

AI IN THE HALAL INDUSTRY: A BIBLIOMETRIC ANALYSIS OF RESEARCH TRENDS AND ESG COMPLIANCE

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ABSTRACT

This study conducts a bibliometric analysis to map the development of Artificial Intelligence (AI) research in the halal industry, with particular attention to emerging trends and thematic evolution. Using the Scopus database, a total of 736 publications were retrieved and analyzed through VOSviewer to identify publication trends, prolific authors, influential works, leading journals, contributing institutions, and keyword networks. The findings reveal a significant growth in publications over the past three years, particularly in 2024 and 2025, reflecting the increasing interest of academics, practitioners, and policymakers in integrating AI into the halal industry. The *Journal of Cleaner Production* emerged as the leading publication outlet, while China and India dominated in terms of research output, followed by the United States, the United Kingdom, and Malaysia. The most prominent keywords include *artificial intelligence*, *sustainability*, *big data*, *machine learning*, and *ESG*, with emerging topics such as *green economy*, *green innovation*, *blockchain*, and *supply chain management*. These findings suggest that AI adoption in the halal industry is increasingly linked to sustainability, governance, and transparency objectives. However, topics such as *halal cosmetics*, *religiosity*, and regional variations remain underexplored, presenting opportunities for future research. The study contributes to the literature by providing a comprehensive overview of the research landscape, offering insights for scholars, industry practitioners, and policymakers to advance innovation and sustainable development in the halal sector.

Keywords: Artificial Intelligence, Halal Industry, Bibliometric Analysis, ESG, VOSviewer, Sustainability

INTRODUCTION

The devastating effects of the climate crisis on our natural ecosystems and socio-economic systems have become increasingly profound in recent decades. Rising sea levels, the intensified frequency of natural disasters, and other extreme climate events have not only disrupted natural ecosystems but also introduced potential health risks to humans and precipitated the extinction of numerous species (Goworek et al., 2018; Sun et al., 2020). These events have imposed substantial economic costs, with the World Meteorological Organisation (2022) reporting that losses attributed to climate change between 1970 and 2021 could reach as high as US\$4.3 trillion. These escalating crises have affected billions of lives and heightened public demand for businesses to pursue profit ethically. Consequently, sustainability has become a critical agenda item for corporate boards worldwide.

In this context, Artificial Intelligence (AI) has emerged as a strategic enabler for advancing Environmental, Social, and Governance (ESG) goals. The convergence of AI with ESG factors is shaping the strategic direction of both enterprises and society in today's fast-paced global environment. This synergy has significant potential to address critical challenges, including reducing the impacts of climate change, fostering social inclusivity, and improving corporate governance. However, AI adoption in ESG initiatives also brings complex risks and ethical concerns, requiring careful consideration to ensure commercial, social, and ecological responsibility (Hulme et al., 1999; Patel et al., 2021).

Given the limited research on the positive and negative impacts of artificial intelligence (AI) on sustainability, there is a pressing need for rigorous mapping of global developments in AI ESG integration (Davidescu et al., 2025; Lee et al., 2024; Xu, 2024; Xiao & Xiao, 2025). Davidescu, Birlan, Manta, and Geambașu (2025) present a bibliometric analysis of Web of Science data (2004–2025), revealing a surge in AI applications in ESG particularly in risk modeling, climate analytics, and AI-powered reporting while highlighting challenges related to data standardization, transparency, and ethical AI in sustainability contexts. Lee, Perera, Liu, Xia, Lu, Zhu, Cairns, and Nottage (2024) propose a structured ESG AI assessment framework co-developed with industry, offering a practical tool for evaluating AI's environmental and social impacts. Xu (2024), in a comprehensive industrial survey, details how AI bolsters ESG capabilities in financial institutions, yet underscores concerns surrounding data governance, privacy, and model robustness. Furthermore, Xiao and Xiao (2025) empirically demonstrate that AI-driven ESG practices positively affect sustainable development in Chinese state-owned enterprises, with ESG performance serving as a mediator between AI adoption and overall sustainability outcomes. Collectively, these works underscore growing academic and practical interest in the AI ESG nexus while exposing methodological and conceptual gaps features this study seeks to address through comprehensive bibliometric mapping.

Parallel to these global sustainability imperatives, the halal industry has emerged as a significant contributor to economic and social development. The halal economy spans diverse sectors including food and beverages, finance, tourism, and pharmaceuticals and continues to grow alongside the increasing Muslim population and rising awareness of halal products (Iskandar et al., 2020). According to the Global Islamic Economy Report, the halal market is projected to reach trillions of dollars in the coming years. Yet, this rapid growth presents significant challenges in ensuring the integrity and traceability of halal products across complex global supply chains. Traditional manual processes in production, monitoring, and certification are often inefficient, costly, and prone to human error (Muhamad, 2020). AI offers innovative solutions to these issues, such as automating quality control, detecting non-halal ingredients, and enhancing supply chain transparency (Bakar & Rosbi, 2019; Alourani & Khan, 2024). Nonetheless, the adoption of AI in the halal industry remains uneven, with most research focusing on isolated technological applications rather than a comprehensive understanding of AI's potential within the halal ecosystem.

The growth of the halal economy also needs to align with the net-zero agenda, which seeks to achieve a balance between greenhouse gas emissions produced and removed by 2050. Halal, in its broader sense, encompasses not only compliance with Islamic law (Laldin, 2006) but also operational practices that are environmentally sustainable, socially responsible, and well-governed. As highlighted during the 2021 Global Halal Business Forum, halal certification implies that a company does not pollute, manages waste responsibly, practices social responsibility, and maintains governance systems meeting global standards (Halal Times, 2021). This underscores the natural convergence between ESG principles and halal practices, where companies in the halal economy are expected to integrate ESG-aligned policies consistent with Shariah requirements.

Against this backdrop, the intersection of AI, ESG, and the halal industry offers immense transformative potential but remains underexplored. Existing literature on these three domains is still fragmented AI and ESG integration studies often overlook halal-specific contexts; AI in the halal industry is seldom examined from an ESG perspective; and ESG halal convergence research rarely considers the role of emerging technologies. This fragmentation creates a significant research gap in understanding how AI can be ethically and effectively applied to strengthen ESG practices in the halal economy while maintaining Shariah compliance.

Therefore, this study seeks to fill this gap by conducting a bibliometric analysis to provide a holistic mapping of global research trends, collaboration patterns, and thematic

developments at the intersection of AI, ESG, and the halal industry. Such mapping will identify leading countries, institutions, and application areas, as well as uncover underexplored issues such as Shariah ESG alignment, ethical AI governance, and sustainable halal production. The findings are expected to offer valuable guidance to academics, industry practitioners, and policymakers in formulating strategies that leverage AI to enhance transparency, sustainability, and competitiveness in the halal economy without compromising its religious, ethical, and governance principles.

LITERATURE REVIEW

Halal studies largely adopt AI for operational assurance (traceability, certification), while ESG studies emphasize data ingestion, risk analytics, and reporting; few papers explicitly integrate Shariah compliance with ESG materiality and responsible-AI governance in a single empirical or comparative design (Azwar, 2025; Davidescu et al., 2025). This leaves open questions on (i) how AI-enabled assurance can simultaneously satisfy halal standards and ESG expectations (e.g., waste, energy, labor), (ii) how explainability and auditability should be adapted for religious-legal requirements, and (iii) what cross-border data and certification interoperability should look like in global halal value chains. Given rapid market growth and rising regulatory and investor scrutiny, the literature consistently points to the need for comprehensive, cross-sector bibliometric mapping and multi-country empirical studies that evaluate AI's value-add for both halal integrity and ESG outcomes. (Azwar, 2025; DinarStandard, 2025; Davidescu et al., 2025).

Artificial Intelligence and Halal Industry

The intersection of artificial intelligence (AI) and the halal industry has gained increasing academic and industrial attention in recent years, driven by the demand for digital transformation across halal value chains. Spanning sectors such as food, pharmaceuticals, cosmetics, finance, tourism, and logistics, the global halal market is projected to reach trillions of dollars, encouraging exploration of how AI can improve efficiency, transparency, and consumer trust in halal-certified products and services. Existing research largely focuses on specific applications, such as machine learning and image processing for halal food traceability, natural language processing for certification, AI-based marketing, and predictive analytics for Muslim consumer behavior (Ellahi et al., 2025; Sunmola et al., 2025). However, these studies are often fragmented, case-specific, and limited to certain regions like Southeast Asia or the Middle East.

Much of the scholarship is conceptual or experimental, lacking large-scale, data-driven insights into AI's impact on the halal industry globally. There are few integrative reviews or comprehensive mappings that outline global trends, key contributors, and future research priorities. To fill this gap, this study applies bibliometric analysis an established method for quantitatively assessing academic literature using Scopus data to examine publication trends, collaboration networks, institutional and country contributions, keyword patterns, and citation dynamics. Such analysis helps identify knowledge clusters, research frontiers, and potential opportunities for innovation.

While bibliometric studies have been conducted on AI adoption in agriculture (Songol et al., 2021; Sood et al., 2024), healthcare (Khanijahani et al., 2022), and Islamic finance (Sarea et al., 2021), similar research for the halal industry is lacking. This makes the present study timely and relevant for positioning the halal sector within the global digital transformation landscape. By comparing findings with related domains, this study highlights the unique trajectory, challenges, and opportunities of integrating AI into halal systems. Ultimately, it offers the first structured bibliometric mapping of AI-related research in the halal industry, providing a foundation for academics, practitioners, and policymakers to address gaps and foster collaboration in building AI-driven halal ecosystems.

Artificial Intelligence and ESG

The integration of big data and artificial intelligence (AI) into environmental, social, and governance (ESG) performance measurement brings significant methodological, ethical, and institutional challenges. While AI offers strong capabilities for processing large and complex ESG datasets, its effectiveness often depends on human interpretation to capture nuanced details in sustainability reports (Kotsantonis & Serafeim, 2019; MacNeil & Esser, 2022; Russell & Norvig, 2003). A recurring concern is the limited transparency and explainability of AI algorithms, particularly deep learning models, which may function as “black boxes” and undermine stakeholder trust (Zheng et al., 2025; Chatterji et al., 2016). Moreover, disparities in technological infrastructure, data management expertise, and AI literacy across countries contribute to uneven adoption and development of AI-based ESG systems (Hamdan et al., 2021). Bibliometric reviews also indicate weak linkages and inconsistent terminology between AI, ESG, and accounting research (Thomas & McElroy, 2016). While some scholars view AI and big data as tools to enhance ESG monitoring and transparency, others regard them as transformative forces redefining ESG reporting and governance (Bickley et al., 2025; Ghauri et al., 2021; Sierra García et al., 2022). These contrasting perspectives highlight an ongoing debate over whether such technologies should be seen as supportive mechanisms or as catalysts driving systemic change in sustainability performance measurement.

HYPOTHESIS

RQ1. What are the influential aspects in the literature on AI applications in the halal industry with respect to ESG compliance?

RQ2. What are the intellectual structures in the literature connecting AI, the halal industry, and ESG principles?

RQ3. What are the thematic trends and emerging topics in the research on AI adoption in the halal industry for ESG-related objectives?

RQ4. What are the research gaps and future research avenues for integrating AI solutions into the halal industry to enhance ESG performance?

METHODS

This research applies bibliometric analysis to examine dominant research trends and propose future research pathways, adopting a methodology that has become increasingly common in recent literature reviews (Hassan et al., 2021; Olczyk., 2016; Tumewang., 2023). As highlighted by Paltrinieri et al. (2019), bibliometric analysis provides several advantages over traditional review approaches, including a more objective process for selecting and extracting relevant studies, thereby minimising selection bias. Furthermore, it combines both quantitative and qualitative indicators while allowing the analysis of extensive datasets.

Following the framework proposed by Tranfield et al. (2003), this study established a review protocol that included the selection of databases, identification of keywords, and systematic data extraction. Scopus was selected due to its recognised quality standards (Durán-Sánchez et al., 2019), comprehensive disciplinary coverage (Mobin et al., 2023; Mongeon & Paul-Hus, 2016), and its frequent utilisation in bibliometric research (Alshater et al., 2021; Tumewang, 2023). Data obtained from Scopus were analysed to identify influential elements such as prolific authors, publication years, leading journals, and publishers, as well as intellectual structures including bibliographic coupling and co-authorship networks. Data mapping and visualisation were conducted using Publish or Perish and VOSviewer.

To capture a broad scope of literature on AI, Halal, and ESG, a focused search strategy was implemented using the query: ("AI" OR "ARTIFICIAL INTELLIGENCE") AND ("Halal" OR "ESG" OR "Sustainability"), applied to titles, abstracts, and keywords. This search initially yielded 9,621 records, as summarized in Table 1. The bibliographic and citation

metadata for all records were exported in CSV format. Subsequently, non-peer-reviewed sources including conference proceedings, book chapters, and news articles were removed. The final dataset was limited to peer-reviewed journal articles categorized under “business, economics, and management” and “economics, econometrics, and finance.”

The time span (2014–2027) was selected to since artificial intelligence experienced notable advancements first demoed in April 2014 (Liu et al., 2018). These developments fueled optimism about AI’s transformative potential in politics, business, economics, healthcare, transportation, and daily life. Including specific industry like halal industry, ESG, and sustainability development. The bibliometric analysis began with performance metrics to determine the most productive authors, institutions, countries, prominent journals, and major funding organizations. Citation analysis was then conducted to identify the most influential publications. Subsequently, network analysis was performed using VOSviewer, incorporating bibliographic coupling and co-authorship mapping. The resulting visual maps classified the literature into distinct research clusters.

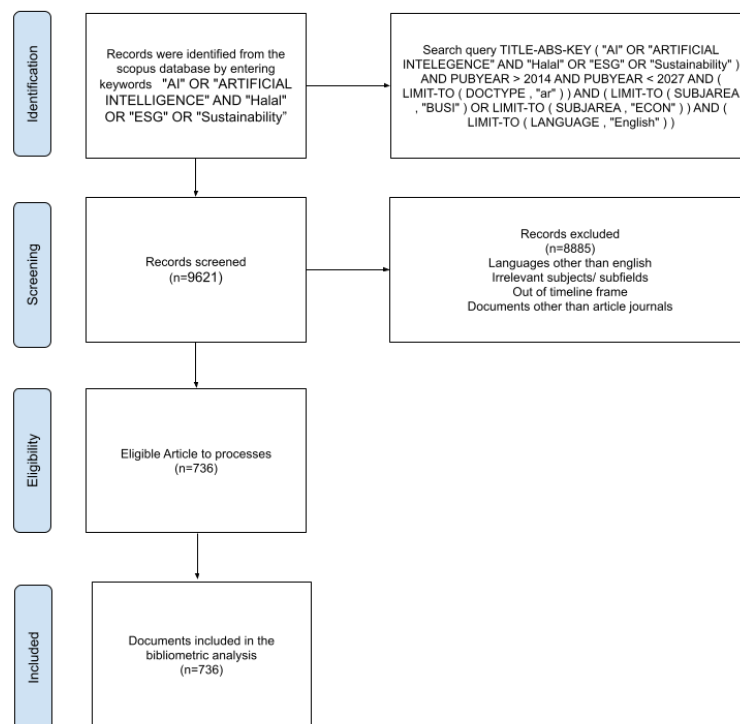


Figure 1. Research Flow Chart Methodology
Source: Created by Authors (2025)

RESULTS

Publications Trends

After extracting and mapping scientific publications on AI, ESG, and the halal industry from the Scopus database, data reflecting the trends in publication growth were obtained.

Table 1. Growth of Publication Numbers

Year	Frequency	Percentage (%)
2016	2	0.3%
2017	1	0.1%
2018	1	0.1%

Year	Frequency	Percentage (%)
2019	4	0.5%
2020	23	3.1%
2021	18	2.4%
2022	36	4.9%
2023	80	10.9%
2024	207	28.1%
2025	364	49.5%
Grand Total	736	100.0%

Source: Processed Data (2025)

Table 1 shows the implementation of refinancing itself is none other than Hajj financing. SPPH is used as a customer guarantee to the Bank. The purpose of MMQ Financing at Panin Dubai Syariah Bank is to facilitate Customer needs with a legal refinancing pattern that has owed the Bank due to the Customer's obligations arising under the MMQ contract. Based on the author's experience during the UIN Malang street vendors at Bank Panin Dubai Syariah, the Bank gave us the task of contacting customers via telephone and the Whatsapp application. We contacted approximately 1,000 contacts, but only a few pilgrims were interested in taking this refinancing product. The main reason for the lack of interest in this refinancing product was that the congregation still needed to learn about it. Refinancing financing at Bank Panin Dubai Syariah is only given to congregations or customers who can meet bank qualifications.

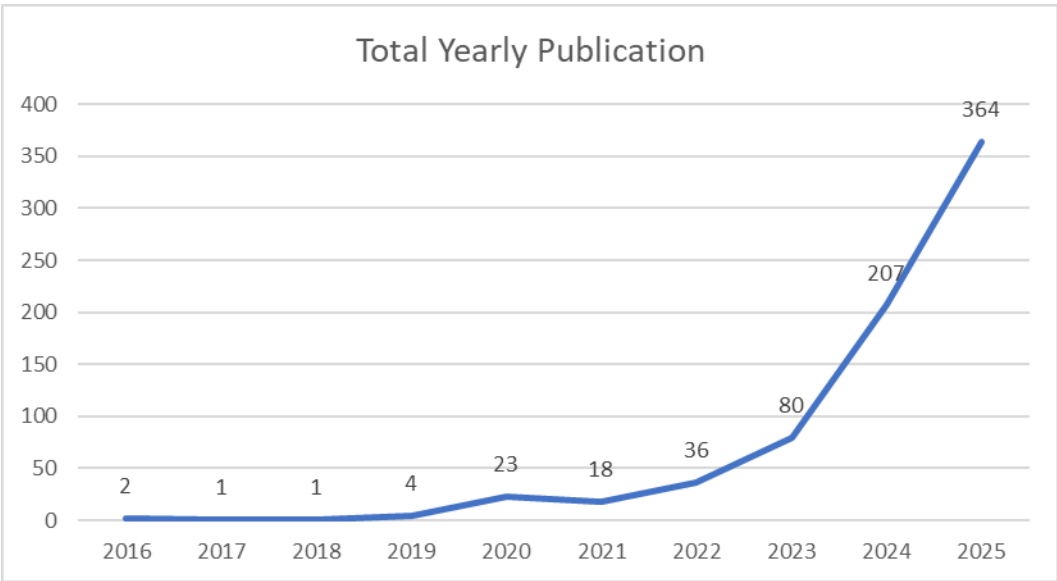


Figure 1. Trends in Publication Growth
Source: Processed Data (2025)

Table 1 and Figure 1 demonstrate the remarkable growth of academic publications at the intersection of Artificial Intelligence (AI), the Halal Industry, and ESG compliance from 2016 to 2025. The data, sourced from Scopus, shows a total of 736 publications, with a pronounced upward trajectory, especially in recent years. Initially, research output was minimal and sporadic. From 2016 to 2019, the number of publications was very low, with a total of just 8 articles over four years. This indicates that the academic community had very limited interest in this specific topic. This period likely represents the nascent stage where the application of AI was not yet widely considered a relevant solution for the

complexities of halal certification and ESG principles.

A significant shift began in 2020. The number of publications surged to 23, marking a turning point in scholarly interest. This spike can be attributed to several factors, including the global push for digital transformation accelerated by the COVID-19 pandemic. The need for contactless and efficient systems likely encouraged researchers to explore how AI could ensure the integrity and traceability of the halal supply chain.

The growth became exponential from 2022 onwards. The number of publications jumped from 36 in 2022 to 80 in 2023, then to 207 in 2024, and finally to a staggering 364 in 2025. This dramatic increase is particularly noteworthy. The years 2024 and 2025 alone account for a combined total of 571 publications, representing nearly 78% of the total output over the entire 10-year period. This rapid escalation points to several key drivers. First, the increasing global awareness and emphasis on Environmental, Social, and Governance (ESG) criteria are pushing industries to adopt more transparent and sustainable practices. Second, AI has matured from a theoretical concept to a practical tool for addressing these complex issues, from ensuring ethical sourcing to validating sustainable production methods. Finally, the integration of ESG principles into the halal framework has created a new, highly relevant area of research that scholars are actively exploring.

Overall, the data clearly illustrates a strong and accelerating scholarly focus on the intersection of AI, the Halal Industry, and ESG. The trend suggests that this field is no longer niche but has become a mainstream topic of interest, with significant research opportunities in addressing the challenges of modernization and compliance within a digital global economy. The data from 2024 and 2025 highlights a strong and dynamic growth, indicating that this area will continue to be a hotbed for research in the coming years.

Table 2. Top 10 Research Keywords in Publications

Fields	Percentage (%)	Frequency
Business, Management	35%	256
Social Sciences	15%	110
Economics, Econometrics, Finance	14%	105
Engineering	8%	57
Decision Sciences	7%	54
Environmental Sciences	7%	53
Computer Science	5%	34
Energy	4%	29
Psychology	2%	14
Arts and Humanities	1%	6
Other	2%	18

Source: Processed Data (2025)

The table illustrates the distribution of publications across different academic fields, shedding light on the multidisciplinary nature of research at the intersection of AI, the Halal Industry, and ESG compliance. The data shows that the field of Business and Management is the most dominant, with 256 publications, accounting for a significant 35% of the total. This highlights a strong academic focus on the practical, strategic, and managerial applications of AI within halal businesses. Researchers are likely exploring how AI can optimize operations, improve marketing strategies, and enhance overall business performance while adhering to halal and ESG standards.

Following this, Social Sciences (15%) and Economics, Econometrics, and Finance (14%) are the next most active fields. The strong presence of Social Sciences suggests that scholars are keenly interested in the societal impacts of AI adoption, including consumer behavior, trust, ethical considerations, and the human element of technology integration in a culturally sensitive context. The focus on Economics and Finance points to research on the economic viability of AI solutions, investment trends, and the financial implications of implementing ESG-compliant technologies in the halal sector.

Fields like Engineering (8%) and Decision Sciences (7%) also show significant activity, reflecting a focus on the technical development and implementation of AI systems. This includes the design of new hardware and software, as well as the creation of algorithms and decision-support systems necessary for automated quality control, supply chain management, and compliance verification. The inclusion of Environmental Sciences (7%) is particularly relevant to the ESG component of the research, indicating a growing focus on sustainability, waste reduction, and the environmental footprint of the halal industry. Conversely, disciplines such as Computer Science (5%) and Energy (4%) have a smaller, but still notable, number of publications. The relatively low percentage for Computer Science might be because much of the core AI research is published within more applied fields like Engineering or Decision Sciences. More niche areas like Psychology (2%) and Arts and Humanities (1%) suggest that a few researchers are exploring the psychological impacts of AI on consumers and the cultural or philosophical aspects of its integration.

This shows that the disciplinary distribution highlights that research on AI in the Halal Industry and ESG compliance is not confined to a single field. Instead, it is a truly interdisciplinary domain, with a primary focus on business and management, underpinned by strong contributions from social sciences, economics, and engineering. This indicates a holistic approach to understanding how AI can be a strategic tool for managing, sustaining, and advancing the halal economy. The data suggests ample opportunities for continued cross-disciplinary collaboration to address the complex challenges that lie ahead.

Authors and Citations

From an authorship standpoint, several researchers have played a leading role in contributing a significant volume of publications.

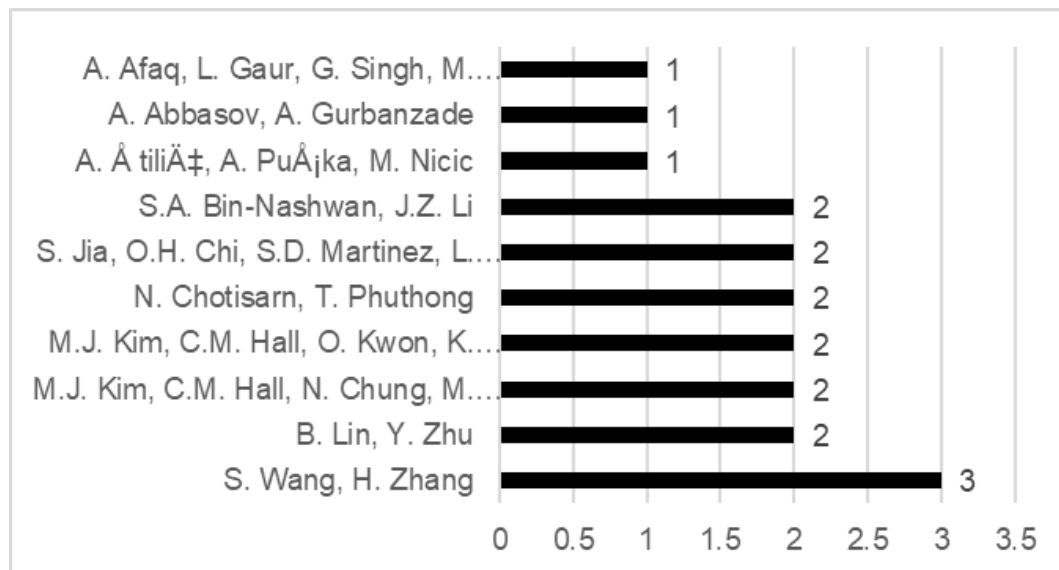


Figure 2. Number of Publications by Author
Source: Processed Data (2025)

The bar chart in figure 2 displays the top authors contributing to the body of literature on AI in the Halal Industry and ESG compliance, based on publications from 2016–2025. The data provides valuable insights into the key researchers driving the discourse in this multidisciplinary field. At the forefront is S. Wang and H. Zhang, who have co-authored the most publications, with a total of 3 documents. Their collaboration indicates a concentrated effort and a leading role in advancing this research area. Following them, several authors are tied with 2 publications each. This group includes S.A. Bin-Nashwan, J.Z. Li; S. Jia, O.H. Chi, S.D. Martinez, L; N. Chotisarn, T. Phuthong; M.J. Kim, C.M. Hall, O. Kwon, K; M.J. Kim, C.M. Hall, N. Chung, M; and B. Lin, Y. Zhu. The presence of multiple authors with two publications highlights a growing community of researchers actively contributing to the field.

A large number of authors, including A. Afaq, L. Gaur, G. Singh, M...; A. Abbasov, A. Gurbanzade; and A. Țiliăș, A. Pușka, M. Nicic, have a single publication each. This signifies that the field is still in a developmental phase, with many new researchers entering the domain and making initial contributions. The distribution of publications, from a few highly prolific authors to a larger number with single papers, is characteristic of an emerging research area with a rapidly expanding base of scholars. To conclude, data on author productivity is useful for identifying the key opinion leaders and potential collaborators in the field. The consistency of authors like Wang and Zhang in their contributions underscores their influence, while the broad participation of other researchers demonstrates the increasing interest and academic relevance of the intersection of AI, the Halal Industry, and ESG compliance.

Table 3. Top Five Most Cited Publications

No	Cites	Authors	Title	Year	Source	Type
1	846	Z. Allam, Z.A. Dhunny	On big data, artificial intelligence and smart cities	2019	Cities	Article
2	788	R. Nishant, M. Kennedy, J. Corbett	Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda	2020	International Journal of Information Management	Article
3	771	A. Di Vaio, R. Palladino, R. Hassan, O. Escobar	Artificial intelligence and business models in the sustainable development goals perspective: A systematic literature review	2020	Journal of Business Research	Article
4	641	Y. Jiang, J. Wen	Effects of COVID-19 on hotel marketing and management: a perspective article	2020	International Journal of Contemporary Hospitality Management	Article
5	506	M.A. Goralski, T.K. Tan	Artificial intelligence and sustainable development	2020	International Journal of Management Education	Article

Source: Processed Data (2025)

The table presents the five most-cited publications relevant to the fields of artificial intelligence, sustainability, and ESG. The citation counts demonstrate which works have had the most significant impact and influence on subsequent research. The most-cited article is "On big data, artificial intelligence and smart cities" by Z. Allam and Z.A. Dhunny (2019), with an impressive 846 citations. While the title doesn't explicitly mention halal, its focus on AI and big data in the context of urban sustainability is highly relevant, given that

halal products and services are primarily consumed in smart urban environments. Its high citation count suggests it's a foundational paper for researchers exploring the broader societal and technological applications of AI and big data. In second place, with 788 citations, is "Artificial intelligence for sustainability: Challenges, opportunities, and a research agenda" by R. Nishant, M. Kennedy, and J. Corbett (2020). This article is a core pillar for your research topic, as it directly connects AI with sustainability, laying out a framework of challenges and opportunities. Its high citation count confirms its role as a key reference for scholars examining the integration of technology and sustainable development goals, which are central to ESG principles. Third is "Artificial intelligence and business models in the sustainable development goals perspective: A systematic literature review" by A. Di Vaio et al. (2020), with 771 citations. This review is essential for understanding how AI is being used to build business models that align with sustainability and ESG goals. It provides a comprehensive overview that is highly valuable for researchers in business, management, and economics.

The fourth most-cited article is "Effects of COVID-19 on hotel marketing and management: a perspective article" by Y. Jiang and J. Wen (2020), with 641 citations. While not directly about AI, its high citation count reflects the significant impact of the COVID-19 pandemic on industries and the subsequent need for technological solutions. This article is relevant to the hospitality and tourism sectors of the halal industry, showing how research quickly adapted to address new challenges. Finally, "Artificial intelligence and sustainable development" by M.A. Goralski and T.K. Tan (2020) is the fifth most-cited article with 506 citations. This paper provides a broad overview of how AI can drive sustainable development, making it a critical reference point for your research. Its popularity suggests it is a go-to source for researchers seeking to link AI to broader sustainability agendas.

Overall, the list of top-cited publications confirms the interdisciplinary nature of your research area. The most influential papers are not exclusively about the halal industry but are foundational works on AI, big data, and sustainability. This highlights that research on AI in the halal industry and ESG compliance is drawing heavily from and contributing to a wider body of literature on technological innovation and sustainable development. The high number of citations for these articles underscores their academic impact and relevance.

Publication Media and Countries

An analysis of the 335 publications retrieved from the Scopus database identified the top ten publication outlets, as shown in Figure 4.

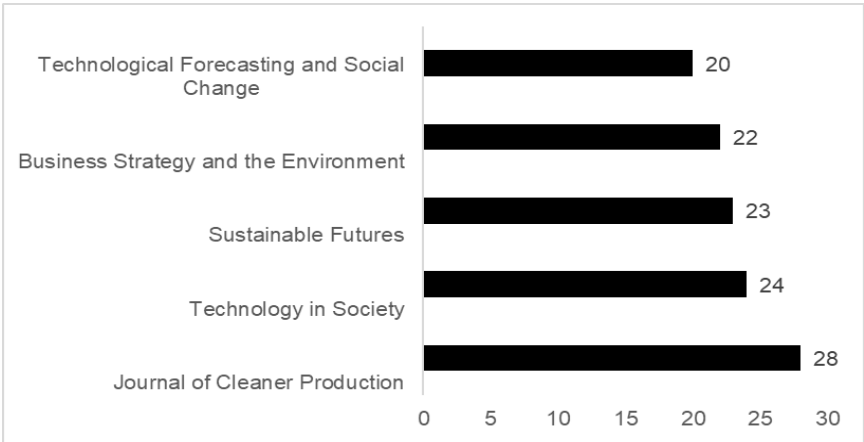


Figure 3. Top Five Publication Outlets and Number of Publications
Source: Processed Data (2025)

Figure 4 illustrates the top five publication outlets for research on AI, the Halal Industry,

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and ESG compliance, based on the number of publications from 2016 to 2025. The data reveals a clear preference for journals with a strong focus on sustainability, business, and the social impacts of technology. The leading outlet is the *Journal of Cleaner Production*, with 28 publications. This journal's prominence highlights the central role of environmental sustainability and "cleaner" production methods in this research field. Its focus aligns directly with the "E" (Environmental) and "S" (Social) components of ESG, as researchers explore how AI can be used to reduce waste and optimize processes to be more eco-friendly and socially responsible.

The second most prominent venue is *Technology in Society*, with 24 publications. The title of this journal directly reflects the overarching theme of your research—the intersection of technology and societal issues. It is a key platform for discussions on how AI impacts society, ethics, and human behavior within the halal industry. The third and fourth leading outlets, *Sustainable Futures* (23 publications) and *Business Strategy and the Environment* (22 publications), further reinforce the primary focus of the research. These journals are dedicated to addressing how businesses can integrate sustainability into their core strategies. Their popularity shows that the research isn't just about the technology itself, but also about the strategic and business-oriented application of AI to achieve sustainability and ESG goals within the halal sector. Finally, *Technological Forecasting and Social Change* has 20 publications, indicating that a significant portion of the research is forward-looking. This journal's focus on future studies and technology assessment suggests that scholars are actively exploring how AI can shape the future of the halal industry and its ESG landscape, analyzing potential trends and long-term impacts.

Overall, the distribution of publications across these journals highlights that the most active research in your field is happening in venues that are not limited to a single discipline. The outlets selected are prestigious, interdisciplinary journals that focus on the broader themes of technology, sustainability, and business strategy. This confirms that research on AI in the Halal Industry and ESG compliance is a rich, integrated field that is well-recognized by a diverse range of high-impact academic platforms.

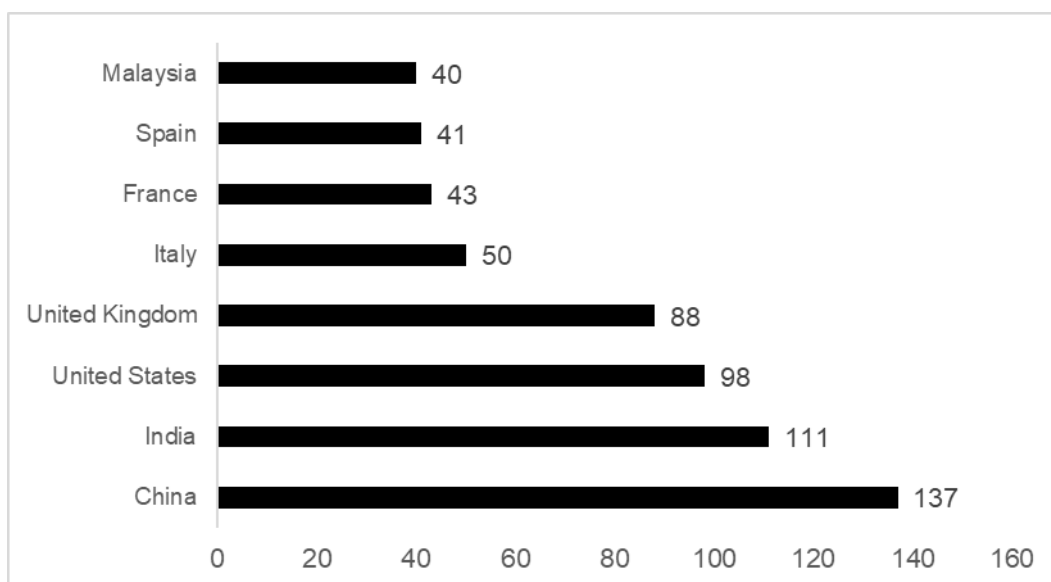


Figure 4. Top 10 Countries with The Highest Number of Publications in The Field of Artificial Intelligence, ESG, and The Halal Industry
Source: Processed Data (2025)

Figure 5 illustrates the geographical distribution of publications, highlighting the top 10 countries with the highest research output in the field of artificial intelligence, ESG, and

the halal industry from 2016–2025. The data reveals key centers of academic activity and the global spread of interest in this interdisciplinary topic. China leads the list with a significant 137 publications. This dominance reflects China's massive investment in AI and technology research, as well as its growing economic ties and interest in the global halal market, which includes exports and trade with Muslim-majority countries. The high number of publications indicates a strategic focus on integrating advanced technology into business and sustainability practices. India ranks second with 111 publications. This position highlights India's emergence as a global leader in both technology and research. The country's large population and significant Muslim community, coupled with its strong tech sector, drive academic interest in applying AI to economic and social sectors like the halal industry, with a focus on efficiency and sustainability.

Following them are the United States (98 publications) and the United Kingdom (88 publications). The strong performance of these two Western nations indicates that research in this field is not limited to Muslim-majority countries or regions. Instead, major research hubs with a focus on business, technology, and global markets are actively exploring the intersection of AI, ESG, and the halal industry. This suggests a recognition of the halal sector's economic importance and the growing relevance of ESG compliance on a global scale. Other countries, including Italy (50), France (43), Spain (41), and Malaysia (40), also show considerable research output. The inclusion of several European countries highlights a widespread interest across the continent, likely driven by a focus on sustainable business practices and the integration of technology into international trade. Malaysia's position with 40 publications confirms its role as a key player in the global halal industry, with strong government support and academic focus on integrating technology and innovation into the sector (Handayati et al., 2025).

Overall, the data demonstrates that the research on AI, ESG, and the Halal Industry has a widespread global footprint. While China and India are the clear leaders, the strong contributions from Western countries and key Muslim-majority nations like Malaysia show that this field is a truly international area of scholarly inquiry with growing relevance worldwide.

Mapping the research development of artificial intelligence, ESG, and the Halal Industry

The mapping of research developments in artificial intelligence and the halal industry, conducted using VOSviewer, generated a visualization depicting the interconnections among frequently discussed topics within this field. The analysis applied the “create a map based on text data” feature, sourcing information through the “read data from the reference manager files” option, with CSV-format files supported by the VOSviewer application. Binary Counting was selected as the counting method, with a minimum occurrence threshold of three terms. This process yielded 31 terms extracted from 736 publications. The resulting topic map, presented in Network Visualization mode, is illustrated in Figure 5.

The VOSviewer network visualization maps the thematic structure of research on AI, ESG, and the Halal Industry, revealing the key concepts and their interconnections. Each node represents a keyword, with the size of the node indicating its frequency of occurrence. The lines connecting the nodes signify co-occurrence, and the line thickness reflects the strength of the link. The color-coded clusters group together keywords that frequently appear together, forming distinct research themes.

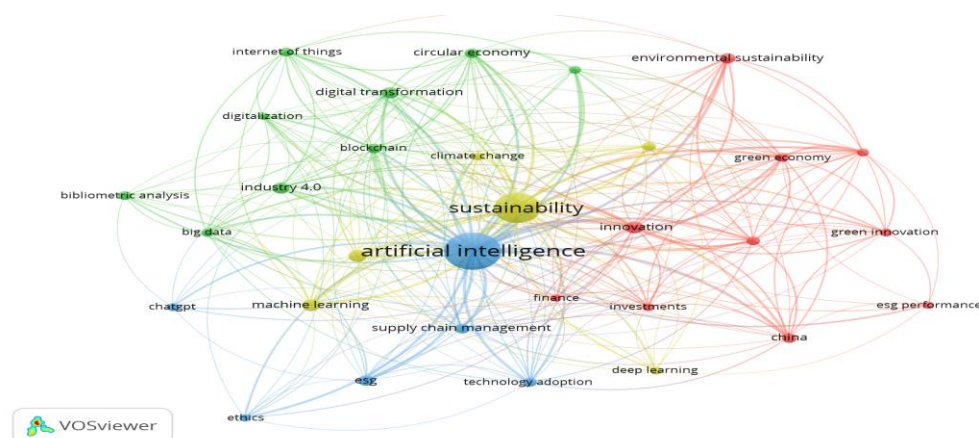


Figure 5. Topic Mapping of Artificial Intelligence, ESG, and The Halal Industry Using Network Visualization Mode
Source: Processed Data (2025)

The map reveals a highly integrated and multidisciplinary research field with four primary thematic clusters:

Cluster 1 (Red): Green Economy and Environmental Sustainability

This cluster is centered on "green economy," "green innovation," and "environmental sustainability." This cluster's direct link to "sustainability" and "ESG" confirms that environmental concerns are a major focus of the research. Topics such as "circular economy" and "climate change" are also present, indicating a deep interest in how the halal industry can use AI to address global environmental challenges and align with green business practices. The close relationship between "green economy" and "china" suggests that a significant portion of this research, particularly from China, is exploring green development strategies. A deeper look at this cluster shows that many studies are focused on theoretical frameworks and policy implications, but there's an emerging need for more empirical research on the practical implementation and impact of these green initiatives.

Cluster 2 (Blue): Technology, Ethics, and Decision Making

This cluster is defined by keywords such as "blockchain," "supply chain management," "digital transformation," and "big data." It shows a strong technical and logistical focus on how AI and related technologies are being used to enhance efficiency and transparency in the supply chain. The presence of "ethics" and "ESG" within this cluster is crucial, indicating that researchers are not only concerned with technological innovation but also the ethical and social dimensions of its application. For instance, studies might explore how blockchain can create a transparent halal supply chain that also ensures fair labor practices and ethical sourcing, directly addressing the "S" in ESG. However, many papers in this cluster are conceptual, and there's a clear gap in large-scale empirical case studies.

Cluster 3 (Yellow): AI and Innovation

This cluster, centered on "artificial intelligence" and "innovation," is a core component of the map. It highlights a general focus on the foundational technologies of AI, such as "machine learning," and its role as a driver of innovation in the broader industry. Keywords like "investments" and "finance" also fall within this cluster, suggesting that this research theme is closely tied to the economic and business aspects of technology adoption. This cluster represents the technological engine of the research field, with many studies exploring the fundamental capabilities of AI to solve industry-specific problems.

Cluster 4 (Green): Sustainable Futures and Social Change

This cluster includes keywords like "digital transformation," "internet of things," and "circular economy." While it overlaps with other clusters, it represents a forward-looking perspective on how technology will shape the future of society. The close proximity to "digitalization" and "Industry 4.0" suggests a focus on the broader technological and social changes that AI brings. Research in this cluster likely investigates the long-term societal impacts of a technologically advanced halal industry, including how it might transform consumer behavior and create new business models that are both technologically savvy and socially responsible.

In summary, the co-occurrence network reveals a highly interconnected research landscape where AI and sustainability are the two central concepts. The field is not just about technology but is deeply engaged with its social, environmental, and economic implications. The clusters show a rich academic dialogue, bridging topics from foundational technology and supply chain logistics to green economics and ethical considerations, providing fertile ground for future research that addresses these complex interconnections. Moreover, the entire network visualization is a representation of the halal industry, viewed through the lens of AI and ESG. The absence of "halal" from the map is not a sign of its irrelevance but rather a deliberate choice to highlight the specific sub-topics and emerging themes within that overarching context.

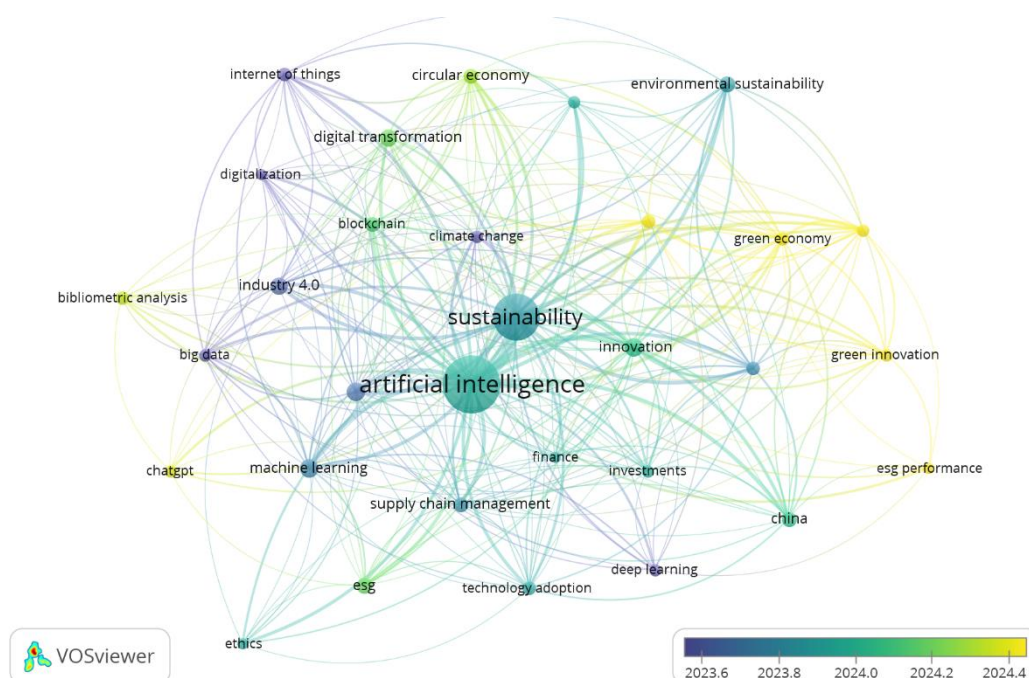


Figure 6. Topic Mapping of Artificial Intelligence, ESG, and The Halal Industry Using Overlay Visualization Mode
Source: Processed Data (2025)

Figure 6, the VOSviewer overlay visualization, provides a dynamic perspective on the evolution of research topics at the intersection of AI, ESG, and the Halal Industry. The color-coding on the map indicates the average publication year of the documents associated with a keyword, transitioning from blue (older topics, circa 2023.6) to green and eventually to yellow (more recent topics, circa 2024.4 and later). This temporal layering reveals the "hot" and emerging areas of research.

The visualization shows that older topics, colored in shades of blue, are foundational concepts. These include core keywords like "artificial intelligence," "sustainability," and "big data." Their blue color confirms that while these topics are central to the field, their

initial discussions and foundational research occurred in the earlier years of the dataset. They form the backbone of the research network, acting as anchor points for newer, more specific topics. The most insightful aspect of this visualization is the emergence of newer, yellow-colored nodes. These represent the most recent research trends. Key recent topics include "green economy," "green innovation," and "ESG performance," all located on the right side of the map. This indicates a clear and rapid shift in academic focus toward the practical and measurable aspects of sustainability and governance. Researchers are moving beyond general discussions of AI and sustainability to investigate tangible outcomes like "ESG performance" and specific strategies such as a "green economy."

Furthermore, the keyword "blockchain" and "supply chain management" are also colored in green and yellow hues, highlighting their growing importance. This suggests that the research community is increasingly focused on using technologies like blockchain to solve real-world problems of transparency and traceability, which are crucial for both halal and ESG compliance. The term "china" also appears with a yellow hue, indicating its recent emergence as a major research contributor and a key subject in the context of these topics.

The growth in publications is not merely linear; it follows a dramatic "hockey stick" curve, indicating a pivotal change in academic interest. The number of publications remained in the single digits from 2016-2019, with a total of only 8 articles. A significant turning point occurred in 2020, with the number of publications jumping to 23. This coincides with the global acceleration of digitalization due to the COVID-19 pandemic, which forced industries including halal to adopt technology for continuity, traceability, and supply chain integrity.

The true explosion of research happens from 2023 onwards. The publication count more than doubles from 36 in 2022 to 80 in 2023, then leaps to 207 in 2024, and reaches an astonishing 364 in 2025. These last two years alone (2024-2025) account for nearly 80% of all publications in your dataset, demonstrating that the intersection of AI, halal, and ESG is no longer a niche topic but a mainstream, high-growth area of scholarly inquiry. This rapid escalation is likely driven by the global corporate push for ESG compliance and the parallel recognition that the multi-trillion-dollar halal industry is a perfect use case for AI-driven solutions. The keyword analysis and overlay visualization provide a deeper insight into the intellectual trajectory of the field. Early research (the blue-colored nodes) focused on foundational, high-level concepts like "artificial intelligence" and "sustainability" (average publication year circa 2023.6). These studies likely explored the general potential of AI and its relationship with broad sustainability goals. However, the more recent, yellow-colored nodes (2024.4 onwards) show a shift towards more specific, applied, and outcome-oriented research. The field has moved from asking "what is the role of AI?" to "how can AI be used to achieve specific goals?" This is evident in the emergence of keywords like "ESG performance," "green economy," and "green innovation." These are not just theoretical concepts but are tied to measurable business and environmental outcomes. This indicates that research is maturing, transitioning from conceptual papers to empirical studies that can provide actionable insights for businesses.

The absence of the keyword "halal" in the visualization is not an oversight; it is an intentional and standard practice in bibliometric analysis. The term "halal" serves as the primary search query that was used to create the entire dataset. Including it in the visualization would cause a massive, disproportionately large node that would obscure the more granular and interesting relationships between other keywords. The software intentionally filters out such core, ubiquitous terms to allow for a clearer analysis of the sub-themes and trends that define the field. The entire map, therefore, can be interpreted as a representation of the "Halal Industry" itself, seen through the lens of AI, ESG, and sustainability. The network shows that the scholarly conversation surrounding the halal industry is not static; it has evolved from a general discussion of its intersection with AI to

a sophisticated and focused dialogue on specific topics like traceability, green finance, ethical considerations, and verifiable ESG performance. The visualization proves that the halal industry is being studied as a modern, dynamic sector that is at the forefront of global trends in technology and responsible business (Kusumadyahdewi et al., 2024).

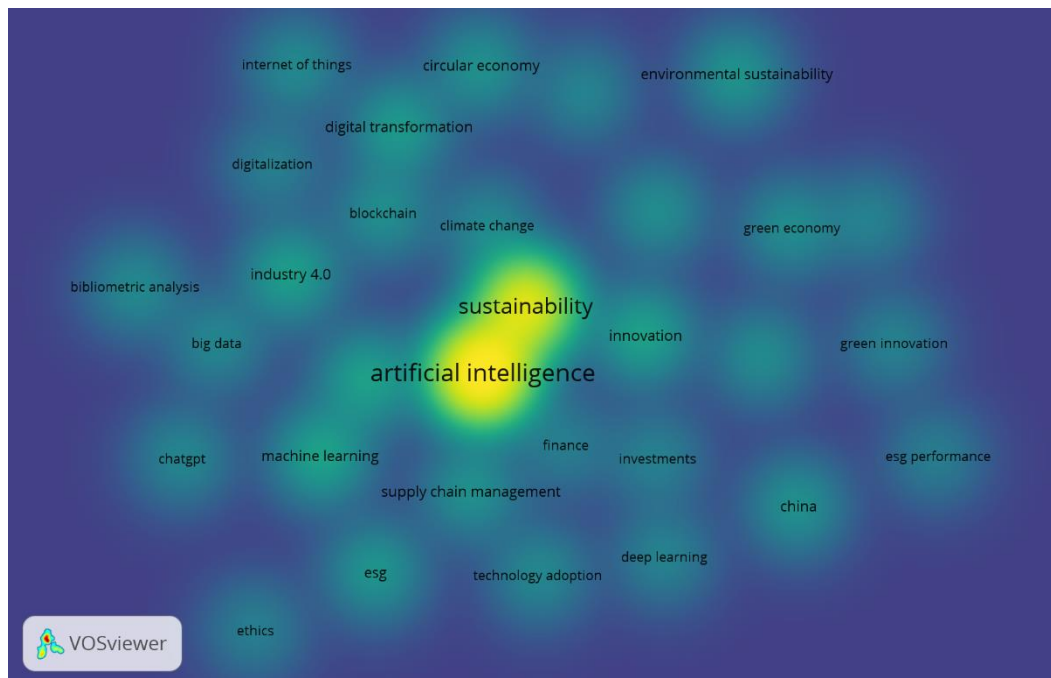


Figure 7. Mapping of Artificial Intelligence, ESG, and The Halal Industry Using Density Visualization Mode
Source: Processed Data (2025)

This figure 7, the keyword density map from VOSviewer provide a clear picture of the most prominent research topics at the intersection of AI, the Halal Industry, and ESG compliance. The data reveals that "artificial intelligence" is the most central keyword, with 381 occurrences and the strongest total link strength (618), confirming its position as the core subject of the research. Closely following is "sustainability," with 246 occurrences and a high total link strength of 480. This highlights that sustainability is not just a secondary theme but a fundamental and integrated aspect of the research, particularly as it relates to ESG compliance (Rahman et al., 2024).

Other significant keywords include "big data," "machine learning," and "innovation," which are all frequently discussed in conjunction with AI. This indicates a strong focus on the technological and strategic aspects of how AI is being applied. The presence of "ESG" as a top-10 keyword with 30 occurrences further confirms that environmental, social, and governance factors are a crucial part of the discourse. The keyword "environmental sustainability" also appears, reinforcing the importance of the environmental dimension within the broader ESG framework.

The VOSviewer density map offers a visual representation of these trends, where warmer colors (yellow) indicate higher keyword density and greater research focus, while cooler colors (blue) represent less concentrated topics. The map clearly shows "artificial intelligence" and "sustainability" as the two brightest and most central keywords. This visual confirms that these two concepts are at the very heart of the research field, with many other topics revolving around them. The close proximity and high density of these two keywords suggest that they are almost always studied together in the analyzed publications. The map also shows smaller, bright clusters around related keywords like "machine learning," "big data," and "innovation," which are frequently linked to the core

themes.

Keywords related to the ESG framework, such as "environmental sustainability," "esg," and "esg performance," are located in different areas of the map, suggesting they form distinct but connected clusters. This indicates that while ESG is a central theme, it is being explored through various sub-topics, from its general application to specific aspects like environmental impact and performance metrics. In summary, the keyword analysis confirms that the research landscape is dominated by the core themes of AI and Sustainability, with a growing emphasis on specific technological applications like machine learning and big data, and a clear, intentional focus on ESG compliance. This multidimensional analysis reveals a rich and evolving field where technology, ethics, and economic principles are converging.

CONCLUSION

Based on the bibliometric analysis of Artificial Intelligence (AI) research in the halal industry from an Environmental, Social, and Governance (ESG) perspective, several conclusions can be drawn that address the study's research questions. First (RQ1), the most influential aspects in the literature are reflected in highly cited works such as Allam and Dhunny (2019), which links AI, big data, and sustainability, and in prolific contributors such as S. Wang and H. Zhang, whose repeated publications demonstrate leadership in advancing AI–ESG–halal integration. The Journal of Cleaner Production emerges as the leading publication outlet, underscoring the dominance of sustainability-oriented scholarship. Second (RQ2), the intellectual structure of this field is shaped by global contributions, with China and India leading in publication volume, followed by the United States, the United Kingdom, and Malaysia, indicating that AI, halal, ESG research transcends Muslim-majority contexts. Third (RQ3), thematic mapping identifies artificial intelligence, sustainability, big data, machine learning, and ESG as core research themes, with emerging trends such as the green economy, green innovation, blockchain, and supply chain management signaling a move toward practical, measurable ESG solutions. Finally (RQ4), research gaps remain in underexplored areas such as halal cosmetics, religiosity, and geographical variations, offering fertile ground for future studies. These findings collectively highlight the rapid growth of this research domain, particularly in 2024–2025, which account for nearly 80% of total publications, and the expanding opportunities for integrating AI into the halal industry to strengthen ESG performance, governance, and Shariah compliance.

Integrating AI with ESG principles presents significant opportunities for industry practitioners to enhance efficiency, uphold halal integrity, and strengthen global competitiveness through transparent, data-driven supply chain systems. For policymakers, these findings provide a foundation for developing regulations that encourage ethical AI adoption while ensuring Shariah compliance and advancing environmental and social sustainability. For academia, the thematic mapping and emerging research trends highlight avenues for interdisciplinary collaboration, including the development of integrated Shariah–ESG models. However, this study is limited to English-language, Scopus-indexed journal articles, potentially excluding relevant works from other databases or languages. Bibliometric analysis offers quantitative insights into trends and topic relationships but does not assess the substantive quality of each publication, and the recent surge in research may mean some emerging themes are not fully captured. Future research should focus on empirical validation through case studies, creating conceptual and practical Shariah–ESG integration frameworks, and developing governance mechanisms for transparent, auditable AI in halal contexts. Additionally, studies on blockchain-based cross-border halal certification, consumer behavior impacts of AI transparency tools, and sector-specific applications in under-researched halal industries such as cosmetics, pharmaceuticals, and tourism can further advance the field.

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