., 2022). In previous studies, the VOS mapping technique has been used to obtain bibliometric visualizations which are then analyzed. Furthermore, VOSviewer is able to create and display author journal maps based on co-citation data or keyword maps based on co-incidence data. Therefore, this study will analyze journal maps related to "*Mosque and Environment*", including author maps, and keywords which are then analyzed for research paths that can be carried out in the future through clusters in *keyword mapping*.

This research uses a descriptive qualitative approach with meta-analysis and descriptive statistical literature study based on 531 journal publications that discuss the theme "*Mosque and Environment*". Meta-analysis is a method that integrates previous research related to a particular topic to evaluate the results of existing studies. Furthermore, the qualitative method used in this research is also referred to as a constructive method, where the data collected in the research process will be constructed into themes that are easier to understand and meaningful. The sampling technique used in this research is purposive non-probability sampling method, which aims to fulfill certain information in accordance with the desired research objectives.

RESULT AND DISCUSSION

This research discusses "*Mosque and Environment*" by utilizing 531 publications of journal articles indexed in Scopus. Bibliometrics is a method used to measure and evaluate scientific performance by taking into account factors such as citations, patents, publications, and other more complex indicators. Bibliometric analysis is conducted to evaluate research activities, laboratories, and scientists, as well as the performance of countries and scientific specializations. Some of the steps in bibliometric analysis include identifying the background of the research, collecting the databases to be used, and determining the main indicators to be used in the research.

This section will deepen the meta-analysis results by showing a visual mapping chart depicting 531 journals related to "*Mosque and Environment*". In this research, mapping is done by analyzing keywords and important or unique terms contained in journal articles. Mapping is a process to identify knowledge elements, configurations, dynamics, dependencies, and interactions among these elements. The results of network visualization of 531 journals with the theme "*Mosque and Environment*" will be explained in more detail in the next section.

Bibliometric Author Mapping

Using bibliometric analysis using VOSviewer software, a mapping of authors contributing to the field of "*Mosque and Environment*" was obtained. The resulting image provides a visual representation of the mapping, the bigger and brighter the point marked in yellow, the more the number of journal publications related to the theme "*Mosque and Environment*" that have been published by that author.

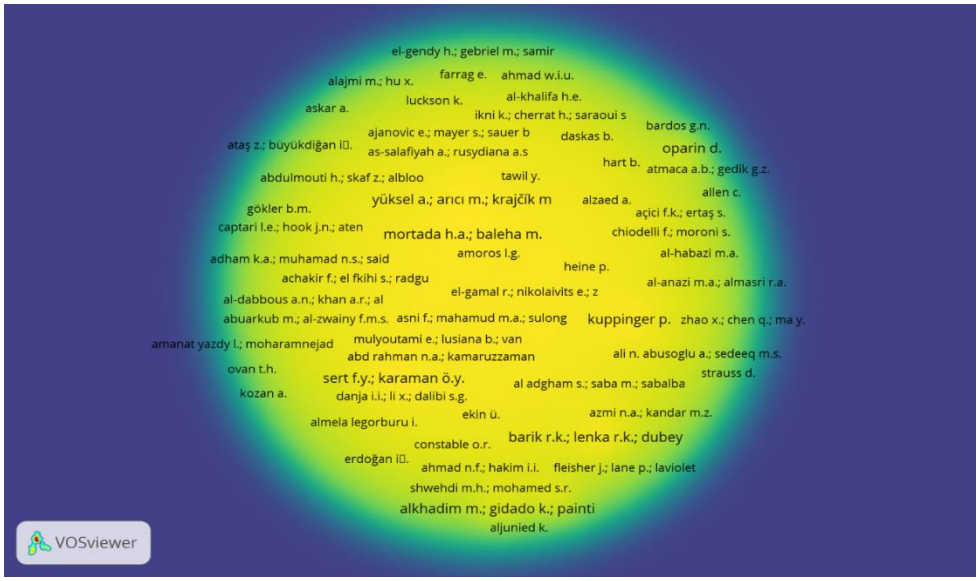

Figure 1. Author Map

The figure above explains that the cluster density in the bibliometric map depends on the intensity of the yellow color shown. And the yellow color on the map depends on how many items are related to other items. For this reason, this section is very important to get an overview of the general structure of the bibliometric map that is considered important to analyze. From this, it is possible to identify the authors who publish the most works.

In general, each author or researcher has different tendencies in each publication of their work. On some occasions, an author appears as a single author, but on other occasions the author may co-author with other authors or researchers, so this will affect the cluster density and some clusters show different densities. However, authors who have a large enough cluster density identify that the author has published the most research on the theme of "*Mosque and Environment*", when compared to authors whose cluster density is lower, so the results found can be a reference for other researchers in the future. From the analysis, it was found that the authors who published the most publications related to "*Mosque and Environment*" include Yüksel A.; Arici M.; Krajčík M.; Mortada H.A.; Baleha M.; Kuppinger P.; Oparin, D.; Sert F.Y.; Karaman Ö.Y.; Barik R.K.; Lenka R.K.; Dubey H.; Mankodiya K.; Alkhadim M.; Gidado K.; Painting N..

Research Map

The figure below describes the trend of keywords appearing in research on the theme "*Mosque and Environment*" and the larger shapes are the most used words in journal publications on the theme "*Mosque and Environment*".

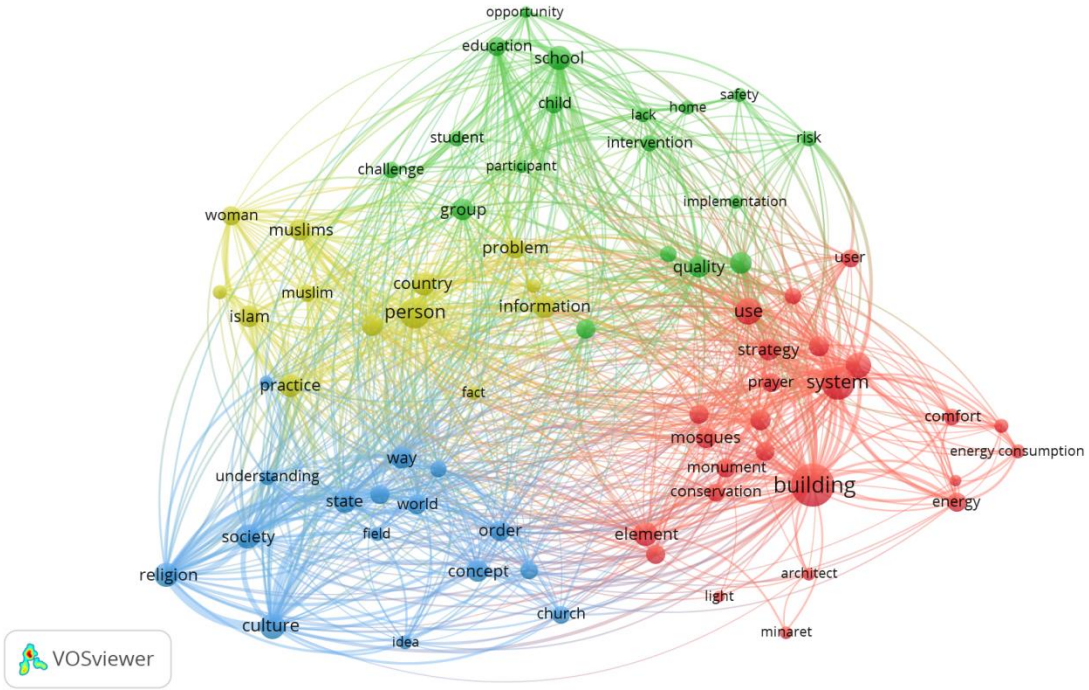

Figure 2. Research cluster

As for the mapping, the keywords that appear most in the publication "*Mosque and Environment*" include building, system, strategy, use, mosque, person, culture, and element, which are then divided into 4 clusters, as follows:

Cluster 1: Energy consumption strategies in mosque buildings

This cluster contains 25 keyword items, namely application, architect, building, characteristic, comfort, condition, conservation, element, energy, energy consumption, house, light, location, minaret, monument, mosque building, mosques, prayer, standard, strategy, system, thermal comfort, type, use, and user. Relevant topics in this cluster include research from Atmaca & Gedik (2023) developing energy-efficient design proposals for air-conditioned mosques in humid climates by evaluating design strategies that minimize energy consumption while maintaining acceptable levels of thermal comfort. The study found

that radiant air conditioning systems are more energy efficient than fan-based HVAC systems, with circular plan schemes and hemispherical designs showing the least energy consumption. In addition, the research highlighted that flat plan types consume less energy than rectangular types, and intermittent HVAC usage leads to higher energy consumption than continuous usage.

Azmi et al (2021) reviewed factors affecting the energy efficiency of mosque buildings, highlighting the unique occupancy patterns and energy-intensive nature of heating and cooling systems. The research identifies issues related to poor thermal performance and operational strategies, indicating that optimizing building design and operations can reduce energy use by up to 50%. It also points out research gaps and proposes future research directions to improve energy efficiency in mosques.

Budaiwi & Abdou (2013) investigated the impact of operational zoning and intermittent HVAC system operation strategies on the energy performance of mosques while maintaining thermal comfort. The results stated that an annual cooling energy reduction of up to 23% was achieved by using appropriate HVAC operation strategies and oversized systems, and a 30% reduction was achieved with proper operational zoning. Comparing the cooling energy consumption of continuous summer HVAC operation of an uninsulated mosque with that of an insulated mosque with an oversized HVAC system operated for 1 hour during each prayer, shows that a 46% reduction in cooling energy can be achieved. Furthermore, proper utilization of operational zoning and HVAC operation strategies is expected to result in significant energy reduction.

Another relevant study by Budaiwi et al (2013) investigated energy savings in mosques through improved envelope and air conditioning operational strategies in hot climates. The study found that the implementation of roof and wall insulation, along with better air conditioning strategies, can result in a reduction in total cooling energy consumption by up to 48%. Taufan et al (2023) reviewed various energy-efficient remodeling strategies for mosque buildings, highlighting the potential to significantly reduce energy consumption and improve thermal comfort. Key findings include the effectiveness of zoning strategies and advanced air conditioning design, which can result in substantial energy savings while maintaining comfort standards.

Harsritanto et al (2021) proposed design strategies to create sustainable mosques, to address the urgent need for environmentally friendly religious buildings given the significant Muslim population worldwide. This research identifies key design strategies, including building layout, lighting, HVAC, water conservation, and IT, to improve mosque sustainability. Samiuddin et al (2023) examined the impact of HVAC operation and air distribution systems on thermal comfort and energy consumption in buildings subject to frequent disruptions, specifically mosques in Saudi Arabia. The findings of this study revealed that irregular HVAC operation can reduce annual energy consumption by up to 30%, while maintaining thermal comfort with suitable air distribution strategies, which highlights the importance of effective design in such environments.

Adam & Ab Ghafar (2022) examined how different mosque roof geometries and orientations affect solar performance in tropical climates, focusing on their effect on solar radiation received at the roof surface. The study found that the rounded dome roof geometry is the most effective in minimizing solar radiation, thus improving energy conservation and indoor thermal comfort. Taleb et al (2023) assessed six energy saving strategies for mosque buildings in Dubai to reduce high energy consumption. The study found that scheduled AC operation yielded the most significant savings, reducing annual load consumption by 19.4%, while combined strategies could lower total annual power consumption by nearly 30% compared to the baseline model. Halabi et al (2024) developed a cost-effective net-zero energy mosque model for Riyadh, Saudi Arabia, utilizing energy conservation measures and passive cooling systems to achieve 80% energy savings, complemented by a solar photovoltaic power system. This research highlights an energy-efficient and economically viable mosque design, providing insights for sustainable development practices in hot and dry climates.

Cluster 2: Effects of mosque-based environmental knowledge programs

This cluster has 18 keyword items, namely challenge, child, education, effect, group, home, implementation, intervention, knowledge, lack, opportunity, participant, quality, risk, safety, school, sense, and student. Research on this topic discusses the impact of environmental education initiatives from programs developed by mosques on Muslim communities. Relevant programs developed by mosques can be in the form of knowledge and awareness raising related to environmental issues, such as energy saving and efficiency, protection of natural resources, and waste management. These programs are integrated with

Islamic principles and environmental teachings in mosque activities.

However, there are still quite a few studies on the topic. One of the studies relevant to this topic is research from Marlina et al (2023) explaining the role of mosques in handling flood natural disasters through environmental education. The background of this research is the phenomenon of flood natural disasters in many areas which causes people to face worrying life risks, the mosque is one of the evacuation sites for affected communities. From this situation, the role of the mosque becomes very important in conditioning the community to stay safe. The results of this study concluded that the role of the mosque in community empowerment must be carried out on an ongoing basis as a controller of organic waste processing as a coordination center for the community. Then, organic waste is processed into liquid and solid local microorganisms that can be used to fertilize the soil, eliminate unpleasant odors in the home, river and surrounding environment, neutralize post-flood bacteria, insecticides, hand sanitizers, environmentally friendly disinfectants. In addition, this research also makes written instructions for practical manufacturing that can be done by the community easily and independently.

Cluster 3: Societal relations and mosque environmental impact

In this cluster there are 16 keyword items, namely church, concept, culture, field, funcion, hand, history, idea, order, relation, religion, society, state, understanding, way, and world. Research on this topic discusses how social relations in the community can influence and be influenced by the environmental impact of the mosque. This aspect includes how interactions between groups, communities, and individuals in the community influence environmental policies and practices in the mosque. Research on this topic explores the social dynamics that shape mosque environmental responsibility and how mosque environmental practices contribute to the well-being and social relations of the wider community.

There is still not much research on this topic, and one of the relevant studies on this topic, Safei & Armstrong (2023), examines the strategies used by the Bandung Grand Mosque to manage and overcome various social problems in the vicinity. Mosques serve as an important element in the structure of Muslim society. The function of the mosque is not only limited to the religious function as a place of worship, but also plays an important role in overcoming various social problems faced by the community. This research explains the challenges faced by the Bandung Grand Mosque include sanitation issues, unregulated street vendors associated with the informal economy, rampant crime, covert prostitution in the vicinity, and increasing consumerism from the nearby shopping center. This research underscores that mosques are not only spiritual oases, but also social-religious institutions that play an active role in providing solutions to various social problems in their urban environments. It emphasizes that the function of the mosque is not only for ritual matters, but also for social activities in urban Islamic societies, especially in managing and overcoming various social problems that exist around the mosque.

Cluster 4: Muslim community responses to mosque environmental issues

There are 13 keywords in this cluster, namely country, covid, fact, information, Islam, life, Muslim, Muslim community, Muslims, person, practice, problem, and women. The topics in this cluster examine how Muslim communities respond to environmental challenges related to mosque management and use. This topic covers from the aspect of community initiatives to address environmental problems to the actions and attitudes of Muslim communities towards these issues. There are still quite a few studies on this topic, and among the relevant studies, Adedeji et al (2021) examined the assessment of urban mosque facilities and environmental issues in Nigeria. The results of this study explain that urban mosque facilities in Nigeria are woefully inadequate in meeting the increasing environmental and spiritual needs of worshipers. Many mosques were built over long periods of time, the facilities within them were designed in traditional ways and capabilities, and now urbanization, combined with various interpretations of religious teachings, is changing people's tastes and perceptions of these facilities, often affecting many worshipers. These points, coupled with the influx of people due to urbanization, affect the environment and health of those using mosque facilities in their neighborhoods.

Koehrsen (2021) examines how Islam, Muslim organizations and religious leaders influence climate change perceptions and mitigation activities. Globally, Muslims constitute the second largest religious group, and there are strong concentrations of Muslims in regions particularly affected by global warming. that there is no uniform interpretation of climate change among Muslims. Based on their interpretation of Islam, Muslims have come up with different approaches to climate change. A small number of Muslim

environmentalists are engaged in public campaigns to raise greater awareness about climate change, seek to reduce carbon emissions through sociotechnological transition efforts, and disseminate a pro-environmental interpretation of Islam. However, it remains unclear to what extent these activities result in broader changes in the daily activities of Muslim communities and organizations.

Ramadhan et al (2019) explained the application of green architecture concepts in mosque design. Mosques as a means of worship are very important for the majority of Indonesian Muslims. There are already many mosques in Indonesia and will continue to grow. Environmental issues due to the large number of building developments are now a global concern, ranging from limited natural resources, global warming, climate change, Urban Heat Island (UHI), to its impact on public comfort and health. The concept of green architecture has been used to minimize environmental damage caused by buildings. The results of the study explain that a green architecture approach with neighborhood perspective criteria can be applied, especially to large-scale mosques such as this case. The approach in this study is more holistic and related to the type of communal building. Criteria such as land ecology enhancement; circulation, movement, and connectivity; water management and conservation; solid waste and materials; community welfare strategies; and building and energy, can be applied by incorporating various design ideas and responses to site issues.

CONCLUSION

This research aims to find out the extent of the development of research on the theme of "*Mosque and Environment*" in the world. The results of the study show that the number of research publications related to "*Mosque and Environment*" is 531 journal articles indexed by Dimension. Furthermore, based on the results of the analysis on bibliometric author mapping shows that Yüksel A.; Arici M.; Krajčík M.; Mortada H.A.; Baleha M.; Kuppinger P.; Oparin, D.; Sert F.Y.; Karaman Ö.Y.; Barik R.K.; Lenka R.K.; Dubey H.; Mankodiya K.; Alkhadim M.; Gidado K.; Painting N is the author who did the most publications with the theme "*Mosque and Environment*". Furthermore, in the development of research related to "*Mosque and Environment*" based on bibliometric keyword mapping, it is divided into 4 clusters with the most used words are building, system, strategy, use, mosque, person, culture, and element. Based on the frequently used keywords, it can be grouped into 4 research map clusters with topics that discuss Energy consumption strategies in mosque buildings, Effects of mosque-based environmental knowledge programs, Societal relations and mosque environmental impact, and Muslim community responses to mosque environmental issues.

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