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EDITED BY

Riaz Ullah Khan,
University of Electronic Science and
Technology of China, China

REVIEWED BY

Musawer Hakimi,
Osmania University, India
Waqas Amin,
Southwest University of Science and
Technology, China

*CORRESPONDENCE

Sandi Lubis
✉ sandi.lubis7@gmail.com

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Synergizing AI and blockchain: a bibliometric analysis of their potential for transforming e-governance in smart cities

Sandi Lubis^{1,2*}, Achmad Nurmandi¹, Jamaluddin Ahmad³,
Eko Priyo Purnomo¹, Titin Purwaningsih¹ and
Hazel D. Jovita-Olvez⁴

¹Department of Government Science, Muhammadiyah University of Yogyakarta, Yogyakarta, Indonesia, ²Department of Government Science, Muhammadiyah University of Sidenreng Rappang, Rappang, Indonesia, ³Department of Public Administration, Muhammadiyah University of Sidenreng Rappang, Rappang, Indonesia, ⁴Department of Political Science, Mindanao State University, Iligan Institute of Technology, Iligan, Philippines

Integrating AI and blockchain technologies holds significant potential for enhancing e-governance, particularly in improving predictive policy execution within smart cities. This study conducts a comprehensive review and bibliometric analysis of existing literature to identify trends, key publications, and research gaps. Using peer-reviewed articles indexed by Scopus and published between 2019 and 2024, we observe a significant rise in research output, focusing on the separate applications of AI and blockchain in e-governance. Key themes identified include enhanced transparency, efficiency in public services, and concerns related to data privacy. However, our analysis uncovers a clear gap in empirical studies addressing the combined use of AI and blockchain technologies. The bibliometric coupling map reveals central clusters around “smart city” and “blockchain,” while topics such as “sustainability” and “climate change” show significant impact, highlighting their relevance to governance. Additionally, the study identifies a lack of cross-disciplinary research, emphasizing the need for future interdisciplinary collaborations. Despite the insights gained, the study is constrained by its reliance on bibliometric methods, which may not capture the complexities of real-world technology integration. Future research should prioritize longitudinal case studies and pilot projects to address regulatory, ethical, and practical challenges, contributing to the responsible adoption of AI and blockchain in digital governance.

KEYWORDS

artificial intelligence, blockchain, e-governance, smart cities, bibliometric analysis, technology integration

1 Introduction

The field of digital governance is developing rapidly, and the integration of AI and blockchain technologies is increasingly seen as a groundbreaking way to improve the efficiency, transparency, and responsiveness of governance systems (Clavin et al., 2020). These technologies are especially relevant in smart cities, which use advanced digital tools to optimize urban management and enhance the quality of life for residents (Peng et al., 2020). AI allows smart cities to process extensive data in real-time, providing predictive insights that inform policy decisions and resource distribution; meanwhile, blockchain offers a secure and unchangeable record of transactions and decisions, encouraging public administration transparency and trust (Bai and

Sarkis, 2022). Despite the growing use of AI and blockchain across various sectors, their potential in e-governance, particularly in smart city frameworks, still needs to be fully explored (Sa et al., 2019). While AI is commonly used for its data analysis and processing abilities, the decentralized nature of blockchain presents distinct benefits for ensuring data integrity and security, especially in contexts where transparency and accountability are essential (Zavolokina et al., 2020). The combination of these technologies has significant potential for transforming governance. However, their joint application in smart city projects has yet to be thoroughly investigated, emphasizing a gap in the existing literature and a missed chance to devise more integrated and effective governance strategies (Natarajan et al., 2022).

However, a critical research gap exists in understanding the joint application of AI and blockchain in smart city governance. Current studies primarily examine these technologies separately, with limited empirical research assessing their synergistic potential in governance contexts (Rejeb et al., 2021). Furthermore, most existing literature focuses on conceptual frameworks rather than real-world implementations, leading to a lack of practical insights into the integration of AI and blockchain for policy enforcement and administrative decision-making (Kumar et al., 2022). Additionally, studies often overlook ethical considerations, regulatory challenges, and security concerns that may arise when deploying these technologies in public administration. This gap necessitates a comprehensive investigation into how AI and blockchain can be integrated to enhance governance efficiency, accountability, and security in smart city environments. This research addresses these gaps by conducting a systematic bibliometric analysis of the literature on AI and blockchain integration in e-governance, with a specific focus on smart city policy enforcement. By examining current trends, challenges, and opportunities, this study aims to provide a structured understanding of the transformative potential of AI-blockchain synergy in governance. The findings will contribute to the existing body of knowledge by identifying emerging research trends, offering insights into practical applications, and outlining strategies for policymakers and urban planners to leverage these technologies effectively (Pang et al., 2020; Gong et al., 2021).

1.1 Research objective and questions

This study aims to achieve several key objectives. First, it seeks to identify the prevailing trends in AI and blockchain applications within e-governance, with a particular emphasis on their roles in smart cities. Second, it examines the extent to which AI and blockchain technologies complement each other in enhancing governance efficiency, transparency, and decision-making. Third, it evaluates the challenges and opportunities associated with their integration in smart city governance. Finally, this study explores ethical and regulatory issues that may impact the adoption of these technologies in public administration.

To address these objectives, the research will investigate the following questions:

- 1 What are the prevalent trends in the application of AI and blockchain technologies in e-governance, particularly within smart city frameworks?
- 2 How do AI and blockchain technologies complement each other in enhancing transparency, efficiency, and decision-making in smart city governance?

- 3 What are the significant challenges and opportunities associated with integrating AI and blockchain in e-governance, as identified in existing literature?
- 4 How do ethical considerations and regulatory frameworks impact the adoption of AI and blockchain technologies in public administration?
- 5 What key research gaps remain in exploring the combined application of AI and blockchain in e-governance, and how can future studies address these challenges to inform policy and practice?

By addressing these research questions, this study seeks to bridge the gap between theory and practice in AI and blockchain integration for smart city governance. It offers a comprehensive examination of real-world implementation challenges, providing policymakers and urban planners with actionable insights into the benefits and limitations of these technologies. This research makes a novel contribution by systematically mapping existing knowledge, identifying unexplored avenues, and offering strategic recommendations for enhancing e-governance efficiency in smart cities (Kumar et al., 2021; Tangi et al., 2021). The findings are expected to advance the global understanding of digital governance and provide a valuable reference for future empirical research and policy development efforts. Through its focus on AI-blockchain synergy, this study highlights the transformative potential of these technologies in reshaping urban governance, making it more efficient, secure, and transparent. Moreover, by identifying gaps in the current literature, it lays a foundation for future research aimed at overcoming existing challenges and optimizing the application of AI and blockchain in public administration.

2 Methodology

This study used a systematic literature review (SLR) approach to identify, evaluate, and synthesize existing research (Lubis et al., 2024; Siddaway et al., 2019) on the integration of AI and blockchain in governance, with a specific focus on smart city policy implementation. The SLR followed established guidelines to ensure a comprehensive and unbiased literature assessment. The literature search was conducted exclusively using the Scopus database, which was selected for its comprehensive coverage of scholarly articles across various disciplines, particularly in technology, governance, and urban planning. The search query applied was as follows: (TITLE-ABS-KEY ("Artificial Intelligence") OR TITLE-ABS-KEY ("Blockchain") OR TITLE-ABS-KEY ("E-Governance") OR TITLE-ABS-KEY ("Smart City")) AND PUBYEAR > 2018 AND PUBYEAR < 2025 AND (LIMIT-TO (SUBJAREA, "SOCI") AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (EXACTKEYWORD, "Smart City") OR LIMIT-TO (EXACTKEYWORD, "Blockchain") OR LIMIT-TO (EXACTKEYWORD, "Artificial Intelligence") OR LIMIT-TO (EXACTKEYWORD, "Governance") OR LIMIT-TO (EXACTKEYWORD, "Literature Review") OR LIMIT-TO (EXACTKEYWORD, "Bibliometric Analysis") AND (LIMIT-TO (LANGUAGE, "English") AND (LIMIT-TO (SRCTYPE, "j") AND (LIMIT-TO (OA, "all")))).

In addition to the SLR, bibliometric analyses were conducted to provide a quantitative perspective on the research landscape (Linnenluecke et al., 2020). This analysis included statistical

assessments of publication trends, citation behavior, and collaboration networks (Ji et al., 2022). The bibliometric analysis began with data extraction from several Scopus-indexed publishers, followed by metadata cleaning and standardization, including authorship, publication year, keywords, and total citations (Singh C. K. et al., 2020). Descriptive analyses of publication metrics, including annual publication trends, leading journals, most cited articles, and geographic distribution, provided an overview of research growth and focus areas (Butt et al., 2021). Keyword co-occurrence analysis was conducted to identify recurring themes and relationships, with network visualization tools such as VOSviewer, R-Studio, and Citespace used to map clusters of related topics such as “smart cities,” “blockchain,” and “AI in electronic governance.” Citation analyses identified influential papers and authors and their impact using metrics such as total citations and key findings in recent research (Ivanović and Ho, 2019; Ghani et al., 2020; Butt et al., 2021).

In contrast, the analysis of collaboration networks reveals key partnerships and interdisciplinary trends among authors and institutions (Fares et al., 2021). Finally, thematic evolution analysis tracks the development of fundamental research areas, highlighting the shift from theoretical frameworks to practical applications in innovative urban governance (Hu, 2022). These bibliometric insights complement the SLR by revealing the intellectual structure and dynamic trends in integrating AI and blockchain for governance. It is important to note that selecting Scopus as the exclusive data source may introduce some bias, as it excludes research published in other databases such as Web of Science (WoS) or open-access repositories, which could impact the comprehensiveness of the findings. However, Scopus was chosen due to its comprehensive coverage of high-quality, peer-reviewed journals across various disciplines, including technology, governance, and urban planning. The database provides well-maintained metadata and supports advanced bibliometric analysis tools, ensuring consistency and reliability in the data. Additionally, using Scopus aligns with prior research in the field, allowing for better comparability and consistency in analyzing AI,

blockchain, and innovative city governance. The methodological framework (Prisma Flow) that guided the research process is depicted in Figure 1.

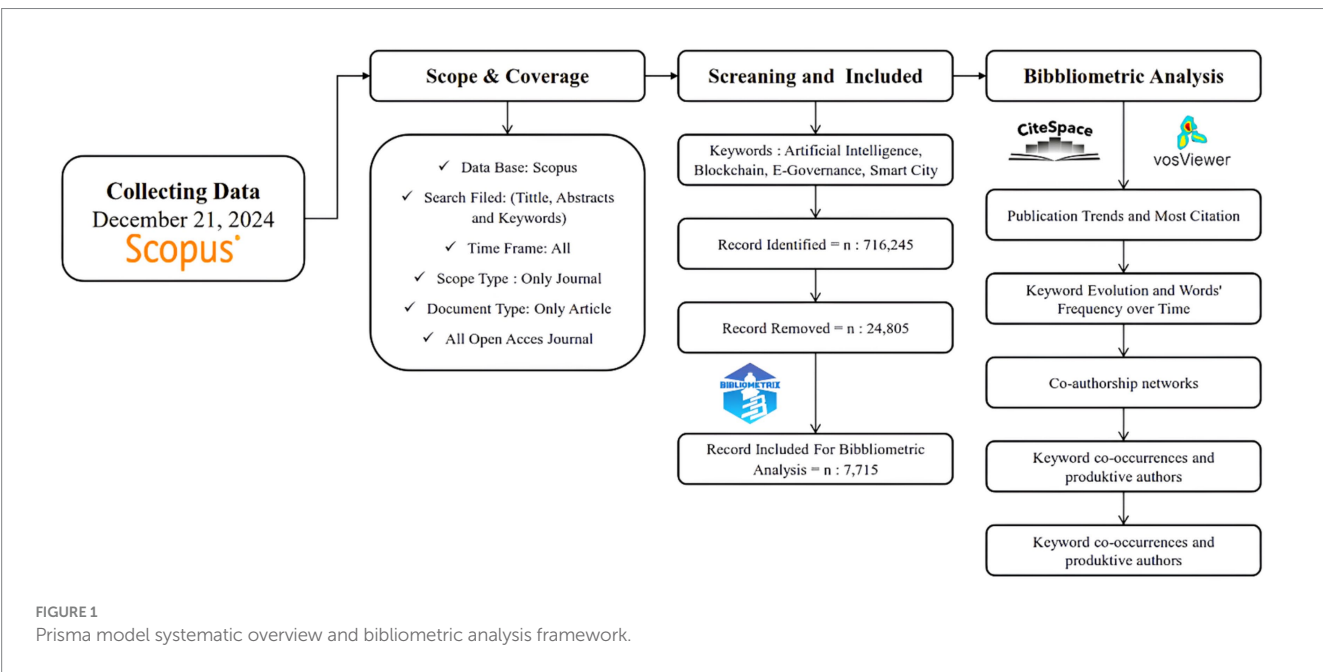
3 Results

3.1 Overview of AI in e-governance

AI has significantly influenced governance, demonstrating the potential to enhance decision-making, service delivery, and operational efficiency (Niyi Ogunbiyi et al., 2021). In smart cities, AI proves particularly advantageous because it can process vast amounts of data generated by sensors and other digital platforms. It provides real-time insights to inform policy choices and improve urban management (Yigitcanlar et al., 2020). For instance, AI can predict traffic patterns, optimize energy consumption, and bolster public safety through techniques like predictive policing and emergency response systems (Mukhopadhyay et al., 2022).

Moreover, AI is increasingly integral to public service delivery as governments implement AI-driven tools to enhance citizen interaction and optimize administrative processes (Khan and Krishnan, 2021). AI-powered chatbots, for example, assist 24/7 access to government services, answer citizen inquiries, and manage routine requests, eventually lessening the burden on government employees and improving service efficiency (Sun and Medaglia, 2019). Besides, AI’s ability to detect patterns in large datasets allows for the early detection of issues such as fraud or inefficiency, promoting more proactive and effective governance (Tan et al., 2023).

However, the deployment of AI in e-governance brings several challenges. These challenges encompass concerns about data privacy, algorithmic bias, and the ethical implications of AI in public administration decision-making (Zhang et al., 2020). As AI becomes increasingly integrated into governance processes, it is essential to address these challenges to guarantee that AI-driven systems remain



transparent, accountable, and aligned with public values (Taeiagh, 2021).

3.2 Overview of blockchain in e-governance

Blockchain technology is acknowledged for its decentralized and unchangeable ledger, offering a solid solution to various issues faced by traditional governance systems, particularly in promoting transparency, security, and trust (Zwitter and Hazenberg, 2020). In smart cities, blockchain can create secure, tamper-resistant records of transactions, contracts, and public decisions, thus enhancing the integrity of governance procedures (Khanna et al., 2021). For example, blockchain can be applied in voting systems to ensure that election results are transparent and verifiable, reducing the risk of fraud and boosting public trust in the electoral process (Yang et al., 2020).

Besides, the potential of blockchain to simplify bureaucratic processes is significant (Jun, 2018). Besides, blockchain's transparency can help fight corruption by making government transactions and decisions more accessible to the public, boosting accountability (Schmidt and Wagner, 2019). For instance, blockchain can assist in the secure sharing of information between different government agencies, improving coordination and collaboration throughout the public sector (Lin et al., 2021). Moreover, the transparency provided by blockchain can help combat corruption by making government transactions and decisions more visible to the public, thereby increasing accountability (Shava and Mhlanga, 2023).

However, the adoption of blockchain in e-governance does pose several challenges (Bhumichai et al., 2024). These challenges include the technical complexities of blockchain systems, needing significant infrastructure investments, and possible resistance from stakeholders who are used to traditional governance models (Mohamed et al., 2022). Additionally, there are legal and regulatory considerations that must be addressed to ensure that blockchain applications in governance are compliant with existing laws and policies (G. Xu et al., 2020).

3.3 Convergence of AI and blockchain

Integrating AI and blockchain in e-governance is essential to how governments manage and safeguard data, improve decision-making, and provide better public services (Tan et al., 2022). The capabilities of AI's data analysis are greatly strengthened by blockchain's secure and transparent data management systems, creating a partnership that is particularly beneficial in smart cities, where real-time data and trust are essential (Bibri et al., 2024). For instance, AI can analyze data stored on a blockchain, delivering valuable insights into urban planning, traffic control, and public safety. In contrast, blockchain technology ensures that this data is secure and remains unchanged (Xu and Zou, 2021).

Besides, integrating AI and blockchain can enhance the transparency and accountability of decision-making procedures (Wen et al., 2023). AI technologies can refine and bolster these processes, while blockchain offers an immutable record of decisions that stakeholders can verify, enhancing accountability (Ellahi et al., 2023). This collaboration is particularly essential in public procurement, where transparency and efficiency are essential for thwarting corruption and ensuring equitable distribution of public resources (Kuznetsov et al., 2024).

However, the convergence of AI and blockchain also presents several challenges that must be addressed (Tsoulakis et al., 2023). These include the technical difficulties of integrating these complex technologies, the potential for increased system complexity, and the need for new regulatory frameworks to accommodate the unique characteristics of AI and blockchain applications in governance (Igbinenikaro and Adewusi, 2024). Additionally, there are concerns about the ethical implications of using AI and blockchain in public administration, particularly regarding privacy, data ownership, and algorithmic transparency (Govindan et al., 2024).

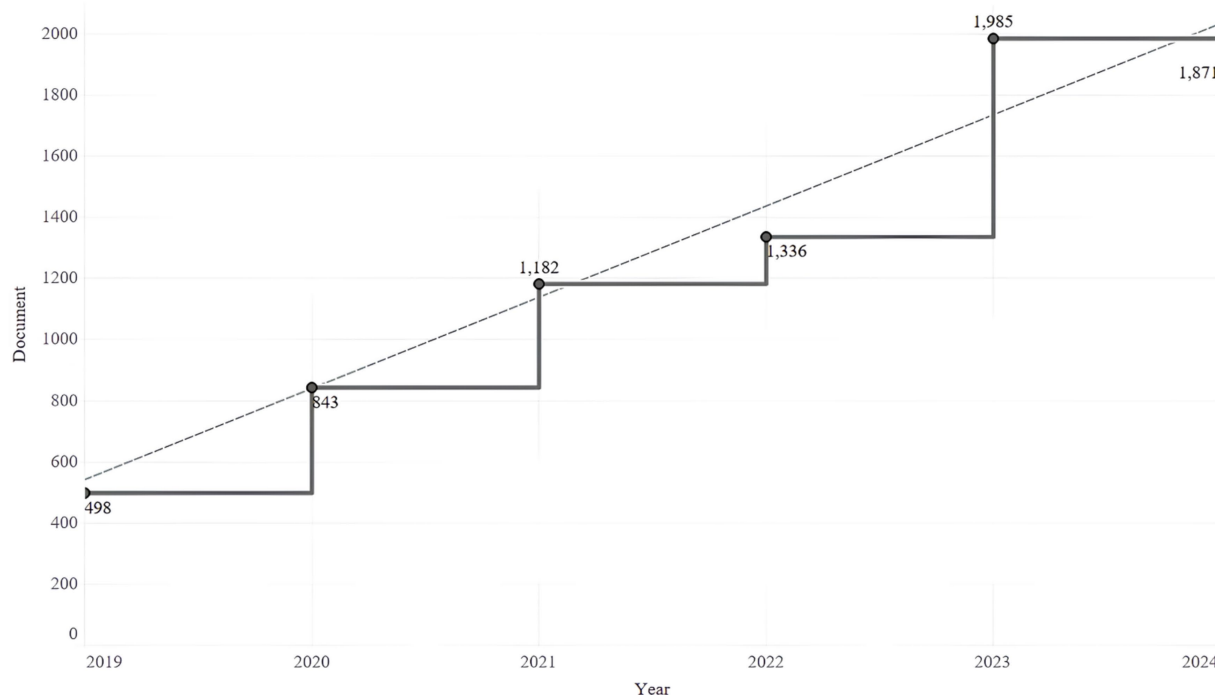
3.4 Gap analysis

There is a growing interest in AI and blockchain; however, there is an essential gap in the research concerning their combined application in e-governance, particularly considering smart cities (Singh J. et al., 2022). Most existing studies focus either on AI or blockchain separately, offering a limited understanding of how these two technologies can work together and the potential advantages of their integration (Bhumichai et al., 2024). This fragmented approach fails to fully represent the potential of AI and blockchain in transforming governance practices and enhancing public administration's efficiency, transparency, and responsiveness (Haug et al., 2024).

Moreover, there is a need for more empirical research that examines the practical implementation of AI and blockchain in governance, as most existing studies are conceptual or theoretical (Abuljadail et al., 2023). Addressing these gaps requires a more integrated approach that explores the combined application of AI and blockchain in real-world governance settings, particularly in smart cities where these technologies can have the most significant impact (Ahmed et al., 2022). This study aims to provide such an approach, offering new insights that can guide future research and inform policy-making in the digital governance domain (Han et al., 2023).

3.5 Publication trends and most citation

Examining publication trends is critical for understanding the evolution of academic and scientific output over time (Ninkov et al., 2022). By analyzing the annual increase and fluctuations in published documents, researchers can identify factors that influence scholarly activity, such as improvements in research methods, funding availability, or significant global events (Roshani et al., 2021). Understanding these trends enables institutions, publishers, and academics to plan how to share research in the future strategically (Liu et al., 2022). Figure 2 shows the consistent rise in the number of documents published annually from 2019 to 2024. It started with 498 documents in 2019, displaying a steady upward trajectory that peaked at 1,985 documents in 2023. A significant increase occurred between 2021 and 2023, with the number of documents increasing from 1,182 to 1,985. However, the data for 2024 indicates a slight drop to 1,871 documents. This information suggests strong growth in academic output in recent years, though there may be emerging factors in 2024 that contribute to this slight decline. Such fluctuations could reflect external factors influencing publication trends, such as economic, political, or technological changes that deserve further investigation. Figure 2 shows the publication trend in 2019–2024, which shows a



The trend of sum of Document for Year.

FIGURE 2
Publication trends in AI and blockchain research for e-governance (2019–2024).

steadily increasing graph indicating researchers' interest in AI and blockchain in e-governance and smart cities.

Table 1 displays the top 10 most impactful authors and their insights on global research collaboration, concentrating on technological advancements such as AI, blockchain, and Industry 5.0. (Dwivedi et al., 2021a) emphasize the groundbreaking potential of AI, comparing its effects to those of the Industrial Revolution. Similarly, (Duan et al., 2019) explore AI's function in decision-making systems and its partnership with Big Data. Research conducted by Dwivedi et al. (2021b) looks into the influence of digital and social media on consumer behavior. Conversely, (Nahavandi, 2019) advocates for a human-centered approach in Industry 5.0, stressing the value of human-robot collaboration. The capacity of blockchain to enhance transparency and security has been examined by Hughes et al. (2019) and Dutta et al. (2020) despite its widespread implementation challenges. Gilson et al. (2023) illustrate AI's efficiency in medical education, demonstrated by ChatGPT's performance on tests. Besides, (Longoni et al., 2019) emphasize public concerns surrounding AI in healthcare, mainly due to issues of privacy and personalization. Together, these studies emphasize the critical role of emerging technologies in transforming industries, decision-making processes, and societal structures while emphasizing the need for further investigation into their integration and acceptance.

3.6 Keyword evolution and words' frequency over time

Recently, there has been an increasing focus on investigating keyword evolution and emerging trends, particularly within data

science, digital content analysis, and information retrieval (Liu J. et al., 2019). As the online environment grows, it becomes more critical for researchers to understand how keywords change, which helps them monitor changes in academic discourse, technological advancements, and societal priorities (Matthies and Torka, 2019). Keywords emphasize critical research areas, novel technologies, and developing terminology across various academic fields (Li et al., 2021). By exploring the evolution of keywords, researchers can acquire meaningful insights into the development of knowledge creation and identify emerging fields that may influence future research trajectories (Chen and Zhang, 2022).

The Sankey diagram in Figure 3 comprehensively visualises the interconnectedness of research topics and authorship in artificial intelligence (AI) and related areas. The diagram highlights vital thematic areas such as "artificial intelligence," "machine learning," "sustainability," and "smart city," demonstrating their central role in contemporary research discourse. The flow of connections suggests that AI is not only a standalone topic but also profoundly integrated with emerging fields like the "Internet of Things," "blockchain," and "deep learning," illustrating the interdisciplinary nature of these subjects. Additionally, the diagram indicates a strong alignment between specific research areas and individual contributors, with authors such as Wang Y, Zhang T, and Lee J showing a broad engagement across diverse topics. This integration of multiple thematic clusters underlines the growing trend of convergence in AI research, where advancements in one area often spur innovations in another, thereby fostering a holistic ecosystem of technological development and application. Such visual mapping aids in

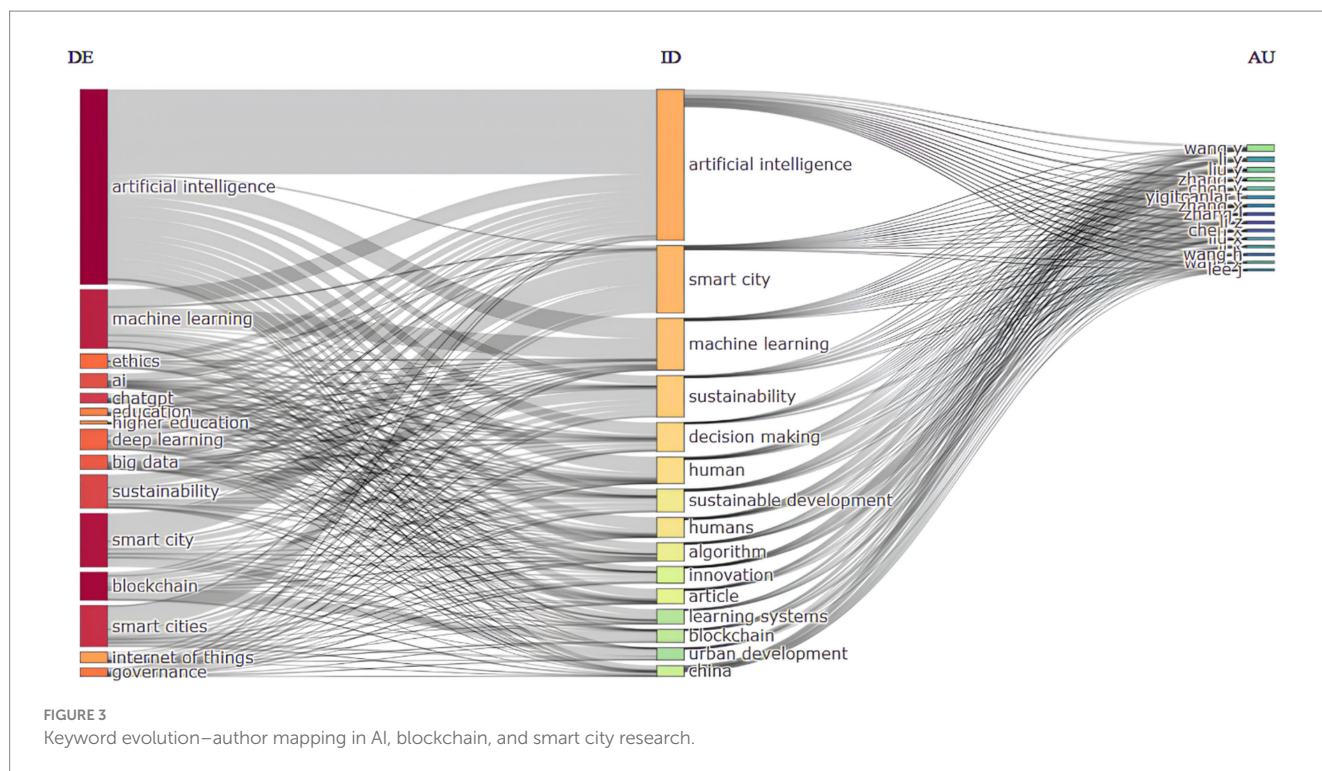
TABLE 1 Top 10 most influential authors and findings on global research collaboration.

No	Author (Year)	Title, Finding and DOI	Total Citations	TC per Year	Normalized TC
1	Dwivedi et al. (2021a)	Title: Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy Finding: This research emphasizes the transformative potential of AI, comparing it to the Industrial Revolution. It highlights the ability of AI to replace or enhance human tasks and examines its impact on various sectors. The research also explores the opportunities, challenges, and ethical issues associated with AI. Doi: https://doi.org/10.1016/j.ijinfomgt.2019.08.002	1,494	373.50	47.13
2	Duan et al. (2019)	Title: Artificial intelligence for decision making in the era of Big Data – evolution, challenges and research agenda Finding: This research examines the resurgence of AI, driven by supercomputing and Big Data, and its role in decision-making systems. Through a literature review, it explores the challenges of integrating AI to support or replace human decision-makers. The study proposes 12 research propositions for IS researchers, focusing on AI-human interaction, conceptual development, and effective AI implementation in the Big Data era. Doi: https://doi.org/10.1016/j.ijinfomgt.2019.01.021	1,289	214.83	25.60
3	Dwivedi et al. (2021b)	Title: Setting the future of digital and social media marketing research: Perspectives and research propositions Finding: This research explores the internet and social media's influence on consumer behavior and business practices, including benefits like reduced costs and increased sales, as well as challenges like negative online word-of-mouth. It gathers insights from experts on topics like AI and mobile marketing, identifies research limitations, and provides propositions for future study. Doi: https://doi.org/10.1016/j.ijinfomgt.2020.102168	901	225.25	28.42
4	Bentéjac et al. (2021)	Title: A comparative analysis of gradient boosting algorithms Finding: The study compares XGBoost, LightGBM, and CatBoost with random forests and traditional gradient boosting. CatBoost achieved the best accuracy, LightGBM was the fastest but less accurate, and XGBoost ranked second in both speed and accuracy. The research also analyzed the effects of hyper-parameter tuning on the performance of these algorithms. Doi: https://doi.org/10.1007/s10462-020-09896-5	897	224.25	28.30
5	Dutta et al. (2020)	Title: This paper reviews the integration of blockchain technology into supply chain operations, highlighting its potential for transforming functions, improving transparency, and enhancing security. The study examines blockchain applications in multiple industries and suggests a future research agenda for exploring its role in supply chain innovation. Doi: https://doi.org/10.1016/j.tre.2020.102067	826	165.20	20.07

(Continued)

TABLE 1 (Continued)

No	Author (Year)	Title, Finding and DOI	Total Citations	TC per Year	Normalized TC
6	Nahavandi (2019)	Title: Industry 5.0—a human-centric solution Finding: The article discusses Industry 5.0, where robots and humans collaborate through brain-machine interfaces and AI to boost productivity without replacing workers. It highlights key features, concerns for manufacturers, and research developments, arguing that Industry 5.0 will create jobs and promote economic growth by enhancing human-robot collaboration. Doi: https://doi.org/10.3390/su11164371	786	131.00	15.61
7	Gilson et al. (2023)	Title: How Does ChatGPT Perform on the United States Medical Licensing Examination? The Implications of Large Language Models for Medical Education and Knowledge Assessment Finding: A study found that ChatGPT performed well on medical exams, outperforming InstructGPT. It had decreasing accuracy with harder questions but consistently provided logical justifications for answers. This suggests ChatGPT could be a useful educational tool in the medical field. Doi: https://doi.org/10.2196/45312	770	385.00	75.61
8	Longoni et al. (2019)	Title: Resistance to Medical Artificial Intelligence Finding: Consumers show reluctance to use and trust AI-based medical services in healthcare due to concerns about the lack of personalization. Resistance can be reduced by emphasizing personalization and supporting human decisions. Doi: https://doi.org/10.1093/jcr/ucz013	711	118.50	14.12
9	Dwivedi et al. (2020)	Title: Impact of COVID-19 pandemic on information management research and practice: Transforming education, work and life Finding: The study explores organizational transformations during COVID-19 from an information systems and technology perspective, gathering insights from 12 experts on areas like AI, cybersecurity, digital strategy, and blockchain. It highlights how the pandemic reshaped these domains and offers key challenges and recommendations for navigating the crisis. Doi: https://doi.org/10.1016/j.ijinfomgt.2020.102211	686	137.20	16.67
10	Hughes et al. (2019)	Title: Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda Finding: This study examines the impact and potential of blockchain technology within Information Systems (IS) and Information Management (IM). While commercial adoption remains limited, it highlights blockchain's promise across various industries and explores key research themes, potential applications, and future directions. The analysis addresses barriers to adoption and emphasizes blockchain's role in advancing the UN Sustainability Development Goals, positioning it as a transformative technology for established industries. Doi: https://doi.org/10.1016/j.ijinfomgt.2019.02.005	571	95.17	11.34



understanding the dynamics of collaborative research efforts and the evolution of critical thematic domains (Khazaneha et al., 2023).

Figure 4 provides information on the longitudinal analysis of word frequencies from 2019 to 2024 reveals an essential increase in research interest across various vital subjects. “Artificial intelligence” emerges as the leading topic, climbing from 210 mentions in 2019 to 3,028 in 2024. This trend emphasizes the significance of AI in academia and research, likely fueled by its groundbreaking potential across multiple sectors. Besides, there is noteworthy growth in related fields such as “smart city” and “machine learning.” These terms signify a shift toward practical, technology-driven solutions to enhance urban environments and refine computational methods. What is more, other important terms like “sustainability,” “decision making,” and “algorithm” indicate a balanced emphasis on technological progress and the ethical and practical dimensions required for societal advancement. The increasing prevalence of terms like “human” and “sustainable development” emphasizes the growing recognition of human-centered and sustainable approaches in technological research. This trend reflects the developing priorities of academia, which are progressively directed towards blending advanced technologies with societal and environmental concerns. It points to a transition towards more comprehensive, interdisciplinary research agendas that address global challenges and necessitate sustainable innovation.

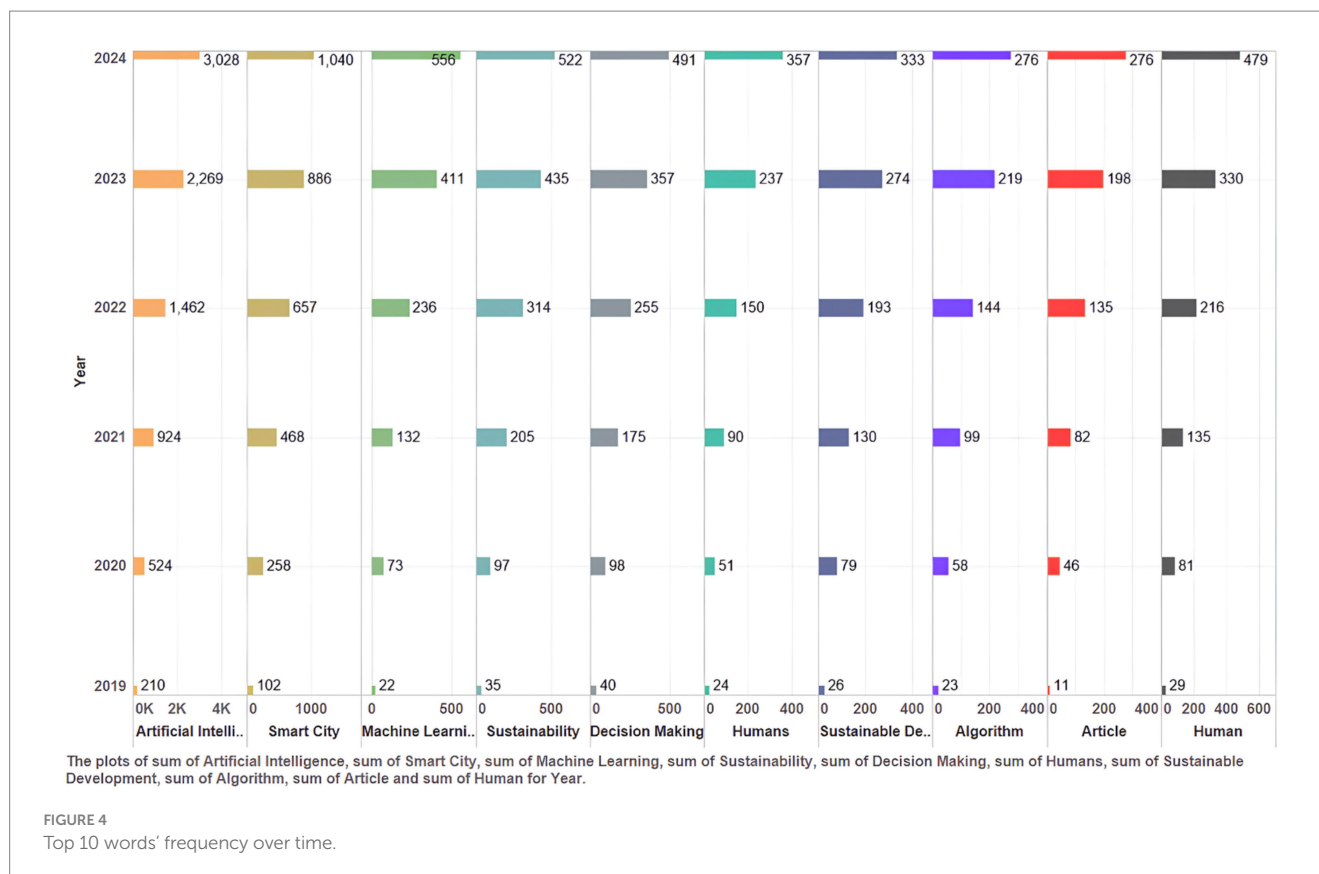
3.7 Co-authorship networks

In academic research, collaboration plays an essential role in creating and disseminating scientific knowledge (Ellemers, 2021). Co-authorship networks demonstrate the relationships between authors who cooperate on academic publications, providing a valuable

and informative perspective on the structure and dynamics within scholarly communities (Schäfermeier et al., 2023). These networks not only reveal collaboration patterns but also indicate intellectual influence, resource sharing, and the dissemination of innovation across various fields (Chen et al., 2019). By analyzing co-authorship networks, researchers can evaluate the impact of interdisciplinary collaboration, assess the significance and connectivity of key contributors, and spot emerging trends in particular academic areas (Reza Habib Agahi et al., 2022). Studying these networks as the research environment evolves provides essential insights into how knowledge is constructed and shared through collective scholarly efforts.

Figure 5 shows a comprehensive visualization of the co-authorship network, illustrating the collaborative landscape among researchers in AI, blockchain, and innovative city governance. The analysis reveals a diverse range of collaborative efforts, highlighting significant contributors to the academic field. Leading the network is Yogesh K. Dwivedi, who has authored 10 documents, accumulating 2,805 citations, indicating both prolific research output and a substantial impact within the research community. Following him are John S. Edwards and Yanqing Duan, whose works, though fewer in number (3 and 2 documents, respectively), have received notable citations (2,021 and 1,975), suggesting a high degree of recognition and influence in the field. The total link strength metric, which reflects the extent of collaborative ties, underscores Dwivedi’s dominant position with a connectivity score of 24, highlighting his extensive academic partnerships.

The presence of highly connected researchers such as Dwivedi, Edwards, and Duan suggests that a core group of scholars is driving knowledge dissemination in AI and blockchain applications within smart city governance. This implies that future research in the field could benefit from targeted interdisciplinary collaborations involving these key scholars, leveraging their established networks to bridge gaps between emerging trends and applied governance models.



Additionally, the visualization reveals several clustered research communities, indicating specialized focus areas within AI and blockchain. The size and density of these clusters suggest a growing but somewhat fragmented research landscape (Alam et al., 2025). This fragmentation presents both a challenge and an opportunity (Donthu et al., 2021). While it underscores the diversity of research themes, it also suggests that stronger cross-disciplinary integration is needed to create a more cohesive knowledge base.

From a policy perspective, understanding co-authorship networks helps identify leading experts who can inform regulatory frameworks and shape governance policies for smart cities. Researchers with extensive collaborations and high citation impact, such as those in Figure 5, are well-positioned to contribute to evidence-based policymaking by providing insights derived from both theoretical and empirical research (Vieira, 2023; Wang et al., 2024). Moreover, the relatively low connectivity of specific authors suggests potential underutilized collaborations (Smith et al., 2023). Strengthening ties between fragmented research clusters could enhance the exchange of ideas and methodologies, fostering more innovative approaches to integrating AI and blockchain in e-governance. This is particularly crucial as smart city development requires multidisciplinary cooperation involving technology, governance, data ethics, and urban planning.

Given the observed co-authorship patterns, future research should explore mechanisms to promote collaborative efforts across different academic domains (Heller et al., 2023). This could involve forming multi-institutional research consortia, enhancing funding opportunities for interdisciplinary projects, and encouraging partnerships between academia, industry, and policymakers (Behfar

et al., 2024). Further analysis of thematic focus areas within clusters could provide deeper insights into which aspects of AI and blockchain integration in innovative city governance remain underexplored. This study highlights the importance of strategic collaborations in advancing knowledge and informing policy decisions by identifying key contributors and analyzing co-authorship structures. Future research should strengthen interdisciplinary linkages, fostering a more integrated approach to the challenges and opportunities of smart city governance through AI and blockchain technologies.

3.8 Keyword co-occurrences and productive authors

In academic research, collaboration plays an essential role in creating and disseminating scientific knowledge (Ellemers, 2021). Co-occurrences demonstrate the relationships between authors who cooperate on academic publications, providing a valuable and informative perspective on the structure and dynamics within scholarly communities (Schäfermeier et al., 2023). These networks not only reveal collaboration patterns but also indicate intellectual influence, resource sharing, and the dissemination of innovation across various fields (Abhari et al., 2019). By analyzing co-occurrences, researchers can evaluate the impact of interdisciplinary collaboration, assess the significance and connectivity of key contributors, and spot emerging trends in particular academic areas (Jin et al., 2021). Studying these networks as the research environment evolves provides essential insights into how knowledge is constructed and shared through collective scholarly efforts (Zhou et al., 2021).



From a research perspective, the visualization underscores the dominance of AI-driven methodologies and the increasing convergence of AI with blockchain, sustainability, and decision sciences (Mulligan et al., 2024; Singh P. et al., 2022). The network structure suggests that interdisciplinary research will be essential for advancing AI applications in governance (Wirtz et al., 2022). Future studies should focus on how AI-driven decision-making integrates

Additionally, while AI dominates the discourse, blockchain's potential for decentralization, data security, and transparency remains underexplored in the network (Shamsan Saleh, 2024; Tripathi et al., 2023). Scholars should investigate how these two technologies can be co-optimized to tackle real-world governance challenges, particularly in public administration, urban planning, and security domains. In conclusion, this visualization provides a comprehensive overview of the evolving research landscape, highlighting the interdependencies between AI, blockchain, and governance-related domains. This analysis offers actionable insights for researchers, policymakers, and industry leaders by identifying key thematic clusters and emerging topics. Going forward, fostering greater interdisciplinary collaboration and

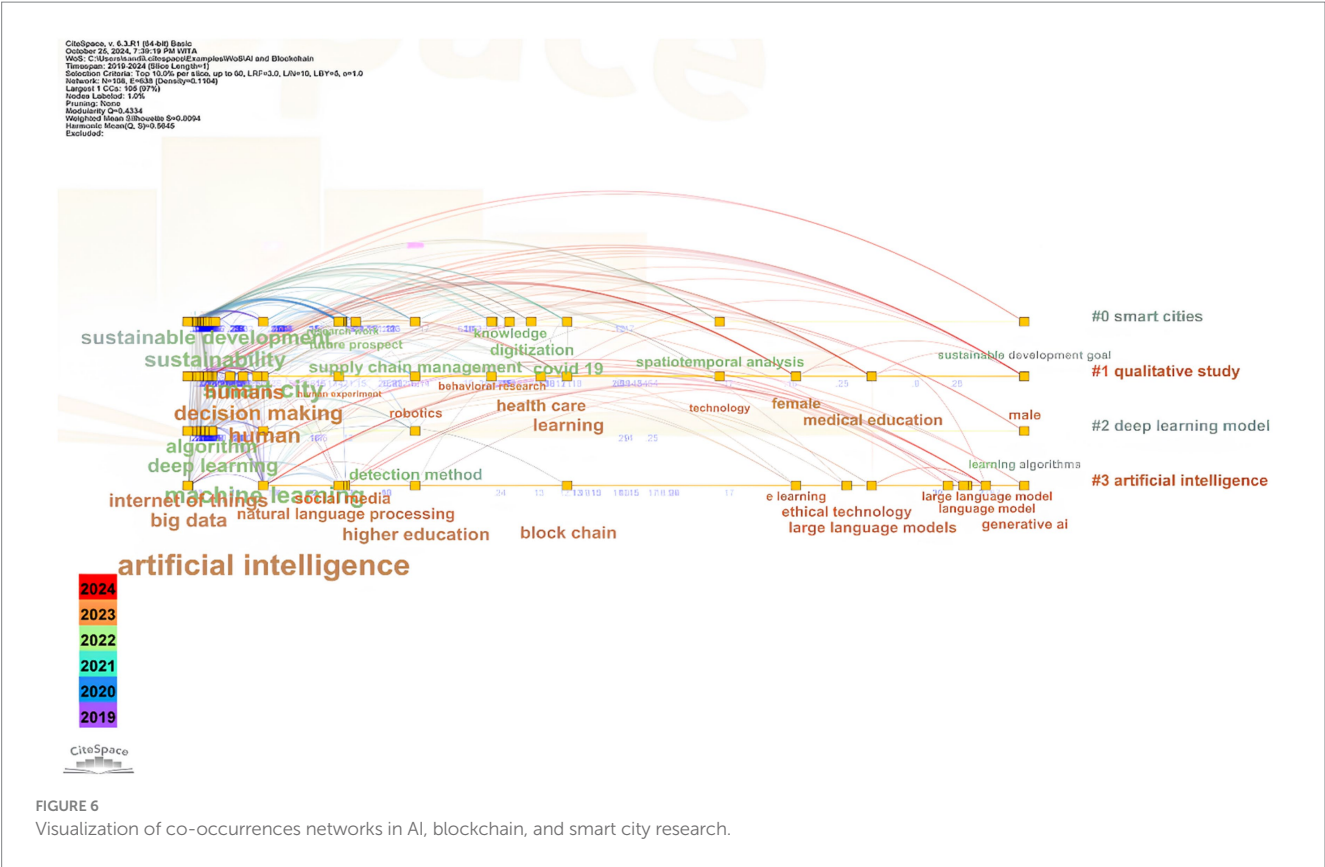


FIGURE 6
Visualization of co-occurrences networks in AI, blockchain, and smart city research.

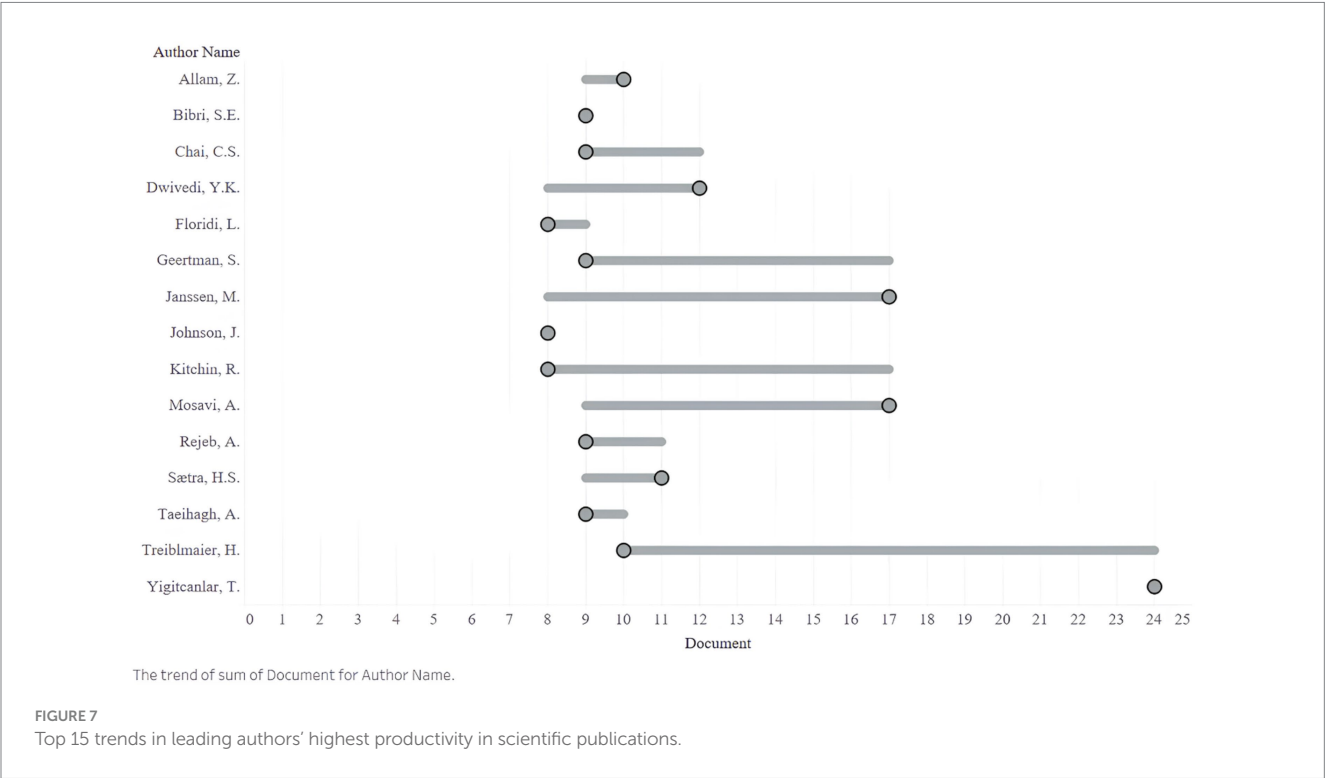


FIGURE 7
Top 15 trends in leading authors' highest productivity in scientific publications.

addressing ethical and regulatory challenges will ensure that AI and blockchain innovations contribute positively to sustainable and transparent governance frameworks.

Figure 7 shows the trend analysis of author productivity in scholarly publications reveals significant contributions from leading academics. The data identifies “Yigitcanlar, T.” as the most prolific

author, with 24 documented publications showcasing their prominent role in advancing research within their domain. Following closely are “Janssen, M.” and “Mosavi, A.” each with 17 contributions, further demonstrating their active engagement in academic discourse. “Dwivedi, Y.K.” and “Sætra, H.S.” also make notable contributions, with 12 and 11 publications, respectively, underscoring their influence in the literature. This distribution of productivity not only highlights individual academic excellence but reflects the collaborative and cumulative nature of knowledge generation. Future research may benefit from a more profound exploration of these high-output authors’ thematic focus and interdisciplinary impact.

4 Discussion

4.1 Key trends, insights and bibliometric coupling map

Examining essential trends and insights in academic research offers a thorough comprehension of the changing environment of scholarly inquiry (Thelwall and Sud, 2021). By pinpointing prominent themes, newly emerging areas of interest, and changes in methodological strategies, researchers can acquire helpful foresight into the future directions of investigations (Liu G. et al., 2019). Key trends frequently mirror more considerable societal, technological, or theoretical changes, while the insights from these trends simplify the practical implications of research across different fields (Alonso-Mencía et al., 2021). This examination also emphasizes patterns of collaboration, innovation spread, and interdisciplinary convergence, providing a refined understanding of how scientific knowledge is influenced by and influences its broader context (Li and Yu, 2023).

Figure 8 explains that the treemap visualization displays the key topics and research directions in current scientific discourse,

emphasizing “artificial intelligence” (23%) and its essential role across numerous fields. Related areas such as “smart city” (8%), “machine learning” (4%), and “sustainability” (4%) further illustrate the interdisciplinary use of AI in urban development and environmental preservation. Additional essential themes, including “decision making,” “human factors,” and “algorithm,” indicate a focus on the convergence of technology and human-focused applications, emphasizing the necessity for research that harmonizes technological progress with social consequences. Emerging fields like “blockchain,” “deep learning,” and “COVID-19” display the discipline’s flexibility in tackling real-world issues, especially in health and governance (Dutta et al., 2020; Nguyen et al., 2019; Dwivedi et al., 2020). The variety of subjects reflects a solid commitment to advancing technology while considering ethical, sustainable, and human-focused strategies, pointing to a comprehensive academic interest in shaping future societal structures through innovation and responsible integration of technology (Shults and Wildman, 2020). This visualization represents existing academic priorities and indicates a balanced research environment that combines technical expertise with societal welfare, aligning with the broader goals of promoting knowledge for comprehensive, sustainable development.

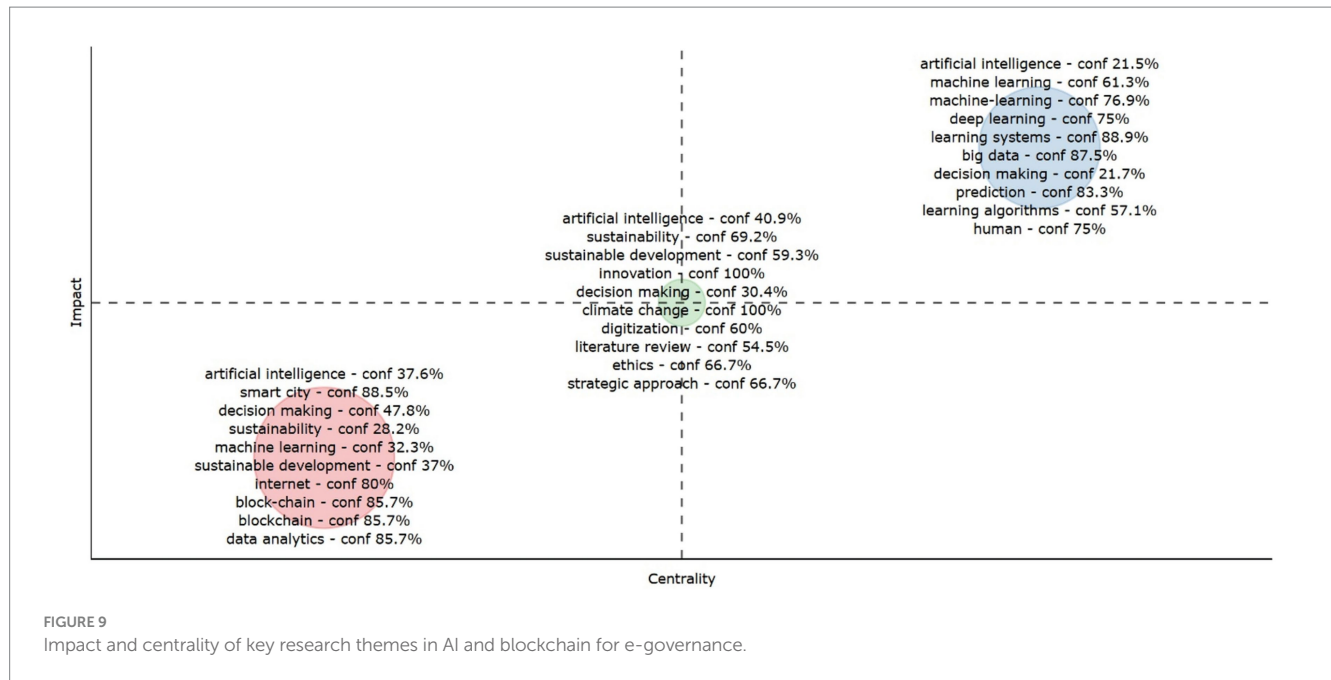
The bibliometric coupling map in Figure 9 offers valuable insights into the thematic relationships and impact of various research clusters within the scientific domain (Dwivedi et al., 2023). By visualizing clusters according to their centrality and impact, the map highlights which topics are at the forefront of academic and practical applications (Tian, 2022). This enables a deeper understanding of emerging trends and research priorities, shedding light on their implications for the academic community and policymakers (El-Agamy et al., 2024). Clusters associated with “smart city” and “blockchain” are prominent due to their high centrality (88.5 and 85.7%, respectively) and significant impact. The high centrality scores indicate that these topics are key areas for interdisciplinary research, facilitating connections

Tree



FIGURE 8

Key trends and insights in emerging research domains and technological advancements.



across various domains, including urban planning, technology, and governance. Their significant impact suggests that they increasingly influence policy decisions, particularly in innovative infrastructure development, decentralized finance, and digital governance. These findings imply that policymakers should prioritize these areas to ensure that innovations in smart cities and blockchain are implemented effectively and in alignment with regulatory frameworks that support sustainable growth and equitable access.

Similarly, “sustainable development” and “climate change,” with impact scores of 59.3 and 100%, demonstrate their critical role in addressing urgent global challenges. The overwhelming impact of “climate change” (100%) indicates that this issue is central to ongoing scientific discourse and a key driver of international policy agendas, particularly related to environmental conservation, carbon reduction, and climate adaptation strategies. This highlights policymakers’ need to prioritize climate-related research to craft actionable, evidence-based policies that mitigate climate risks. Further interdisciplinary research on sustainability and climate change could lead to the development of more comprehensive frameworks for addressing global environmental challenges. In contrast, clusters focused on “artificial intelligence” and “machine learning” exhibit more nuanced patterns of centrality and impact, with “artificial intelligence” (40.9% centrality and 21.5% impact) positioned as a key but somewhat specialized area within technology and innovation. Despite its growing centrality, its lower impact suggests that AI is still in the early stages of translating research into widely adopted applications. This points to the need for further research to bridge the gap between theoretical advancements and practical implementations, particularly in healthcare, education, and autonomous systems. Policymakers may need to regulate and support AI development in ways that promote ethical usage and prevent bias, ensuring that AI systems are both innovative and equitable (Onososen and Musonda, 2022; Saheb and Saheb, 2024). This visualization also illustrates the interconnectedness of various fields, underscoring the potential for cross-disciplinary research. For example, exploring collaborations between AI,

blockchain, and sustainability could lead to novel solutions that address global challenges such as data security, environmental conservation, and energy efficiency (Bucea-Manea-țoniș et al., 2021; Rana et al., 2022). Future studies could examine the synergies between these clusters to develop innovative technologies and policies that foster sustainable growth and societal well-being.

4.2 Global research contributions

The results outlined in this study greatly enhance the worldwide understanding of e-governance by clarifying the complex relationship between emerging technologies and governance systems. As digital transformation influences the public sector, incorporating technologies like AI and blockchain is essential for improving transparency, accountability, and citizen involvement in governance practices (Pérez et al., 2020). This research adds to the conversation on how innovative digital tools can improve governance frameworks, thus tackling current issues in public administration (Dunleavy and Margetts, 2023). Besides, this study’s findings align with global movements promoting data-driven decision-making and the necessity for flexible regulatory frameworks, which are essential for building trust and inclusivity in e-governance initiatives (Janssen et al., 2020). By investigating the consequences of these technological advancements, this research not only enhances academic knowledge but also acts as a valuable resource for policymakers aiming to improve the effectiveness of e-governance strategies around the globe.

Figure 10 shows the global distribution of research on e-participation and cybersecurity, demonstrating a significant concentration of productivity among the top 10 contributing countries, reflecting their critical role in advancing these crucial areas. The United States has 1,146 publications, demonstrating its strong commitment to digital governance and cybersecurity frameworks. The United Kingdom followed closely with 1,062 documents, highlighting

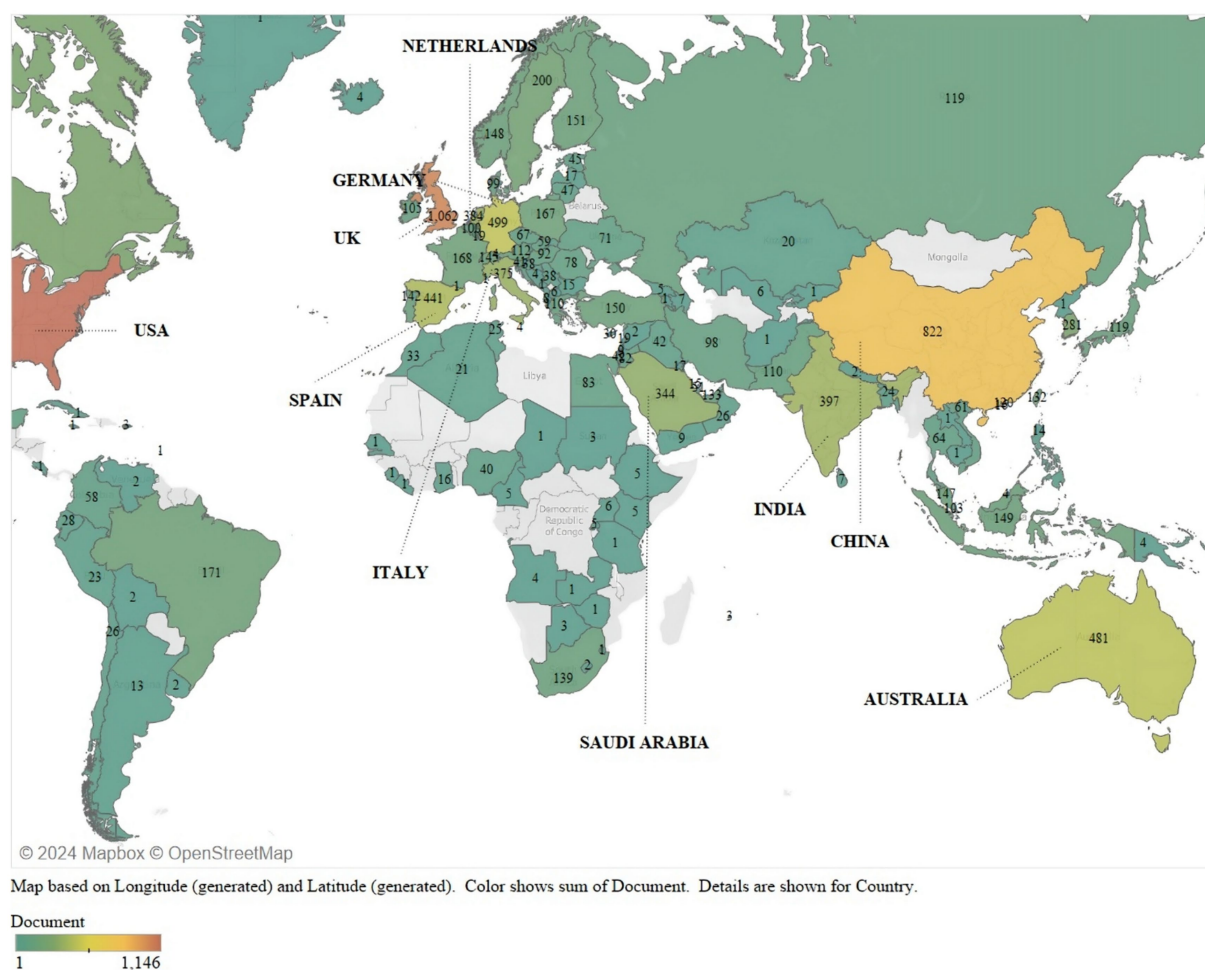


FIGURE 10

Top 10 global contributions to research on AI, blockchain, and e-governance in smart cities.

vital research initiatives and policy-driven studies in e-participation. With 822 contributions, China demonstrated its strategic focus on integrating cybersecurity into its vast digital infrastructure. Germany and Australia, which contributed 499 and 481 documents, respectively, further reinforced the importance of developed countries in driving innovation and knowledge in this domain. Other key contributors, including India, Canada, South Korea, Japan, and Italy, collectively underscore the global interconnectedness and shared responsibility in addressing challenges and opportunities in e-participation and cybersecurity. This distribution also underscores gaps in research outcomes, which invite further exploration of how regional capacities and international collaboration influence the dissemination of knowledge and best practices in this area.

4.3 Synergies and challenges

The combination of AI and blockchain technology in governance presents exciting opportunities to enhance the efficiency and transparency of public administration. AI's strengths in data analysis and predictive modeling work well with blockchain's secure

and transparent ledger, promoting knowledgeable decision-making and building trust among stakeholders (Wang et al., 2020). By using AI to examine data stored on blockchain networks, governance organizations can gain insights for policy formulation and resource distribution. For example, AI's capability to identify trends and anomalies in real time supports fast responses to issues, improving governance flexibility (Gao et al., 2021). Also, AI can automate routine tasks such as compliance checks and reporting, which decreases administrative burdens and simplifies processes (Rais et al., 2020).

However, despite these benefits, deploying AI and blockchain in governance encounters essential obstacles. The technical details of these technologies require expertise often lacking in public sector organizations, a situation worsened by the swift evolution of technology that creates skill disparities (Jansen and Boulianne, 2020). Regulatory and ethical challenges hinder adoption, as current frameworks may fall short in addressing the unique issues posed by these technologies, potentially hampering innovation (Dafoulas et al., 2022). Ethical dilemmas, especially those concerning data privacy and security, emerge since blockchain's transparency could reveal sensitive information, necessitating robust data protection protocols (Zhao

J. et al., 2021). It is essential to develop adaptive regulatory frameworks and targeted capacity-building programs to overcome these challenges. Future studies should focus on comprehensive approaches to responsibly integrating AI and blockchain, ensuring innovation aligns with public welfare and ethical principles.

4.4 Ethical and practical considerations

The application of AI and blockchain technology in governance raises critical ethical and practical challenges that require careful consideration (Salah et al., 2019). One major ethical concern is the risk of bias embedded within AI algorithms, which often reflects historical inequalities, potentially perpetuating discrimination in public decision-making processes (Saeidnia, 2023). Such biases undermine principles of fairness and justice, particularly for marginalized groups (Mehrabi et al., 2021). To address this, governance frameworks must adopt robust auditing mechanisms to identify and mitigate algorithmic bias, ensuring equitable outcomes. Blockchain technology, while enhancing transparency and accountability, introduces data privacy and security challenges (Xu et al., 2023). The immutable and transparent nature of blockchain can expose sensitive information, necessitating comprehensive data governance frameworks to balance transparency with individual privacy rights (Zhao N. et al., 2021).

From a practical perspective, the successful integration of AI and blockchain in governance is hindered by technical expertise gaps and resource constraints (Faccia and Petratos, 2021). Public sector organizations often lack the necessary skills and financial resources to implement and maintain these advanced technologies (Albertus and Hamman-Fisher, 2021). Furthermore, the rapidly evolving regulatory landscape struggles to keep pace with technological advancements, creating misalignments that stifle innovation (Dafoulas et al., 2022). Policymakers must develop adaptive regulatory frameworks that safeguard public interests while promoting ethical considerations (Dafoulas et al., 2022). Collaborative efforts among technologists, ethicists, and regulators are crucial to addressing these challenges and ensuring that the transformative potential of AI and blockchain enhances transparency, accountability, and equity in governance systems (Ouyang et al., 2022).

4.5 Policy implications

As urban development speeds up, AI and blockchain technology offer revolutionary opportunities for improving governance in smart cities (Xie et al., 2019). AI allows policymakers to examine extensive urban datasets, including information from transportation, energy, and public services, to reveal patterns and forecast trends, thereby optimizing systems like traffic management and bolstering public safety (Ali et al., 2021). This data-driven strategy promotes responsive governance that aligns with the changing needs of urban populations (Hughes et al., 2020). Simultaneously, blockchain's decentralized and unchangeable ledger system boosts transparency and trust by securely monitoring resource distribution and ensuring accountability in government operation (Zheng, 2020). For example, blockchain-based procurement systems can help reduce corruption and enhance public

trust, with pilot projects displaying their ability to simplify bureaucratic processes (Mircea et al., 2022).

In addition to efficiency and transparency, combining AI and blockchain can improve citizen engagement and participation in governance (Oliveira et al., 2020). AI-driven platforms assist in real-time public consultations, guaranteeing that governance aligns with community needs (Blasi et al., 2021). Blockchain enables citizens by granting secure access to their data and encouraging active involvement in decision-making (Sousa, 2023). Nonetheless, integrating these technologies necessitates tackling ethical and regulatory challenges, particularly concerning data privacy and security in smart cities (Yogi et al., 2023). Policymakers must develop comprehensive data governance frameworks and adaptable regulatory environments to protect public interests while promoting innovation (Schneider et al., 2020). By strategically using these technologies, policymakers can build efficient, accountable, and comprehensive governance systems that respond to the changing needs of urban populations (Jiang, 2021).

4.6 Theoretical implications

Integrating AI and blockchain technologies in governance, especially in the context of smart cities, holds significant theoretical promise for advancing our understanding of governance models in the digital age (Nechesov and Ruponen, 2024; Khan et al., 2024). From a theoretical perspective, combining AI's data analysis capabilities and blockchain's secure and transparent ledger system opens up new avenues for research in governance and decision-making (Liu et al., 2024). Several theoretical frameworks can be used to explain the convergence of these technologies. One possible framework is the Technology–Organization–Environment (TOE) framework, which could help explain how institutional and technological contexts influence the adoption of AI and blockchain in public administration (Zhou et al., 2025; Madan and Ashok, 2023). Additionally, the Institutional Theory may provide insights into how public sector institutions adapt and respond to new technological advancements like AI and blockchain, focusing on regulatory challenges, governance structures, and organizational change (Tan et al., 2022).

Another theoretical approach involves Systems Theory, which can be applied to study the interactions between various subsystems such as AI, blockchain, and governance in smart cities (Zhu et al., 2024; Bagloee et al., 2021). This perspective emphasizes the need for a holistic view of technology integration and its impact on public administration processes, efficiency, and transparency. Additionally, theories of public administration, such as New Public Management (NPM), can be extended to assess how these technologies impact public service delivery and citizen engagement, offering new theoretical insights into digital governance (Idzi and Gomes, 2022).

4.7 Practical implications

On the practical side, merging AI and blockchain in governance can revolutionize how public administrations manage data, make decisions, and interact with citizens (Zuiderwijk et al., 2021). AI in data processing and predictive analysis, combined with blockchain's

transparent and immutable ledger, offers the potential for more transparent, secure, and efficient governance systems in smart cities (Dahmane et al., 2023). For instance, AI can analyze data stored on blockchain platforms to optimize traffic management, resource allocation, and urban planning, while blockchain ensures data integrity, security, and accountability (Son et al., 2023). From a policy perspective, the findings of this study suggest that policymakers need to focus on creating adaptive regulatory frameworks that foster the responsible use of AI and blockchain in governance. These frameworks should address concerns related to data privacy, algorithmic transparency, and the ethical implications of AI in decision-making processes.

Furthermore, industry leaders and public administrators must collaborate to ensure that these technologies are implemented to enhance public trust and improve service delivery while being mindful of these technologies' ethical challenges (Madan and Ashok, 2023; Ressi et al., 2024). For smart cities, this research recommends that local governments invest in training and capacity-building programs to equip their staff with the necessary skills to manage AI and blockchain technologies. It also suggests piloting AI and blockchain applications in limited areas (e.g., public health services, traffic management, voting systems) to test their effectiveness before full-scale implementation. This approach would allow cities to gather real-world data and adjust their strategies as needed, ensuring that these technologies are applied responsibly and maximize their benefits for urban populations.

4.8 Future research directions

Integrating AI and blockchain technology in governance presents numerous opportunities for future research to address existing challenges and maximize their potential (Salah et al., 2019; Singh S. et al., 2020). A key area is the development of ethical frameworks that mitigate biases in AI algorithms and address privacy concerns associated with blockchain's transparency (Zhang et al., 2021; Gao et al., 2020). Researchers can use case studies and empirical analyses to evaluate the effectiveness of these frameworks in ensuring fairness and accountability. Additionally, the interoperability of AI and blockchain systems within governance frameworks requires further investigation (Singh S. et al., 2020). As intelligent cities adopt various digital technologies, understanding the technical and organizational challenges of integrating these systems is essential to creating cohesive and efficient governance solutions (Ahad et al., 2020). Collaborative studies involving policymakers, developers, and urban planners can yield insights into best practices for achieving effective integration (Mora et al., 2019; Medeiros and van der Zwet, 2020).

Data governance and regulatory frameworks also represent critical areas for exploration (Ienca et al., 2022). Research should examine how data quality, ownership, and access impact the effectiveness of AI and blockchain in governance while also considering implications for public trust and transparency (Jiang et al., 2022; Schneider, 2020). Comparative studies on regulatory approaches across jurisdictions can assess their influence on innovation, public trust, and ethical use, offering valuable

guidance for policymakers (Dhali et al., 2023; Vrabie and Ianole-Călin, 2020). Finally, the socio-economic implications of these technologies warrant attention, particularly their potential to address inequality and inclusivity in governance, especially in developing regions (Patnaik and Bhowmick, 2019). Investigating strategies to make digital governance accessible and affordable can ensure these benefits extend to all citizens, fostering equitable and effective governance solutions (Trevisan and Cogburn, 2020).

5 Conclusion

This study thoroughly examines the combination of AI and blockchain technology in e-governance, especially considering innovative city frameworks. The results indicate that AI's ability to perform real-time data analysis, predictive modeling, and improved decision-making is greatly enhanced by blockchain's features that provide transparency, data security, and trust through its decentralized and unalterable framework. These technologies present a synergistic opportunity to change public administration by enhancing efficiency, accountability, and public trust in governance systems. The bibliometric analysis carried out in this study emphasizes the swift increase in research interest in this domain, charting key trends, essential studies, and ongoing gaps, particularly the shortage of empirical assessments on their integrated application. In promoting global research, this study offers several significant contributions. It fills the gap between theoretical discussion and practical application by systematically reviewing the existing state of AI and blockchain integration in e-governance. The work explains the complementary aspects of these technologies, delivering actionable insights for researchers and policymakers to develop frameworks that harmonize technological advancements with governance requirements. Besides, it enhances the academic conversation surrounding technology-driven governance, stressing the necessity to tackle scalability, interoperability, and inclusivity issues. This research sets the stage for future investigations. It is an essential resource for policymakers aiming to deploy AI and blockchain solutions that improve public service delivery while ensuring ethical and sustainable results.

Despite its essential contributions, the study recognizes some limitations. Firstly, the research is primarily based on bibliometric analysis, which, although practical, does not offer the contextual depth that field-based empirical studies can provide. Secondly, focusing on intelligent cities leaves space for exploring these technologies in broader governance contexts, such as rural administration or international governance networks. To address these gaps, upcoming research should focus on longitudinal case studies and pilot projects evaluating the practical implementation of AI and blockchain in different e-governance settings. Besides, regulatory and ethical issues, including worries about data privacy and the ethical use of AI, need continuous attention from academics and policymakers to guarantee that these technologies are used responsibly. In summary, the combined potential of AI and blockchain technologies signifies a revolutionary shift in governance, presenting unique opportunities to enhance decision-making, transparency, and citizen involvement. However, achieving this potential requires ongoing interdisciplinary research,

robust policy frameworks, and ethical considerations to navigate the complexities of incorporating these technologies into governance systems. By confronting these challenges, AI and blockchain can become foundational technologies for establishing more innovative, more comprehensive, and more resilient governance frameworks in the digital age.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

SL: Conceptualization, Formal analysis, Funding acquisition, Methodology, Visualization, Writing – original draft, Writing – review & editing, Software. AN: Formal analysis, Investigation, Supervision, Validation, Writing – review & editing. JA: Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – review & editing. EP: Conceptualization, Investigation, Project administration, Resources, Supervision, Validation, Writing – review & editing. TP: Conceptualization, Data curation, Investigation, Methodology, Validation, Writing – review & editing. HJ: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Supervision, Validation, Visualization, Writing – review & editing.

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References

- Abhari, K., Davidson, E. J., and Xiao, B. (2019). Collaborative innovation in the sharing economy. *Internet Res.* 29, 1014–1039. doi: 10.1108/INTR-03-2018-0129
- Abuljadail, M., Khalil, A., Talwar, S., and Kaur, P. (2023). Big data analytics and e-governance: actors, opportunities, tensions, and applications. *Technol. Forecast. Soc. Chang.* 193:122612. doi: 10.1016/j.techfore.2023.122612
- Ahad, M. A., Paiva, S., Tripathi, G., and Feroz, N. (2020). Enabling technologies and sustainable smart cities. *Sustain. Cities Soc.* 61:102301. doi: 10.1016/j.scs.2020.102301
- Ahmed, I., Zhang, Y., Jeon, G., Lin, W., Khosravi, M. R., and Qi, L. (2022). A blockchain-and artificial intelligence-enabled smart IoT framework for sustainable city. *Int. J. Intell. Syst.* 37, 6493–6507. doi: 10.1002/int.22852
- Alam, M. S., Tahriri, F., and Chen, G. (2025). Trends, challenges, and research pathways in emerging contaminants: a comprehensive bibliometric analysis. *Integr. Environ. Assess. Manag.* 1–11:vjae036. doi: 10.1093/inteam/vjae036
- Albertus, R. W., and Hamman-Fisher, D. (2021). Investigating information technology skills retention challenges in South Africa's public sector. *Afr. J. Sci. Technol. Innov. Dev.* 13, 541–549. doi: 10.1080/20421338.2020.1791386
- Ali, K., Khan, A., and Parveen, S. (2021). Role of AI in smart city traffic management: a review. *Sustain. Cities Soc.* 75:103307. doi: 10.1016/j.scs.2021.103307
- Alonso-Mencia, M. E., Alario-Hoyos, C., Estévez-Ayres, I., and Estévez-Ayres, I. (2021). Analysing self-regulated learning strategies of MOOC learners through self-reported data. *Australas. J. Educ. Technol.* 37, 56–70. doi: 10.14742/ajet.6150
- Bagloee, S. A., Heshmati, M., Dia, H., Ghaderi, H., Pettit, C., and Asadi, M. (2021). Blockchain: the operating system of smart cities. *Cities* 112:103104. doi: 10.1016/j.cities.2021.103104
- Bai, C., and Sarkis, J. (2022). Blockchain technology in public administration: a transparent future. *Int. J. Public Adm.* 29, 103–120. doi: 10.23919/MIPRO55190.2022.9803797
- Behfar, S. K., Shekhtman, L., and Crowcroft, J. (2024). Competitive funding and academic-industry collaboration: policy trends and insights. *Data Policy* 6:e82. doi: 10.1017/dap.2024.81
- Bentéjac, C., Csörgő, A., and Martínez-Muñoz, G. (2021). A comparative analysis of gradient boosting algorithms. *Artif. Intell. Rev.* 54, 1937–1967. doi: 10.1007/s10462-020-09896-5
- Bhumichai, D., Smiliotopoulos, C., Benton, R., Kambourakis, G., and Damopoulos, D. (2024). The convergence of artificial intelligence and Blockchain: the state of play and the road ahead. *Information (Switzerland)* 15, 1–32. doi: 10.3390/info15050268
- Bibri, S. E., Huang, J., Jagatheesaperumal, S. K., and Krogstie, J. (2024). The synergistic interplay of artificial intelligence and digital twin in environmentally planning sustainable smart cities: a comprehensive systematic review. *Environ. Sci. Ecotechnol.* 20:100433. doi: 10.1016/j.ese.2024.100433
- Blasi, S., Gobbo, E., and Sedita, R. (2021). Smart cities and citizen engagement: an ethical approach. *J. Urban Technol.* 28, 89–106. doi: 10.1080/10630732.2021.1883055
- Bucea-Manea-țoniș, R., Martins, O. M. D., Bucea-Manea-țoniș, R., Gheorghită, C., Kuleto, V., Ilić, M. P., et al. (2021). Blockchain technology enhances sustainable higher education. *Sustainability (Switzerland)* 13:2347. doi: 10.3390/su132212347
- Butt, N. S., Malik, A. A., and Shahbaz, M. Q. (2021). Bibliometric analysis of statistics journals indexed in web of science under emerging source citation index. *SAGE Open* 11:8870. doi: 10.1177/2158244020988870
- Chen, Y., and Zhang, W. (2022). Trends in academic research: a bibliometric analysis of keyword evolution. *J. Inf. Sci.* 48, 455–470. doi: 10.1177/01655515221001045

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that Generative AI was used in the creation of this manuscript. ChatGPT was utilized to assist in drafting and refining certain sections of the text. All content generated by AI has been thoroughly reviewed and edited to ensure accuracy and alignment with the research objectives.

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- Chen, K., Zhang, Y., and Fu, X. (2019). International research collaboration: an emerging domain of innovation studies? *Res. Policy* 48, 149–168. doi: 10.1016/j.paid.2019.109507
- Clavin, J., Duan, S., Zhang, H., Janeja, V. P., Joshi, K. P., Yesha, Y., et al. (2020). Blockchains for government: use cases and challenges. *Digit. Gov. Res. Pract.* 1, 1–21. doi: 10.1145/3427097
- Dafoulas, G. E., Whelan, E., and Bouskila, Y. (2022). Regulatory challenges in the deployment of AI and blockchain: a framework for governance. *Comput. Secur.* 120:102831. doi: 10.1016/j.cose.2022.102831
- Dahmane, W. M., Ouchani, S., and Bouarfa, H. (2023). Smart cities services and solutions: a systematic review. *Data Inform. Manag.* 2024:100087. doi: 10.1016/j.dim.2024.100087
- Dhali, M., Hassan, S., Mehar, S. M., Shahzad, K., and Zaman, F. (2023). Cryptocurrency in the Darknet: sustainability of the current national legislation. *Int. J. Law Manag.* 65, 261–282. doi: 10.1108/IJLMA-09-2022-0206
- Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., and Lim, W. M. (2021). How to conduct a bibliometric analysis: an overview and guidelines. *J. Bus. Res.* 133, 285–296. doi: 10.1016/j.jbusres.2021.04.070
- Duan, Y., Edwards, J. S., and Dwivedi, Y. K. (2019). Artificial intelligence for decision making in the era of big data – evolution, challenges and research agenda. *Int. J. Inf. Manag.* 48, 63–71. doi: 10.1016/j.jinfomgt.2019.01.021
- Dunleavy, P., and Margetts, H. (2023). Data science, artificial intelligence and the third wave of digital era governance. *Public Policy Admin.* 40, 185–214. doi: 10.1177/09520767231198737
- Dutta, P., Choi, T.-M., Somani, S., and Butala, R. (2020). Blockchain technology in supply chain operations: applications, challenges and research opportunities. *Trans. Res. Part E Logist. Transport. Rev.* 142:102067. doi: 10.1016/j.tre.2020.102067
- Dwivedi, Y. K., Hughes, D. L., Coombs, C., Constantiou, I., Duan, Y., Edwards, J. S., et al. (2020). Impact of COVID-19 pandemic on information management research and practice: transforming education, work and life. *Int. J. Inf. Manag.* 55:102211. doi: 10.1016/j.jinfomgt.2020.102211
- Dwivedi, Y. K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., et al. (2021a). Artificial intelligence (AI): multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *Int. J. Inf. Manag.* 57:101994. doi: 10.1016/j.jinfomgt.2019.08.002
- Dwivedi, Y. K., Ismagilova, E., Hughes, D. L., Carlson, J., Filieri, R., Jacobson, J., et al. (2021b). Setting the future of digital and social media marketing research: perspectives and research propositions. *Int. J. Inf. Manag.* 59:102168. doi: 10.1016/j.jinfomgt.2020.102168
- Dwivedi, R., Nerur, S., and Balijepally, V. (2023). Exploring artificial intelligence and big data scholarship in information systems: a citation, bibliographic coupling, and co-word analysis. *Int. J. Inform. Manag. Data Insights* 3:100185. doi: 10.1016/j.jime.2023.100185
- El-Agamy, R. F., Sayed, H. A., AL Akhatatneh, A. M., Aljohani, M., and Elhosseini, M. (2024). Comprehensive analysis of digital twins in smart cities: a 4200-paper bibliometric study. *Artif. Intell. Rev.* 57:154. doi: 10.1007/s10462-024-10781-8
- Ellahi, R. M., Wood, L. C., and Bekhit, A. E. D. A. (2023). Blockchain-based frameworks for food traceability: a systematic review. *Food Secur.* 12, 1–28. doi: 10.3390/foods12163026
- Ellemers, N. (2021). Science as collaborative knowledge generation. *Br. J. Soc. Psychol.* 60, 1–28. doi: 10.1111/bjso.12430
- Faccia, A., and Petratos, P. (2021). Blockchain, enterprise resource planning (ERP) and accounting information systems (AIS): research on e-procurement and system integration. *Appl. Sci.* 11:6792. doi: 10.3390/app11156792
- Fares, J., Chung, K. S. K., and Abbasi, A. (2021). Stakeholder theory and management: understanding longitudinal collaboration networks. *PLoS One* 16:e0255658. doi: 10.1371/journal.pone.0255658
- Gao, F., Chen, D.-L., Weng, M.-H., and Yang, R.-Y. (2021). Revealing development trends in blockchain-based 5g network technologies through patent analysis. *Sustainability (Switzerland)* 13, 1–24. doi: 10.3390/su13052548
- Gao, S., Wang, Y., and Chen, Z. (2020). Enhancing trust in AI decision-making through blockchain technology. *Int. J. Inf. Manag.* 52, 102019–102080. doi: 10.1016/j.jinfomgt.2019.10.004
- Ghani, M., Hurrell, R., Verceles, A. C., McCurdy, M. T., and Papali, A. (2020). Geographic, subject, and authorship trends among LMIC-based scientific publications in high-impact Global Health and general medicine journals: a 30-month bibliometric analysis. *J. Epidemiol. Glob. Health* 11, 92–97. doi: 10.2991/jegh.k.200325.001
- Gilson, A., Safranek, C. W., Huang, T., Socrates, V., Chi, L., Taylor, R. A., et al. (2023). How does ChatGPT perform on the United States medical licensing examination? The implications of large language models for medical education and knowledge assessment. *JMIR Med. Educ.* 9:e45312. doi: 10.2196/45312
- Gong, L., Huang, Y., and Wang, S. (2021). Blockchain applications in urban governance: lessons from smart city initiatives. *Govern. J.* 13, 279–296. doi: 10.1080/governance.2021.1211047
- Govindan, K., Jain, P., Singh, R., and Mishra, R. (2024). Blockchain technology as a strategic weapon to bring procurement 4.0 truly alive: literature review and future research agenda. *Trans. Res. Part E Logist. Transport. Rev.* 181:103352:103352. doi: 10.1016/j.tre.2023.103352
- Han, H., Shiwakoti, R. K., Jarvis, R., Mordi, C., and Botchie, D. (2023). Accounting and auditing with blockchain technology and artificial intelligence: a literature review. *Int. J. Account. Inf. Syst.* 48:100598. doi: 10.1016/j.accinf.2022.100598
- Haug, N., Dan, S., and Mergel, I. (2024). Digitally-induced change in the public sector: a systematic review and research agenda. *Public Manag. Rev.* 26, 1963–1987. doi: 10.1080/14719037.2023.2234917
- Heller, J., Mahr, D., de Ruyter, K., Schaap, E., Hilken, T., Keeling, D. I., et al. (2023). An interdisciplinary co-authorship networking perspective on AR and human behavior: taking stock and moving ahead. *Comput. Hum. Behav.* 143:107697. doi: 10.1016/j.chb.2023.107697
- Hu, B. (2022). Research on the nonlinear random matrix model for urban information model and modern urban governance. *Math. Probl. Eng.* 2022, 1–11. doi: 10.1155/2022/9128675
- Huang, J., Bibri, S. E., and Keel, P. (2025). Generative spatial artificial intelligence for sustainable smart cities: a pioneering large flow model for urban digital twin. *Environ. Sci. Ecotechnol.* 24:100526. doi: 10.1016/j.ese.2025.100526
- Hughes, L., Dwivedi, Y. K., Misra, S. K., Rana, N. P., Raghavan, V., and Akella, V. (2019). Blockchain research, practice and policy: applications, benefits, limitations, emerging research themes and research agenda. *Int. J. Inf. Manag.* 49, 114–129. doi: 10.1016/j.jinfomgt.2019.02.005
- Hughes, S., Giest, S., and Tozer, L. (2020). Accountability and data-driven urban climate governance. *Nat. Clim. Chang.* 10, 1085–1090. doi: 10.1038/s41558-020-00953-z
- Idzi, F. M., and Gomes, R. C. (2022). Digital governance: government strategies that impact public services. *Glob. Public Policy Gov.* 2, 427–452. doi: 10.1007/s43508-022-00055-w
- Ienca, M., Fins, J. J., Jox, R. J., Jotterand, F., Voeneky, S., Andorno, R., et al. (2022). Towards a governance framework for brain data. *Neuroethics* 15, 1–14. doi: 10.1007/s12152-022-09498-8
- Igbinenikaro, E., and Adewusi, A. O. (2024). Navigating the legal complexities of artificial intelligence in global trade agreements. *Int. J. Appl. Res. Soc. Sci.* 6, 488–505. doi: 10.51594/ijarss.v6i4.987
- Ivanović, L., and Ho, Y.-S. (2019). Highly cited articles in the education and educational research category in the social science citation index: a bibliometric analysis. *Educ. Rev.* 71, 277–286. doi: 10.1080/00131911.2017.1415297
- Jansen, B. J., and Boulianne, E. (2020). The challenges of implementing blockchain technology in public services. *Gov. Inf. Q.* 37:101433. doi: 10.1016/j.giq.2020.101433
- Janssen, M., Brous, P., Estevez, E., Barbosa, L. S., and Janowski, T. (2020). Data governance: organizing data for trustworthy artificial intelligence. *Gov. Inf. Q.* 37:101493. doi: 10.1016/j.giq.2020.101493
- Ji, P., Jin, J., Ke, Z. T., and Li, W. (2022). Co-citation and co-authorship networks of statisticians. *J. Bus. Econ. Stat.* 40, 469–485. doi: 10.1080/07350015.2021.1978469
- Jiang, H. (2021). Smart urban governance in the 'smart' era: why is it urgently needed? *Cities* 111:103004. doi: 10.1016/j.cities.2020.103004
- Jiang, S., Li, J., and Chen, Z. (2022). Regulatory challenges of AI and blockchain technologies: a comprehensive review. *J. Bus. Res.* 138, 374–386. doi: 10.1016/j.jbusres.2021.09.040
- Jin, T., Wu, Q., Ou, X., and Yu, J. (2021). Community detection and co-author recommendation in co-author networks. *Int. J. Mach. Learn. Cybern.* 12, 597–609. doi: 10.1007/s13042-020-01190-8
- Jun, M. S. (2018). Blockchain government - a next form of infrastructure for the twenty-first century. *J. Open Innov. Technol. Mark. Complex.* 4, 1–12. doi: 10.1186/s40852-018-0086-3
- Khan, B. U. I., Goh, K. W., Khan, A. R., Zuhairi, M. F., and Chaimanee, M. (2024). Integrating AI and Blockchain for enhanced data security in IoT-driven smart cities. *PRO* 12:1825. doi: 10.3390/pr12091825
- Khan, A., and Krishnan, S. (2021). Citizen engagement in co-creation of e-government services: a process theory view from a meta-synthesis approach. *Internet Res.* 31, 1318–1375. doi: 10.1108/INTR-03-2020-0116
- Khanna, A., Sah, A., Bolshev, V., Jasinski, M., Vinogradov, A., Leonowicz, Z., et al. (2021). Blockchain: future of e-governance in smart cities. *Sustainability (Switzerland)* 13, 1–21. doi: 10.3390/su132111840
- Khazaneha, M., Tajadini, O., Esmaeili, O., Abdi, M., Khasseh, A. A., and Sadatmoosavi, A. (2023). Thematic evolution of coronavirus disease: a longitudinal co-word analysis. *Lib. Hi Tech* 41, 7–24. doi: 10.1108/LHT-10-2021-0370
- Kumar, S., Lim, W. M., Sivarajah, U., and Kaur, J. (2022). Artificial intelligence and blockchain integration in business: trends from a bibliometric-content analysis. *Inf. Syst. Front.* 25, 871–896. doi: 10.1007/s10796-022-10279-0
- Kumar, N., Liu, X., Narayanasamydamodaran, S., and Pandey, K. K. (2021). A systematic review comparing urban flood management practices in India to China's sponge city program. *Sustainability (Switzerland)* 13:6346. doi: 10.3390/su13116346

- Kuznetsov, O., Sernani, P., Romeo, L., Frontoni, E., and Mancini, A. (2024). On the integration of artificial intelligence and blockchain technology: a perspective about security. *IEEE Access* 12, 3881–3897. doi: 10.1109/ACCESS.2023.3349019
- Li, H., Wang, X., and Yang, Q. (2021). Uncovering research trends and opportunities through keyword analysis. *Scientometrics* 126, 5157–5173. doi: 10.1007/s11192-021-04116-9
- Li, J., and Yu, Q. (2023). The evolutionary characteristics and interaction of Interdisciplinarity and scientific collaboration under the convergence paradigm: analysis in the field of materials genome engineering. *Sustainability (Switzerland)* 15:3417. doi: 10.3390/su151813417
- Lin, X., Li, X., Kulkarni, S., and Zhao, F. (2021). The application of blockchain-based life cycle assessment on an industrial supply chain. *Sustainability (Switzerland)* 13:3332. doi: 10.3390/su132313332
- Linnenluecke, M. K., Marrone, M., and Singh, A. K. (2020). Conducting systematic literature reviews and bibliometric analyses. *Aust. J. Manag.* 45, 175–194. doi: 10.1177/0312896219877678
- Liu, D., Che, S., and Zhu, W. (2022). Visualizing the knowledge domain of academic mobility research from 2010 to 2020: a bibliometric analysis using cite space. *SAGE Open* 12:8510. doi: 10.1177/21582440211068510
- Liu, J., Kong, X., Zhou, X., Wang, L., Zhang, D., Lee, I., et al. (2019). Data mining and information retrieval in the 21st century: a bibliographic review. *Comput. Sci. Rev.* 34:100193. doi: 10.1016/j.cosrev.2019.100193
- Liu, Y., Lu, Q., Zhu, L., and Paik, H.-Y. (2024). Decentralized governance-driven architecture for designing foundation-model-based systems: exploring the role of Blockchain in responsible AI. *IEEE Softw.* 41, 34–42. doi: 10.1109/MS.2024.3369551
- Liu, G., Nzige, J. H., and Li, K. (2019). Trending topics and themes in offsite construction (OSC) research. *Constr. Innov.* 19, 343–366. doi: 10.1108/CI-03-2018-0013
- Longoni, C., Bonezzi, A., and Morewedge, C. K. (2019). Resistance to Medical Artificial Intelligence. *J. Consum. Res.* 46, 629–650. doi: 10.1093/jcr/ucz013
- Lubis, S., Purnomo, E. P., Lado, J. A., and Hung, C.-F. (2024). Electronic governance in advancing sustainable development goals through systematic literature review. *Discover Glob. Soc.* 2:77. doi: 10.1007/s44282-024-00102-3
- Madan, R., and Ashok, M. (2023). AI adoption and diffusion in public administration: a systematic literature review and future research agenda. *Gov. Inf. Q.* 40:101774. doi: 10.1016/j.giq.2022.101774
- Matthies, H., and Torka, M. (2019). Academic habitus and institutional change: comparing two generations of German scholars. *Minerva* 57, 345–371. doi: 10.1007/s11024-019-09370-9
- Medeiros, E., and van der Zwet, A. (2020). Sustainable and integrated urban planning and governance in metropolitan and medium-sized cities. *Sustainability (Switzerland)* 12:5976. doi: 10.3390/su12155976
- Mehrabi, N., Morstatter, F., Saxena, N., Lerman, K., and Galstyan, A. (2021). A survey on Bias and fairness in machine learning. *ACM Comput. Surv.* 54, 1–35. doi: 10.1145/3457607
- Mircea, M., Stoica, M., and Ghilic-Micu, B. (2022). Analysis of the impact of Blockchain and internet of things (IIoT) on public procurement. *IEEE Access* 10, 63353–63374. doi: 10.1109/ACCESS.2022.3182656
- Mohamed, A. A. D., Abdelwahab, A. R., Alkhateeb, Y. M., Alrababah, O., Agarwal, P., and Abu Salim, T. (2022). Characteristics of Blockchain and smart services, for smart governments: a systematic review of the literature. *Int. J. Inf. Syst. Proj. Manag.* 10, 30–55. doi: 10.12821/ijispm100302
- Mora, L., Deakin, M., and Reid, A. (2019). Strategic principles for smart city development: a multiple case study analysis of European best practices. *Technol. Forecast. Soc. Chang.* 142, 70–97. doi: 10.1016/j.techfore.2018.07.035
- Mukhopadhyay, A., Pettet, G., Vazirizade, S. M., Lu, D., Jaimes, A., Said, S. E., et al. (2022). A review of incident prediction, resource allocation, and dispatch models for emergency management. *Accid. Anal. Prev.* 165:106501. doi: 10.1016/j.aap.2021.106501
- Mulligan, C., Morsfield, S., and Cheikosman, E. (2024). Blockchain for sustainability: a systematic literature review for policy impact. *Telecommun. Policy* 48:102676. doi: 10.1016/j.telpol.2023.102676
- Nahavandi, S. (2019). Industry 5.0-a human-centric solution. *Sustainability (Switzerland)* 11:4371. doi: 10.3390/su11164371
- Natarajan, R., Verma, S., and Krishnan, P. (2022). Integrating AI and blockchain for smarter governance: a future outlook. *Smart Cities J.* 12, 32–45. doi: 10.1109/SCJ.2022.976514
- Nechesov, A., and Ruponen, J. (2024). Empowering government efficiency through civic intelligence: merging artificial intelligence and Blockchain for smart citizen proposals. *Technologies* 12:271. doi: 10.3390/technologies12120271
- Nguyen, G., Dlugolinsky, S., Bobák, M., Tran, V., López García, Á., Heredia, I., et al. (2019). Machine learning and deep learning frameworks and libraries for large-scale data mining: a survey. *Artif. Intell. Rev.* 52, 77–124. doi: 10.1007/s10462-018-09679-z
- Ninkov, A., Frank, J. R., and Maggio, L. A. (2022). Bibliometrics: methods for studying academic publishing. *Perspectives on Medical Education* 11, 173–176. doi: 10.1007/s40037-021-00695-4
- Ogunbiyi, N., Basukoski, A., and Chausaulet, T. (2021). An exploration of ethical decision making with intelligence augmentation. *Sociol. Sci.* 10:57. doi: 10.3390/socsci10020057
- Oliveira, T. A., Oliver, M., and Ramalhinho, H. (2020). Challenges for connecting citizens and smart cities: ICT, e-governance and blockchain. *Sustainability (Switzerland)* 12:2926. doi: 10.3390/su12072926
- Onososen, A. O., and Musonda, I. (2022). Perceived benefits of automation and artificial intelligence in the AEC sector: an interpretive structural modeling approach. *Front. Built Environ.* 8:864814. doi: 10.3389/fbuil.2022.864814
- Ouyang, L., Yuan, Y., and Wang, F.-Y. (2022). Learning markets: an AI collaboration framework based on Blockchain and smart contracts. *IEEE Internet Things J.* 9, 14273–14286. doi: 10.1109/JIOT.2020.3032706
- Pang, Z., Yan, Y., and Jiang, X. (2020). Smart cities and AI: a bibliometric review of research trends and future directions. *Cities J.* 109, 45–63. doi: 10.1016/j.cities.2020.103013
- Patnaik, J., and Bhowmick, B. (2019). Revisiting appropriate technology with changing socio-technical landscape in emerging countries. *Technol. Soc.* 57, 8–19. doi: 10.1016/j.techsoc.2020.11.004
- Peng, S., Zhou, L., He, X., and Du, J. (2020). GPS-aided inter-microcell interference avoidance for request-transmission splitting slotted ALOHA-based scheme in smart cities with connected vehicles. *Futur. Gener. Comput. Syst.* 108, 501–511. doi: 10.1016/j.future.2020.03.007
- Pérez, L. M., Oltra-Badenes, R., Gutiérrez, J. V. O., and Gil-Gómez, H. (2020). A bibliometric diagnosis and analysis about smart cities. *Sustainability (Switzerland)* 12:6357. doi: 10.3390/su12166357
- Rais, S., Masud, M. M., and Bakar, N. A. (2020). Automating governance processes using AI and blockchain: a framework. *J. Govern. Regul.* 9, 35–46. doi: 10.22495/jgr.v9i1.4251
- Rana, S. K., Rana, S. K., Nisar, K., Ag Ibrahim, A. A., Rana, A. K., Goyal, N., et al. (2022). Blockchain technology and artificial intelligence based decentralized access control model to enable secure interoperability for healthcare. *Sustainability (Switzerland)* 14:9471. doi: 10.3390/su14159471
- Rejeb, A., Keogh, J., and Treiblmaier, H. (2021). Exploring the potential of blockchain technology for smart city governance. *J. Strateg. Innov. Sustain.* 10, 89–102. doi: 10.14448/jsis.2021.0332
- Ressi, D., Romanello, R., Piazza, C., and Rossi, S. (2024). AI-enhanced blockchain technology: a review of advancements and opportunities. *J. Netw. Comput. Appl.* 225:103858. doi: 10.1016/j.jnca.2024.103858
- Reza Habib Agahi, M., Agha Mohammad Ali Kermani, M., and Maghsoudi, M. (2022). On the co-authorship network analysis in the process mining research community: a social network analysis perspective. *Expert Syst. Appl.* 206:117853. doi: 10.1016/j.eswa.2022.117853
- Roshani, S., Bagherlooie, M.-R., Mosleh, M., and Coccia, M. (2021). What is the relationship between research funding and citation-based performance? A comparative analysis between critical disciplines. *Scientometrics* 126, 7859–7874. doi: 10.1007/s11192-021-04077-9
- Sa, R., Sesma-solance, J., and Bilbao-jayo, A. (2019). Smart cities survey: technologies, application domains and challenges for the cities of the future. *Int. J. Distributed Sensor Netw.* 15:155014771985398. doi: 10.1177/1550147719853984
- Saeidnia, H. R. (2023). Ethical artificial intelligence (AI): confronting bias and discrimination in the library and information industry. *Lib. Hi Tech News* doi: 10.1108/LHTN-10-2023-0182 [Epub ahead of print].
- Saheb, T., and Saheb, T. (2024). Mapping ethical artificial intelligence policy landscape: a mixed method analysis. *Sci. Eng. Ethics* 30:9. doi: 10.1007/s11948-024-00472-6
- Salah, K., Rehman, M. H. U., Nizamuddin, N., and Al-Fuqaha, A. (2019). Blockchain for AI: review and open research challenges. *IEEE Access* 7, 10127–10149. doi: 10.1109/ACCESS.2018.2890507
- Schäfermeier, B., Hirth, J., and Hanika, T. (2023). Research topic flows in co-authorship networks. *Scientometrics* 128, 5051–5078. doi: 10.1007/s11192-022-04529-w
- Schmidt, C. G., and Wagner, S. M. (2019). Blockchain and supply chain relations: a transaction cost theory perspective. *J. Purch. Supply Manag.* 25:100552. doi: 10.1016/j.pursup.2019.100552
- Schneider, I. (2020). Democratic governance of digital platforms and artificial intelligence? Exploring governance models of China, the us, the eu and mexico. *EJ. EDemoc. Open Gov.* 12, 1–24. doi: 10.29379/jedem.v12i1.604
- Schneider, J., Kauffman, R. J., and De Vries, H. (2020). The economics of blockchain and the future of the public sector. *J. Bus. Res.* 116, 176–182. doi: 10.1016/j.jbusres.2020.05.030
- Shamsan Saleh, A. M. (2024). Blockchain for secure and decentralized artificial intelligence in cybersecurity: a comprehensive review. *Blockchain Res. Appl.* 5:100193. doi: 10.1016/j.bcr.2024.100193
- Shava, E., and Mhlanga, D. (2023). Mitigating bureaucratic inefficiencies through blockchain technology in Africa. *Front. Blockchain* 6, 1–11. doi: 10.3389/fbloc.2023.1053555

- Shults, F. L., and Wildman, W. J. (2020). Human simulation and sustainability: ontological, epistemological, and ethical reflections. *Sustainability (Switzerland)* 12, 1–16. doi: 10.3390/su122310039
- Siddaway, A. P., Wood, A. M., and Hedges, L. V. (2019). How to do a systematic review: a best practice guide for conducting and reporting narrative reviews, Meta-analyses, and Meta-syntheses. *Annu. Rev. Psychol.* 70, 747–770. doi: 10.1146/annurev-psych-010418-102803
- Singh, P., Elmi, Z., Lau, Y., Borowska-Stefańska, M., Wiśniewski, S., and Dulebenets, M. A. (2022). Blockchain and AI technology convergence: applications in transportation systems. *Veh. Commun.* 38:100521. doi: 10.1016/j.vehcom.2022.100521
- Singh, C. K., Filho, D. V., Jolad, S., and O’Neale, D. R. J. (2020). Evolution of interdependent co-authorship and citation networks. *Scientometrics* 125, 385–404. doi: 10.1007/s11192-020-03616-0
- Singh, J., Sajid, M., Gupta, S. K., and Haidri, R. A. (2022). Artificial intelligence and blockchain technologies for smart city. *Intelligent Green Technologies for Sustainable Smart Cities*, October. pp. 317–330.
- Singh, S., Sharma, P. K., Yoon, B., Shojafar, M., Cho, G. H., and Ra, I.-H. (2020). Convergence of blockchain and artificial intelligence in IoT network for the sustainable smart city. *Sustain. Cities Soc.* 63:102364. doi: 10.1016/j.scs.2020.102364
- Smith, M., Sarabi, Y., and Christopoulos, D. (2023). Understanding collaboration patterns on funded research projects: a network analysis. *Netw. Sci.* 11, 143–173. doi: 10.1017/nws.2022.33
- Son, T. H., Weedon, Z., Yigitcanlar, T., Sanchez, T., Corchado, J. M., and Mehmood, R. (2023). Algorithmic urban planning for smart and sustainable development: systematic review of the literature. *Sustain. Cities Soc.* 94:104562. doi: 10.1016/j.scs.2023.104562
- Sousa, M. J. (2023). Blockchain as a driver for transformations in the public sector. *Policy Design Pract.* 6, 415–432. doi: 10.1080/25741292.2023.2267864
- Sun, T. Q., and Medaglia, R. (2019). Mapping the challenges of artificial intelligence in public sector: evidence from public healthcare. *Gov. Inf. Q.* 36, 368–383. doi: 10.1016/j.giq.2018.09.008
- Taeiagh, A. (2021). Governance of artificial intelligence. *Polic. Soc.* 40, 137–157. doi: 10.1080/14494035.2021.1928377
- Tan, E., Mahula, S., and Cromptvoets, J. (2022). Blockchain governance in the public sector: a conceptual framework for public management. *Gov. Inf. Q.* 39:101625. doi: 10.1016/j.giq.2021.101625
- Tan, E., Petit Jean, M., Simonofski, A., Tombal, T., Kleizen, B., Sabbe, M., et al. (2023). Artificial intelligence and algorithmic decisions in fraud detection: an interpretive structural model. *Data Policy* 5:22. doi: 10.1017/dap.2023.22
- Tangi, L., Janssen, M., Benedetti, M., and Noci, G. (2021). Digital government transformation: a structural equation modelling analysis of driving and impeding factors. *Int. J. Inf. Manag.* 60:102356. doi: 10.1016/j.ijinfomgt.2021.102356
- Thelwall, M., and Sud, P. (2021). Do new research issues attract more citations? A comparison between 25 Scopus subject categories. *J. Assoc. Inf. Sci. Technol.* 72, 269–279. doi: 10.1002/asi.24401
- Tian, T. (2022). “Application of virtual simulation Technology in the Teaching of practical courses under the background of specialty clusters.” in *2022 IEEE international conference on electrical engineering, big data and algorithms (EEBDA)*. pp. 831–835.
- Trvisan, F., and Cogburn, D. L. (2020). Technology and accessibility in global governance and human rights: the experience of disability rights advocates. *J. Inf. Commun. Ethics Soc.* 18, 377–391. doi: 10.1108/JICES-02-2020-0016
- Tripathi, G., Ahad, M. A., and Casalino, G. (2023). A comprehensive review of blockchain technology: underlying principles and historical background with future challenges. *Decision Anal. J.* 9:100344. doi: 10.1016/j.dajour.2023.100344
- Tsolakis, N., Schumacher, R., Dora, M., and Kumar, M. (2023). Artificial intelligence and blockchain implementation in supply chains: a pathway to sustainability and data monetisation? *Ann. Oper. Res.* 327, 157–210. doi: 10.1007/s10479-022-04785-2
- Vieira, E. S. (2023). The influence of research collaboration on citation impact: the countries in the European innovation scoreboard. *Scientometrics* 128, 3555–3579. doi: 10.1007/s11192-023-04715-4
- Vrabie, A., and Ianole-Călin, R. (2020). A comparative analysis of municipal public innovation: evidence from Romania and United States. *J. Open Innov. Technol. Mark. Complex.* 6, 112–121. doi: 10.3390/joitmc6040112
- Wang, J., Frietsch, R., Neuhausler, P., and Hooi, R. (2024). International collaboration leading to high citations: global impact or home country effect? *J. Inf.* 18:101565. doi: 10.1016/j.joi.2024.101565
- Wang, J., Zhang, L., and Liu, C. (2020). The role of machine learning in keyword extraction and trend analysis. *IEEE Trans. Neural Netw. Learn. Syst.* 31, 4051–4064. doi: 10.1109/TNNLS.2020.2993458
- Wen, C., Liu, W., He, Z., and Liu, C. (2023). Research on emergency management of global public health emergencies driven by digital technology: a bibliometric analysis. *Front. Public Health* 10:1100401. doi: 10.3389/fpubh.2022.1100401
- Wirtz, B. W., Weyerer, J. C., and Kehl, I. (2022). Governance of artificial intelligence: a risk and guideline-based integrative framework. *Gov. Inf. Q.* 39:101685. doi: 10.1016/j.giq.2022.101685
- Xie, J., Tang, H., Huang, T., Yu, F. R., Xie, R., Liu, J., et al. (2019). A survey of Blockchain technology applied to smart cities: research issues and challenges. *IEEE Commun. Surv. Tutor* 21, 2794–2830. doi: 10.1109/COMST.2019.2899617
- Xu, G., Guo, B., Su, C., Zheng, X., Liang, K., Wong, D. S., et al. (2020). Am I eclipsed? A smart detector of eclipse attacks for Ethereum. *Comput. Secur.* 88:101604. doi: 10.1016/j.cose.2019.101604
- Xu, R., Li, C., and Joshi, J. (2023). Blockchain-based transparency framework for privacy preserving third-party services. *IEEE Trans. Dependable Secure Comp.* 20, 1–2313. doi: 10.1109/TDSC.2022.3179698
- Xu, Z., and Zou, C. (2021). What can blockchain do and cannot do? *China Econ. J.* 14, 4–25. doi: 10.1080/17538963.2020.1748968
- Yang, X., Yi, X., Nepal, S., Kelarev, A., and Han, F. (2020). Blockchain voting: publicly verifiable online voting protocol without trusted tallying authorities. *Futur. Gener. Comput. Syst.* 112, 859–874. doi: 10.1016/j.future.2020.06.051
- Yigitcanlar, T., Desouza, K. C., Butler, L., and Roozkhosh, F. (2020). Contributions and risks of artificial intelligence (AI) in building smarter cities: insights from a systematic review of the literature. *Energies* 13:1473. doi: 10.3390/en13061473
- Yogi, M. K., Chakravarthy, A. S. N., and Assistant. (2023). Role of privacy metrics in next generation smart cities. *Tuijin Jishu/J. Propul. Technol.* 44, 3151–3159. doi: 10.52783/tjpt.v44.i4.1407
- Zavolokina, L., Schlegel, M., and Schwabe, G. (2020). Blockchain and transparency in governance: applications in smart cities. *Gov. Inf. Q.* 37, 101480–101468. doi: 10.1016/j.giq.2020.101480
- Zhang, Y., Dong, Z. Y., Yip, C., and Swift, S. (2020). Smart campus: a user case study in Hong Kong. *IET Smart Cities* 2, 146–154. doi: 10.1049/iet-smc.2020.0047
- Zhang, G., Raina, A., Cagan, J., and McComb, C. (2021). A cautionary tale about the impact of AI on human design teams. *Des. Stud.* 72:100990. doi: 10.1016/j.destud.2021.100990
- Zhao, J., Chen, Y., and Yang, K. (2021). Blockchain and privacy: a survey. *IEEE Trans. Inf. Forensics Secur.* 16, 1697–1711. doi: 10.1109/TIFS.2021.3066779
- Zhao, N., Sheng, Z., and Yan, H. (2021). Emission trading innovation mechanism based on blockchain. *Chin. J. Popul. Resour. Environ.* 19, 369–376. doi: 10.1016/j.cjpre.2022.01.010
- Zheng, G. G. (2020). China’s grand design of people’s smart courts. *Asian J. Law Soc.* 7, 561–582. doi: 10.1017/als.2020.20
- Zhou, X., Liang, W., Wang, K. I. K., Huang, R., and Jin, Q. (2021). Academic influence aware and multidimensional network analysis for research collaboration navigation based on scholarly big data. *IEEE Trans. Emerg. Top. Comput.* 9, 246–257. doi: 10.1109/TETC.2018.2860051
- Zhou, Z., Liu, D., Chen, Z., and Pancho, M. (2025). Government adoption of generative artificial intelligence and ambidextrous innovation. *Int. Rev. Econ. Financ.* 98:103953. doi: 10.1016/j.iref.2025.103953
- Zhu, X., Chen, Z., Cheng, T., Yang, C., Wu, D., Wu, Y., et al. (2024). Blockchain for urban governance: enhancing trust in smart city systems with advanced techniques. *Sustain. Cities Soc.* 108:105438. doi: 10.1016/j.scs.2024.105438
- Zuiderwijk, A., Chen, Y.-C., and Salem, F. (2021). Implications of the use of artificial intelligence in public governance: a systematic literature review and a research agenda. *Gov. Inf. Q.* 38:101577. doi: 10.1016/j.giq.2021.101577
- Zwitter, A., and Hazenberg, J. (2020). Decentralized network governance: Blockchain technology and the future of regulation. *Front. Blockchain* 3, 1–12. doi: 10.3389/fbloc.2020.00012