

# The Scientific, Intellectual, Conceptual, and Collaborative Landscape of Digital Hajj Management Research: A Bibliometric Mapping Review

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**Abstract:** *Understanding digital Hajj management is important for the future development of Hajj administration and to improve the services provided to the pilgrims throughout their spiritual journey. This paper presented a comprehensive bibliometric mapping review with BiblioSpy® to analyse the distribution of document types, trends in citations, global patterns of publication and networks of keyword co-occurrence. The analysis indicates that Saudi Arabia is the most active jurisdiction in terms of research output followed by Malaysia, India and the United States. The majority of the highly cited papers are focused on key issues related to Hajj, such as crowd management through mobile and wireless technologies, emergency preparedness during mass gatherings and the use of the Internet of Things (IoT) for Hajj and Umrah services. The keyword co-occurrence networks reveal the main clusters, including the use of technologies such as the Internet of Things (IoT) and RFID; sophisticated technical solutions for crowd management using AI, machine learning, and computer vision; and contextual themes such as mass gatherings, COVID-19, and healthcare. The study concludes by highlighting the fact that the intellectual structure of digital Hajj management research is highly skewed towards crowd and emergency technological solutions. The study suggests that these findings can be used in future research to explore underdeveloped themes and integrate advanced technologies more deeply for a resilient Hajj administration.*

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**Keywords:** Hajj management, Crowd management, AI, Digital technologies, Bibliometric mapping

## Introduction

The Hajj pilgrimage is the fifth pillar of Islam and holds significant importance for the Muslim community globally. Consequently, ensuring the smooth and secure conduct of the pilgrimage is the primary objective of Hajj management (Mundzir & Arif, 2025). Hajj is the largest gathering of millions of Muslims at the same time and, therefore, poses extraordinary logistical and administrative challenges at all times (Showail, 2022). This scenario calls for Hajj authorities to have effective and strong management that will lead to a major shift towards integration of digital technologies, popularly called ‘digital Hajj management’ (Faiza & Sholehah, 2025).

A major focus of digital management of Hajj is the use of digital technologies to tackle major challenges, such as crowd management and the resolution of problems faced by pilgrims in Mecca (Alshalani et al., 2020; Shah, 2024). The number of studies on digital management of the Hajj is increasing, but a comprehensive, systematic, and quantitative overview of this academic landscape is absent at present. It is argued that understanding the scientific, intellectual, conceptual and collaborative structure of this research domain is indispensable for identifying key trends, major contributors and, more importantly, underdeveloped research themes. Thus, the present study aims to undertake a comprehensive bibliometric mapping review for a systematic analysis of the current research landscape.

The research questions and objectives of this study are as follows:

Research question (RQ)	Research objective (RO)
RQ1: Does digital Hajj management research rely more heavily on empirical articles, review papers, conceptual papers, or conference-based outputs?	RO1: To analyse the distribution of document types (empirical, review, conceptual, or conference-based outputs) in digital Hajj management research.
RQ2: What are the main descriptive statistics (collaboration index, average citations, and authors per paper) of the digital Hajj management dataset?	RO2: To determine the main descriptive statistics (collaboration index, average citations, and authors per paper) of the digital Hajj management dataset.
RQ3: What are the intellectual contributions of the most cited papers in digital Hajj management?	RO3: To identify and describe the intellectual contributions of the most cited papers.
RQ4: Which regions are most active in producing research on digital Hajj management?	RO4: To map the regions most active in producing research on digital Hajj management.

<p>RQ5: Which themes in digital Hajj management are important but underdeveloped?</p>	<p>RO5: To identify important but underdeveloped themes in digital Hajj management.</p>
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**Table 1.** Research Questions (RQs) and Research Objectives (ROs)

The main driver for research in digital Hajj management is the pressing need to resolve the multi-dimensional logistical and safety issues of one of the world’s largest annual mass gatherings (Alshalani et al., 2020; Faiza & Sholehah, 2025; Showail, 2022). The trend of using digital solutions to improve pilgrim services and the efficiency of administration has been widely recorded in the academic literature (Faiza & Sholehah, 2025; Showail, 2022). Digital Hajj management is a key area of interest in digital technologies to address critical issues such as crowd management (Alshalani et al., 2020; Shah, 2024). The central focus of this research area is on two key and interlinked domains: advanced crowd management and the deployment of new digital technologies.

The dominant thematic area in digital Hajj management research continues to be crowd management, given the high-risk environment associated with massive human density (Showail, 2022). Early contributions focused on using simple communication and tracking technologies to monitor and control pilgrims' movement. For instance, studies have explored the application of Radio Frequency Identification (RFID) and general wireless and mobile technologies as foundational tools for crowd management (Yamin & Ades, 2009; Yamin et al., 2018). More recently, there is a shift of attention to sophisticated digital systems. The digital revolution in Hajj crowd management: A comprehensive survey. Felemban et al. (2020) studied the digital revolution in Hajj crowd management that has been moving towards complex technological solutions. Research has assessed the efficacy of specific crowd control measures in the avoidance of stampedes . The ongoing need for strong safety protocols is underscored in terms of direct impact (Alaska et al. , 2017). Another, but related, field is emergency preparedness, in which studies examine the readiness of key personnel, such as emergency nurses, to deal with disasters during mass gatherings in Mecca (Alzahrani & Kyratsis, 2017).

The second main theme is the utilisation of advanced technologies such as artificial intelligence (AI) and the Internet of Things (IoT) in addressing challenges associated with Hajj (Shah, 2024; Showail, 2022). The potential of the Internet of Things (IoT) to develop a 'smart' Hajj environment is acknowledged and Shambour and Gutub (2022) explore the development of IoT research and applications specifically for Hajj and Umrah pilgrims. Besides, much work is devoted to the application of machine learning, deep learning and computer vision for the accurate monitoring and counting of crowds. These sophisticated techniques are designed to provide real-time, granular data for better decision making as exemplified by work on composition loss for density map estimation and localisation in dense crowds (Idrees et al., 2018). In a comprehensive survey, Shah (2024) examines the use of AI technologies to improve the Hajj and Umrah rituals and crowd management. These technical contributions often aim at providing real-time answers to traffic, resource allocation, and safety issues during peak periods.

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Although there is a large body of literature that has provided abundant evidence on the technological progress in crowd and emergency management, there is still no comprehensive understanding of the entire scholarly landscape, including the intellectual structure, the major contributors, and the underdeveloped thematic areas. To this end, the present study utilises a bibliometric mapping approach to systematically map the research domain and identify directions for future scholarly inquiry.

## Methodology

A comprehensive bibliometric analysis of the dataset was conducted using BiblioSpy® (Ahmi, 2026). In particular, the application was used to explore the distribution of document types; analyse annual publication output and citation trends; identify highly cited publications; analyse global publication patterns; and map the conceptual structure through keyword co-occurrence networks.

### 2.1 Search Strategy and Data Extraction

The data for this bibliometric mapping review were extracted from the Scopus database on June 1, 2026. Scopus was chosen because it covers a wide range of journals, conference proceedings and book chapters in technology and social science fields, which are relevant to digital Hajj management. The search string used in the title, abstract and keywords fields was: TITLE-ABS-KEY ("Hajj" OR "Umrah") AND TITLE-ABS-KEY ("Digital Management" OR "Crowd Management") OR ("Smart Hajj" OR "Technology") OR ("IoT" OR "AI" OR "Artificial Intelligence") This initial search returned a preliminary set of documents.

### 2.2 Inclusion and Exclusion Criteria

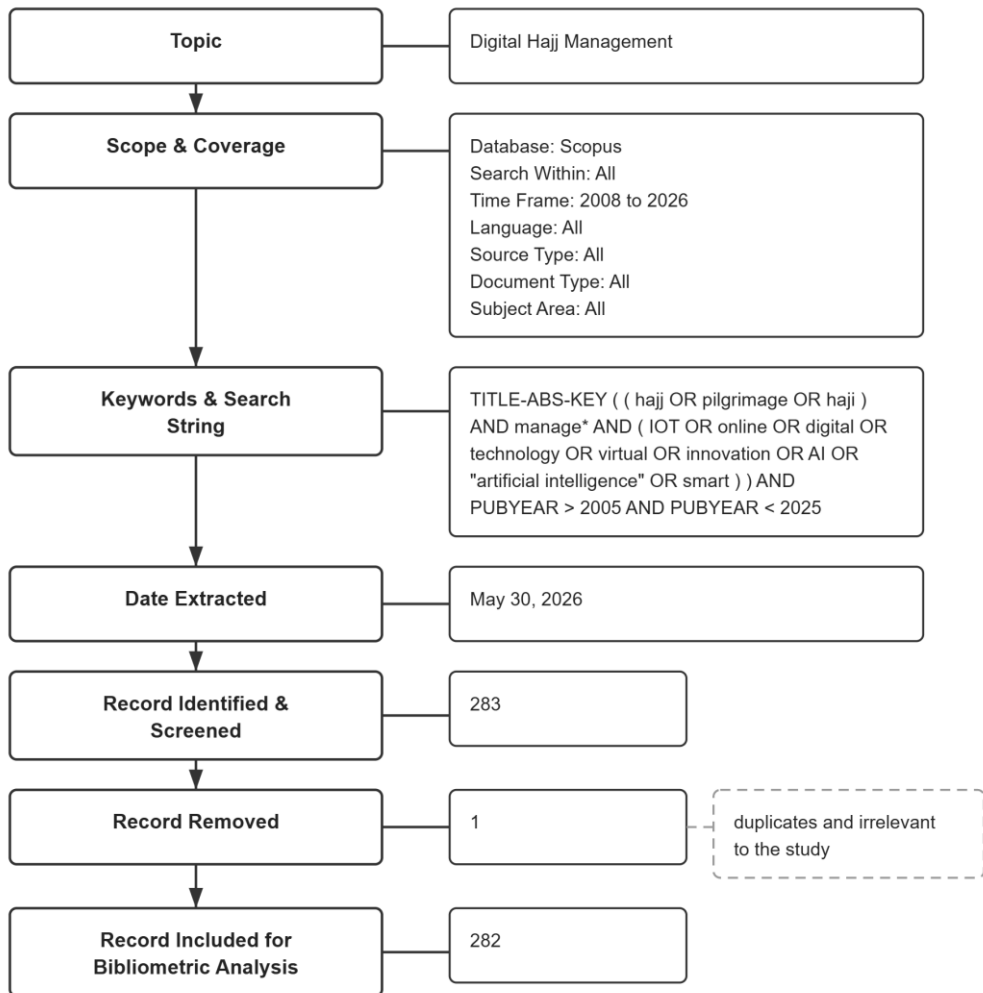
The preliminary dataset was filtered according to the following criteria:

- (1) Only publications in English were included.
- (2) Deleting duplicates.
- (3) The search was limited to document types such as articles, conference papers and reviews, and book chapters, editorials and short surveys were omitted to ensure emphasis on the core research outputs.

The filters were applied, and a manual screening was performed to ensure the relevance to digital Hajj management. Finally, a dataset of 282 publications was obtained and further analysed.

### 2.3 Analytical Approach

This paper used BiblioSpy® (Ahmi, 2026) to conduct a comprehensive bibliometric analysis of the final dataset. The summarised study flow for this research is as outlined below.



**Figure 1.** Bibliometric Study Flow Diagram.

**Source:** Generated by the authors using BiblioSpy® (Ahmi, 2026).

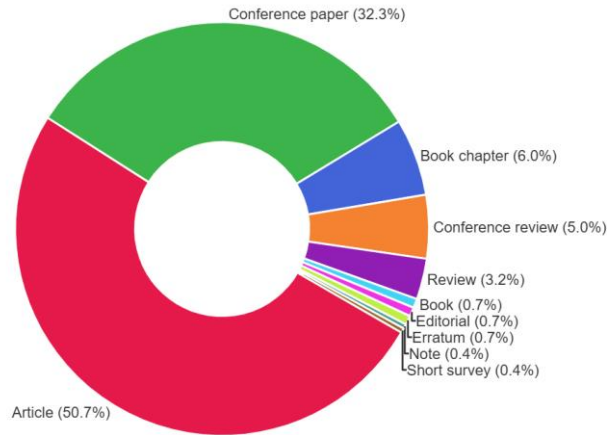
**Results**

The results of the bibliometric mapping review provide a robust quantification of the research landscape for digital Hajj management.

*3.1 The Distribution of Document Types in Digital Hajj Management Research*

Figure 2 illustrates the compositional breakdown of scholarly literature published on digital Hajj management.

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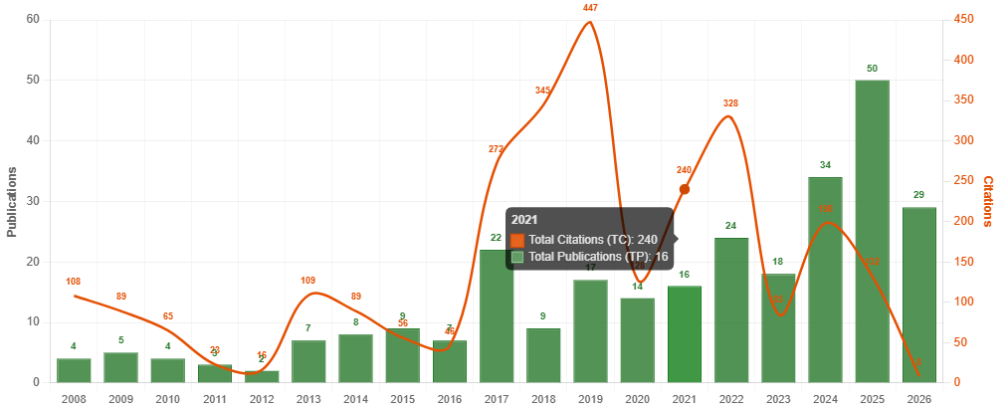


**Figure 2.** Distribution of Document Types in Digital Hajj Management Research  
**Source:** Generated by the authors using BiblioSpy® (Ahmi, 2026).

The largest share of the dataset consists of regular journal articles (50.7% of all publications), which are well established on the basis of formal peer-reviewed primary research. Conference papers are the second most frequent document type (32.3% of the literature distribution), which is an indicator that researchers prefer to present preliminary results and technical innovations in conferences than in journals due to the former's simpler format and quicker publication cycles. Book chapters account for 6% and conference reviews for 5%, indicating that more profound discussions on digital Hajj management are not that frequent in this document type. The small percentage of other document types indicates that the large number of primary research articles and conference papers makes other document formats less visible. The high percentage of research in articles and conference papers (83% combined) shows that digital Hajj management is a dynamic and rapidly changing field that is empirically driven. Researchers are interested in rapidly disseminating technological applications and field studies rather than producing longer publications such as standard books.

### 3.2 Annual Publications and Citations

Figure 3 shows the annual trajectory of publications and the number of citations from 2008 to 2026. The data shows fluctuating but an increasing academic interest in digital Hajj management. The total citations also showed huge variations. They peaked in 2018 for the first time with 447 citations but then sharply fell down in the following year. Recently the publication volume has shown a clear upward momentum. Research output rose from 16 publications in 2021 to a high of 50 publications in 2025. As of the date of data extraction, in May 2026, there are 29 publications for the year.



**Figure 3. Annual Publications and Citations**  
**Source: Generated by the authors using BiblioSpy® (Ahmi, 2026).**

As shown in Figure 3, the research output during the period of 2008–2016 was always low, with a relatively stagnant trend of research output. Annual publications ranged from a low of 4 publications (2008, 2009 and 2011) to a high of 14 publications in 2013, varying in the single digits. Research output started to increase from 2017 to 2023, with 22 publications in 2017 and 28 publications in 2019. One specific data callout shows the year 2021 and the number of total publications for that year, which was 16. The field is currently undergoing its sharpest period of growth from 2024 to 2026. Publications nearly doubled from 18 in 2023 to 34 in 2024 and reached an all-time dataset high of 50 publications in 2025. There are 29 publications in the year 2026 (partial year count based on the data extraction date of 30 May 2026).

Total citations remained modest until a dramatic upsurge starting in 2017 (273 citations). Most Cited Years: The year 2019 had the highest scholarly impact, with an all-time peak of 447 total citations. Other highly cited years were 2018 (345 citations), 2022 (328 citations) and 2021, with precisely 240 citations. Analytical Takeaway The visual connection between publications and citations points to a maturing academic field. Most of the citations are concentrated on older articles (in particular, those published between 2017 and 2022), which can be considered as the foundational literature of the domain. The enormous increase in raw publication volume in 2024 and 2025 shows a rapid, recent growth in research interest and technology development. The large drop in citations for the 2024–2026 period is typical of "citation lag", where recently published research has not been around long enough to be extensively cited by other authors.

*3.3 Highly Cited Papers*

Table 2 shows and ranks the top 10 most influential publications in the digital Hajj management dataset based on their Total Citations (TC). It also shows their immediate impact (Citations per Year - C/Y) and their relative weight (Normalised Total Citations - NTC).

#	Authors	Title	Source	TC	C/Y	NTC
1	Husemann & Eckhardt (2019)	Consumer Deceleration	Journal of Consumer Research	212	26.5	8.06

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2	Idrees et al. (2018)	Composition Loss for Counting, Density Map Estimation and Localization in Dense Crowds	Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)	210	23.33	5.48
3	Yamin et al. (2018)	Managing Crowds with Wireless and Mobile Technologies	Wireless Communication s and Mobile Computing	83	9.22	2.17
4	Alzahrani & Kyratsis (2017)	Emergency Nurse Disaster Preparedness During Mass Gatherings: a Cross-sectional Survey of Emergency Nurses' Perceptions in Hospitals in Mecca, Saudi Arabia	BMJ Open	77	7.7	6.23
5	Brewer & Dourish (2008)	Storied Spaces: Cultural Accounts of Mobility, Technology, and Environmental Knowing	International Journal of Human Computer Studies	76	4	2.81
6	Felemban et al. (2020)	Digital Revolution for Hajj Crowd Management: a Technology Survey	IEEE Access	69	9.86	7.55
7	Alaska et al. (2017)	The Impact of Crowd Control Measures on the Occurrence of Stampedes During Mass Gatherings: the Hajj Experience	Travel Medicine and Infectious Disease	67	6.7	5.42
8	Yamin & Ades (2009)	Crowd Management with RFID & Wireless Technologies	1st International Conference on Networks and Communication s, NetCoM 2009	61	3.39	3.43
9	Yamin (2019)	Managing Crowds with Technology: Cases of Hajj and Kumbh Mela	International Journal of Information Technology (Singapore)	61	7.62	2.32
10	Shambour & Gutub (2022)	Progress of IoT Research Technologies and Applications	Arabian Journal for Science and Engineering	56	11.2	4.1

		Serving Hajj and Ummrah				
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Note: TC = Total Citations; C/Y = Citations per Year; NTC = Normalised Total Citations

**Table 2.** Highly Cited Papers

**Source: Generated by the authors using BiblioSpy® (Ahmi, 2026).**

The dataset is topped by two very influential papers, each of which has passed the 200-citation threshold. The first entry, published in the *Journal of Consumer Research*, is Husemann & Eckhardt (2019) with 212 total citations and the highest annual impact rate in the table (26.5 citations per year). This paper is followed closely by Idrees et al. (2018), published in *Lecture Notes in Computer Science*, with 210 total citations and 23.33 citations per year. The Mid-Tier Influence: There is a substantial quantitative gap between the top two papers and the rest of the list. Yamin et al. (2018) is the third most cited paper, with a total of 83 citations, closely followed by Alzahrani & Kyratsis (2017) on health and mobility in mass gatherings with 77 citations and Brewer and Dourish (2008) with 76 citations. Moreover, Shambour and Gutub (2022) are the latest publication on the top 10 list. Even though it is a relatively recent article, it has already received a total of 56 citations, indicating its high relevance in the present context and a very high citation rate per year (11.2).

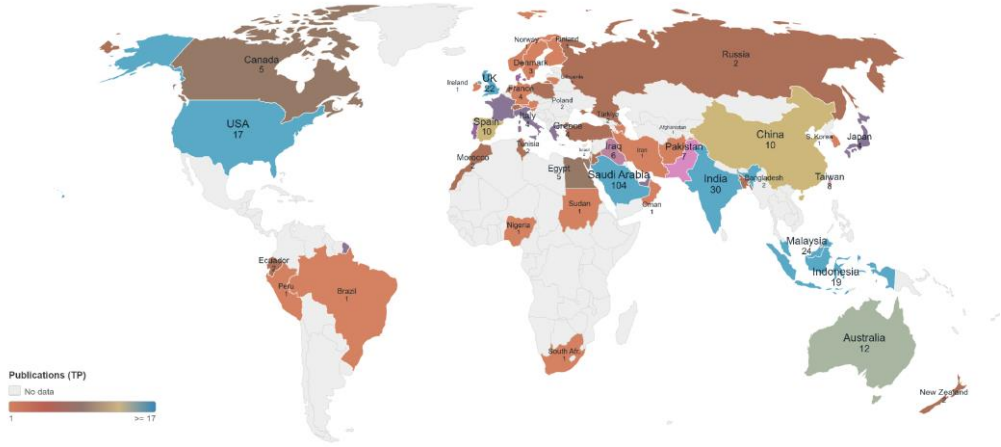
Thematic analysis of the titles indicates that the primary research priority in this dataset is crowd control. Seven of the ten papers in the top ten are explicitly focused on crowd density, tracking technologies, stampede prevention or mass gathering logistics (Idrees et al., 2018; Yamin et al., 2018; Alzahrani & Kyratsis, 2017; Felemban et al., 2020; Alaska et al., 2017; Yamin & Ades, 2009; Yamin, 2019). The structural mechanisms of “service betterment” in literature are based mainly on hardware and network solutions. This is evidenced by large numbers of citations received by papers evaluating Radio Frequency Identification (RFID), Internet of Things (IoT), and mobile tracking frameworks (Yamin et al., 2018; Felemban et al., 2020; Yamin & Ades, 2009; Shambour & Gutub, 2022). Moreover, the highly cited literature spans a wide range of scientific fields, mixing computer science and technical engineering (e.g., IEEE Access, *Lecture Notes in Computer Science*) with medical disaster response (*BMJ Open*, *Travel Medicine and Infectious Disease*) and consumer behaviour (*Journal of Consumer Research*). This cross-disciplinary foundation illustrates that digital Hajj management is not only a technical issue but also a complex intersection of safety, healthcare and human experience.

### 3.4 Geographical Distribution

The global output of research is represented in Figure 4. It is evident that Saudi Arabia dominates with 104 publications, which underscores the primacy and vested interest of Saudi Arabia as the host country of the Hajj. Other main contributors are India (30 papers), Malaysia (24 publications), the USA (17 publications) and Indonesia (17 publications), which indicates that although the Hajj event is localised in Saudi Arabia, the academic and technological interest is globally distributed. There is a strong secondary presence from countries such as India, Malaysia and Indonesia, which is to be expected from countries with large Muslim populations and therefore large numbers of pilgrims travelling to Mecca. Moreover, the active involvement of countries where Muslims are in the minority, such as the USA, Australia and

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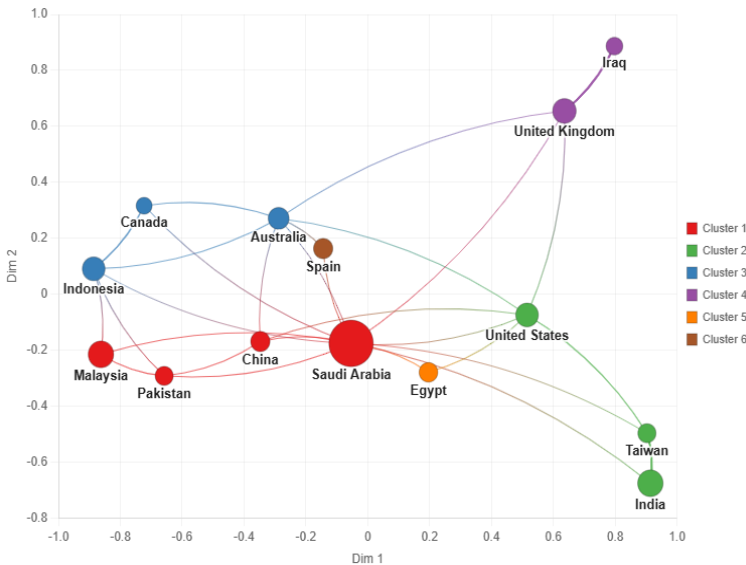
China, indicates that the technological complexities of the Hajj, including crowd control, IoT implementation and mass-gathering logistics, are acknowledged as important research challenges of universal significance that garner global academic expertise.



**Figure 4.** Geographical Distribution of Papers based on Research Output  
**Source:** Generated by the authors using BiblioSpy® (Ahmi, 2026).

3.5 Country Collaboration Network

Figure 5 and its accompanying tables display a VOSviewer-style network visualisation that maps international collaboration patterns among the 14 countries that met the research threshold. The countries are organised into six distinct, colour-coded clusters based on the strength and frequency of their co-authorship links.



**Figure 5.** Network Visualisation of Countries  
**Source:** Generated by the authors using BiblioSpy® (Ahmi, 2026).

This is a network visualisation analysis based on countries generated using a VOSviewer-style mapping technique (association-strength normalisation by default, weighted majorisation layout, and Smart Local Moving (SLM) clustering). The map was generated using the full counting method with association-strength normalisation. The minimum number of occurrences of a term was set to 5, the minimum cluster size to 1, the clustering resolution to 1, and the maximum number of terms retained to 600 (ranked by total link strength). Of the 54 countries, 14 meet the threshold, 14 were retained on the map, and 6 clusters have been generated.

■ Cluster 1 (#E41A1C) consists of the following 4 items:

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
Saudi Arabia	1	105	12	42.00	105.00
Malaysia	1	24	3	8.00	24.00
China	1	10	4	6.00	10.00
Pakistan	1	8	4	11.00	8.00

This is the most dominant and influential cluster in the study. It represents an alliance between the host nation of Hajj (Saudi Arabia) and major Asian contributors. Saudi Arabia leads the cluster with 105 occurrences, and Malaysia offers significant regional support with 24 occurrences and a total link strength of 8.00. Meanwhile, China appears in 10 research publications with a total link strength of 6.00, while Pakistan forms a very concentrated network, with a total link strength of 11.00 from only 8 occurrences. This indicates that China and Pakistan significantly contribute to the discussion on digital Hajj management.

■ Cluster 2 (#4DAF4A) consists of the following 3 items:

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
India	2	24	2	2.00	24.00
United States	2	17	6	16.00	17.00
Taiwan	2	8	3	5.00	8.00

This cluster connects high-capacity technology research sectors. The United States serves as the anchor for collaboration here, establishing 6 links and a strong total link strength of 16.00. India contributes a high volume of literature (24 occurrences) but remains more internally focused or selective in its direct cross-border partnerships (total link strength of 2.00).

■ Cluster 3 (#377EB8) consists of the following 3 items:

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
Indonesia	3	17	5	5.00	17.00
Australia	3	13	7	11.00	13.00
Canada	3	5	3	4.00	5.00

This cluster represents strong collaborative ties spanning Southeast Asia and Western nations. The majority of the data volume comes from Indonesia (17 occurrences), while Australia is the

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dominant networking engine with 7 linkages and a total link strength of 11.00, which effectively brings in smaller contributors such as Canada (5 occurrences) into the wider global conversation.

■ Cluster 4 (#984EA3) consists of the following 2 items:

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
United Kingdom	4	19	4	9.00	19.00
Iraq	4	6	1	1.00	6.00

Cluster 4 represents a tighter, more specialised cluster, with 19 occurrences from the United Kingdom and 6 from Iraq. This cluster is led by the UK, which has a solid tendency for international collaboration with 4 links and a total link strength of 9.00.

■ Cluster 5 (#FF7F00) consists of the following 1 item:

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
Egypt	5	9	2	6.00	9.00

■ Cluster 6 (#A65628) consists of the following 1 item:

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
Spain	6	10	2	4.00	10.00

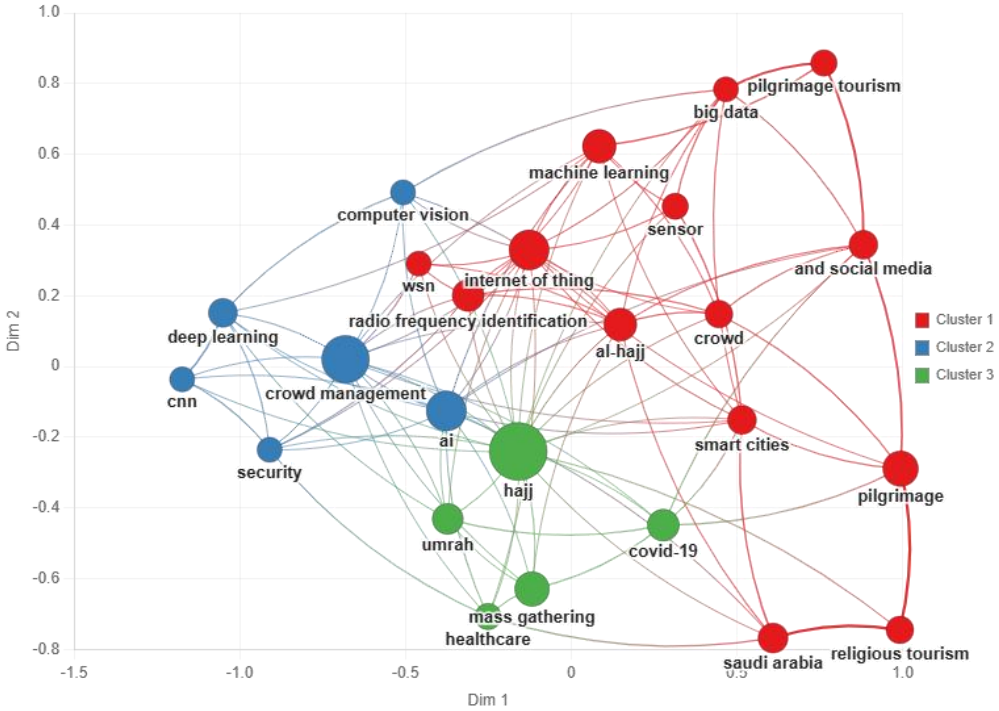
These single-item clusters (Clusters 5 & 6) represent countries that have made notable individual contributions to digital Hajj management research but maintain highly specific or isolated collaborative lines. Egypt shows a solid collaborative footprint with 2 links and a total link strength of 6.00, while Spain logs 10 occurrences with a total link strength of 4.00.

The analysis reveals that Saudi Arabia is the main hub of the whole network. It records the highest number of occurrences (105) and retains 12 distinct collaboration links, which leads to the highest total link strength (42.00) in the dataset. The United States has a lower individual occurrence count (17) and acts as a key collaborative bridge across networks with the highest number of links (6) outside of Saudi Arabia. Australia is next with 7 links and a total link strength of 11.00. India has a high individual occurrence rate (24), but it has a relatively weak collaborative network, with only 2 links and a total link strength of 2.00.

### 3.6 Author Keywords Conceptual Structure

Figure 6 illustrates the conceptual structure of digital Hajj management research by mapping the co-occurrence of author keywords. This is a network visualisation analysis based on author keywords generated using a VOSviewer-style mapping technique (association-strength normalisation by default, weighted majorisation layout, and Smart Local Moving (SLM) clustering). The map was generated using the full counting method with association-strength normalisation. The minimum number of occurrences of a term was set to 5, the minimum cluster size to 5, the clustering resolution to 1, and the maximum number of terms retained to 600 (ranked by occurrences). Of the 966 author keywords, 25 meet the threshold, 25 were

retained on the map, and 3 clusters have been generated. The keyword network is a clear example of the organisational structure of the academic discipline.



**Figure 6.** Network Visualisation of Authors’ Keywords  
**Source:** Generated by the authors using BiblioSpy® (Ahmi, 2026).

■ Cluster 1 (#e41a1c) consists of the following 14 items:

Term

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
internet of thing	1	21	16	44.00	21.00
pilgrimage	1	15	6	7.00	15.00
machine learning	1	13	10	20.00	13.00
al-hajj	1	12	12	22.00	12.00
radio frequency identification	1	11	8	17.00	11.00
saudi arabia	1	9	6	7.00	9.00
and social media	1	8	8	10.00	8.00
smart cities	1	8	10	15.00	8.00
crowd	1	7	7	12.00	7.00
religious tourism	1	7	3	3.00	7.00

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pilgrimage tourism	1	6	3	3.00	6.00
sensor	1	6	5	9.00	6.00
big data	1	5	8	9.00	5.00
wsn	1	5	5	9.00	5.00

The largest cluster is Cluster 1, consisting of 14 items, and encompasses basic digital infrastructure, hardware technologies, and the wider context of religious tourism. This cluster covers the data and hardware ecosystem needed to revolutionise and modernise the pilgrimage experience. The data suggest that researchers are showing greater interest in tracking and data-gathering technologies (IoT, RFID, sensors, WSN and big data) for building smart city infrastructures directly supporting both the religious and tourist aspects of the journey.

■ Cluster 2 (#377eb8) consists of the following 6 items:

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
crowd management	2	33	16	67.00	33.00
ai	2	21	15	45.00	21.00
deep learning	2	8	8	16.00	8.00
cnn	2	5	5	9.00	5.00
computer vision	2	5	7	12.00	5.00
security	2	5	8	11.00	5.00

Cluster 2 is composed of 6 items that focus on computational intelligence and algorithmic solutions directly applied to safety and operational efficiency. This cluster is the software and automation part of the administration of Hajj. The high connectivity of crowd management, AI, deep learning and computer vision indicates that modern research relies on massive visual data and automated AI models for crowd density monitoring and predictive movements to maintain security and avoid historical logistical crises in Mecca such as stampedes.

■ Cluster 3 (#4daf4a) consists of the following 5 items:

Term	Cluster	Occurrences	Links	Total Link Strength	Relevance
hajj	3	54	22	87.00	54.00
mass gathering	3	14	7	21.00	14.00
covid-19	3	11	7	13.00	11.00
umrah	3	10	7	22.00	10.00
healthcare	3	6	7	12.00	6.00

The cluster comprises 5 items that connect the digital technologies to the larger physical reality, the public health challenges, and situational crises of mass gatherings. This cluster defines the study parameters in terms of environment and health issues. Healthcare integration in mass gathering and COVID-19 pandemic The urgency to meet the health screening, medical tracking

and social distancing requirements during the COVID-19 pandemic has driven a significant portion of the literature on digital Hajj management.

## **Discussion**

### *4.1 Interpretation of Results*

The bibliometric results show a significant techno-centric versus pilgrim-centric gap. The domain is excellent in quantifying crowd density and hardware deployment, but it lacks a deep qualitative understanding of the pilgrim's psychological and spiritual experience. Furthermore, the 'Validation of Global Interest' study demonstrates that digital Hajj management is no longer a regional administrative matter but a global laboratory for mass-gathering technologies, drawing on cross-continental research expertise.

### *Intellectual Contributions of the Highly-Cited Papers*

The core of the field is defined by the analysis of the most cited 10 papers. Emphasis is placed on the technical implementation of crowd management systems. Works by Yamin and colleagues (Yamin et al., 2018; Yamin & Ades, 2009; Yamin, 2019) show the seminal role of basic wireless, mobile and RFID technologies. More recently, the field has moved on to more sophisticated solutions, as evidenced by the highly cited work of Idrees et al. (2018) on using composition loss for deep learning-based crowd counting and localisation. A high number of citations for surveys such as Felemban et al. (2020) further demonstrate a continuous need to synthesise the rapidly evolving digital technology applications. It is important to note that the presence of studies on emergency preparedness (Alzahrani & Kyratsis, 2017) and the effect of crowd control on stampedes (Alaska et al., 2017) show that safety and disaster management are still the highest-impact and most urgent topics in the literature. Interestingly, the high ranking of papers outside the direct Hajj domain, such as Consumer Deceleration (Husemann & Eckhardt, 2019) and Storied Spaces (Brewer & Dourish, 2008), points to an opportunity for the field to employ more diverse theoretical frameworks, particularly from consumer research and human-computer interaction, to better understand pilgrim behaviour and technology adoption.

### Global Publication Patterns and Collaboration

The country co-occurrence analysis shows that Saudi Arabia is at the centre of the research output and the major collaborative clusters. This indicates the significant role of the host country in producing and driving research, given the direct administrative requirements for successful management. There are strong collaborative networks between the host country and the major pilgrim-sending countries such as Malaysia and Pakistan. India and the United States, being technical hubs, are coming up with sophisticated computational solutions. Specifically, Indonesia's positioning with Australia and Canada suggests thematic collaborations that could be channelled for management and logistics of pilgrims from geographically dispersed locations.

### *Conceptual Framework and Thematic Focus*

The author's keywords network visualisation presents the conceptual structure systematically in three main thematic clusters: Advanced Technical Solutions (AI, deep learning and security); Digital Infrastructure (IoT and RFID); and Foundational Context (Hajj, mass gathering and

healthcare). This structure suggests that contemporary research depends on automated AI models and basic tracking technologies to predict movement and maintain security, especially after the COVID-19 pandemic, which has made healthcare a permanent part of smart Hajj administration.

#### *4.2 Implications for Theory, Practice, and Policy*

From a theoretical point of view, there is a pressing need to move from purely descriptive technical models to integrative frameworks combining engineering and social science theories. In the practice and policy domain, the Hajj authorities need to move from ‘reactive crowd control’ to ‘proactive digital service design’, ensuring that technological interventions do not undermine the spiritual sanctity of the pilgrimage.

These needed shifts are evidenced by several underdeveloped themes in the current study. Keywords of the social sciences, tourism or more advanced administrative logistics (beyond immediate crowd flow) are less central. The research is rich in technical solutions for immediate crowd safety but less so on the broader administrative or economic or pilgrim experience aspects. Future research should build on the strong technical foundation established in the literature to explore the intersection of technology with broader urban planning, long-term administrative resilience, and the economic impact of digitalisation of Hajj management.

#### *4.3 Limitations of the Study*

This bibliometric review has several limitations. First, the ‘Data Source Scope’ is limited to Scopus. Although Scopus is comprehensive, the exclusion of other databases such as Web of Science, Researchgate, or Google Scholar could have excluded specific regional or emerging conference outputs. Second, the search string’s ‘Keyword Sensitivity’ may accidentally have excluded studies that use more generic terminology (e.g., ‘Mass Gathering Logistics’) without expressly mentioning ‘Hajj’ or ‘Umrah’ in their primary metadata. Third, this bibliometric review is also restricted to articles written in English. This potentially omits valuable researches published in other languages such as in Arabic, Malay, or Indonesian.

### **Conclusion**

In this study, a bibliometric mapping review is systematically conducted to quantify the research landscape on digital management of Hajj. The results show that the field is dominated by technical solutions for crowd safety and emergency readiness. The analysis confirms that the intellectual structure is strong in relation to IoT, AI and wireless tracking technologies but there is a significant ‘techno-centric’ bias. Saudi Arabia is the hub of this global research network, with close ties to key countries sending a large number of pilgrims, such as Malaysia, Indonesia, India and Pakistan. But the study also highlights a disconnect between these advanced technical implementations and the larger, more nuanced needs of the pilgrim experience. In other words, the ‘what’ of digital infrastructure is maturing, but the ‘how’ of pilgrim-centric accessible and inclusive design is underdeveloped.

Future research should move away from a purely technical focus towards integrative, interdisciplinary frameworks linking engineering, sociology and Islamic studies. Scholars are

encouraged to move beyond crowd monitoring and to consider “digital accessibility” in terms of how technology can convey complex religious and logistical information to a diverse, ageing and non-technical pilgrim audience. In addition, there is an urgent need to extend the research to encompass long-term administrative resilience, economic impacts and the implementation of ‘soft-tech’ human-centred guidance models. A shift of bibliometric focus towards these under-researched thematic areas can help the academic community to better promote a truly ‘Smart Hajj’ environment that is both technologically advanced and accessible.

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### **Author Declaration**

We hereby declare that:

- The work has not been published anywhere previously and is not currently under consideration for publication by any other journal or publisher.
- All individuals listed as authors have significantly contributed to the research and writing of this manuscript and approve of its submission.
- All sources, data, and referenced materials have been appropriately cited and credited.
- There are conflicts of interest, financial or otherwise, associated with this publication that could have influenced the research or writing of this manuscript.