Journal of Intelligent Systems and Internet of Things

♦ ISSN: 2690-6791 Vol: 19, No. 01, 2027 ♦ PP. 01–15

♦ Article DOI: https://doi.org/10.54216/JISIoT.190101



REVIEW ARTICLE

Sustainability through IoT and Big Data Analytics in Tertiary Industry: A Literature Review and Bibliometric Analysis

Mohammad Mizenur Rahaman[1,*] **Sayma Sadia Shawon**[2] **Sakufa Chowdhury**[3] **Mainul Islam Rayhan**[4] **Anamul Haque Uzzol**[4]

[1] Professor, Department of Business Administration, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh, India

[2] Assistant Professor, Department of Business Administration, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh, India

[3] Associate Professor, Department of Business Administration, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh, India

[4] Research Student, Department of Business Administration, Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh, India

Emails: mizen-ban@sust.edu; sayma_sadia-bus@sust.edu; sakufa-bus@sust.edu mainul17@student.sust.edu; anamul85@student.sust.edu

Received: July 06, 2026 Revised: August 28, 2026 Accepted: October 09, 2026 ⋆ Corresponding author

ABSTRACT

The tertiary industry is increasingly influenced by digital technologies that support service efficiency, data-driven decision-making and sustainability-oriented transformation. This study reviews the way the Internet of Things (IoT) and Big Data Analytics (BDA) contribute to sustainability in service sectors, including healthcare, education, tourism, hospitality, logistics, transport, finance and smart-city services. A systematic literature review and bibliometric analysis were conducted using Scopus and Web of Science for records dated from 2015 through 28 February 2025. From 1,969 initial records, 551 were used for bibliometric and metadata analysis and 136 studies were included in qualitative synthesis. The publication trend, productive sources, authors, countries, subject areas, keywords and science-mapping pattern were studied by using Bibliometrix, Biblioshiny and VOSviewer. The findings show rapid growth after 2019 and strong concentration in computer science, engineering, smart healthcare, smart cities and digital sustainability research. The main contribution is an integrated service-sector synthesis showing that IoT functions as the sensing and connectivity layer, while BDA, AI, cloud-edge architectures, blockchain and predictive analytics convert service data into monitoring, optimization, decision support and automation. Sustainability outcomes appear across environmental, economic and social dimensions, including energy savings, emissions reduction, waste recovery, cost efficiency, healthcare access, inclusion and service quality. Finally, the review concludes that IoT and BDA, among other factors, have sustainable value if supported by governance, data quality, cybersecurity, interoperability, skills and organizational readiness.

Keywords: Internet of Things ▪ Big Data Analytics ▪ Sustainability ▪ Tertiary industry ▪ Bibliometric analysis ▪ Smart services ▪ Digital transformation

1. INTRODUCTION

Digital technologies are now key to the service-based economies due to emerging pressures of sustainability-related issues. In recent years, tertiary industries such as healthcare, education, finance, logistics, transport, tourism and hospitality have grown to rely on connected devices, digital platforms, and data-driven decision-making to enhance service quality, operational efficiency, and resource utilization [1, 2]. The Internet of Things (IoT) and Big Data Analytics (BDA) stand out among those technologies because they allow linking the physical service environment and the analytical systems to monitor, predict and optimize activities in real time [3, 4]. This is evident from the extent of electronic information that is being produced. By 2020, the amount of data created around the world is expected to be about 44 zettabytes [5]. This fast growth opens the door for enhanced service intelligence,

© 2027 The Author(s). Published by ASPG. This article is licensed under CC BY 4.0.

while simultaneously driving the demand for serviceable analytical capability, data governance, and sustainable digital infrastructure.

The impact of IoT and BDA on sustainability is apparent in various aspects of the service sector. Smart transport and energy systems can, for instance, be supported with data gathered from electric vehicles, charging stations, smart meters and connected grid devices, to provide energy-efficient planning, smart charging and low emission mobility [3]. Furthermore, sustainability challenge is paramount in the smart-city scenario since the urban system consumes approximately 70% of the world resources, and, for this reason, digital monitoring and intelligent service coordination are becoming increasingly important when dealing with resource efficiency and the management of the environment [6]. Healthcare IoT allows remote monitoring, prediction and data-driven diagnosis, while privacy, security, latency and energy consumption are still challenges [4]. Additionally, machine-learning-based control systems have also shown their practical sustainability potential for educational and building-service applications. For example, Duhirwe et al. [7] determined that a deep reinforcement learning control method can reduce ventilation energy consumption by 58% whilst maintaining the level of CO2 in the indoor environment within an acceptable limit.

As these examples show, sustainability in tertiary industries is not only about protecting the environment. It also includes aspects of economic resilience, cost reductions, social inclusion and access to services, as well as the responsible adoption of technologies [8, 9]. AI, IoT and smart technologies are also being used in the hospitality and tourism sectors to improve destination management, improve operational efficiency, improve the visitor experience and improve service design for sustainability [2, 12]. AI, business intelligence and predictive analytics are associated with efficiency, competitiveness and cost savings in logistics and supply chain services [1, 29]. The sectoral developments are proof that IoT and BDA are not only technical tools. They sit within the wider digital transformation programmes that are re-shaping the planning, delivery and measurement of sustainable value for service organisations.

However, the literature remains fragmented across technologies, sectors and sustainability outcomes [9]. The majority of studies are restricted to the smart city domain, healthcare, tourism, education and supply chain management and, very few studies have tried to explain the contributions of IoT and BDA to sustainability in the wider tertiary sector [9, 10]. However, a disconnect exists between technical research, which focuses on system design and performance, and management-oriented research, which looks at aspects of adoption, organisational readiness, governance and realised sustainability outcomes [29]. This fragmentation complicates the task of viewing the entire scenario from a single point of view, and of pinpointing dominant knowledge structures, key actors, sectoral applications, enabling factors, and constraints as well as areas for further study.

For this reason, the present study systematically reviewed and analysed the literature to map the fragmented knowledge on IoT, BDA, and Sustainability in the tertiary industries. It is guided by three research questions. First, what are the publication patterns and intellectual structures of research on IoT, BDA and sustainability in tertiary industries? Second, how are IoT and BDA applied across service sectors such as healthcare, education, logistics, transport, tourism, hospitality, and finance? Third, what sustainability outcomes, drivers, barriers, and future research directions are reported in this literature? The study addresses these questions, offering a structured understanding of how IoT and BDA can contribute to the transformation of the service sector in a sustainable fashion and it highlights gaps for future research.

2. CONCEPTUAL BACKGROUND

2.1 Tertiary industry/service sector

The tertiary industry refers to service-based economic activities where value is created mainly through knowledge, information, interaction, coordination, and experience rather than the direct production of physical goods [11]. Service sector comprises healthcare, education, tourism and hospitality, finance, logistics, transport and other smart city services etc. These industries are suitable for the current study as they are becoming more and more reliant on digital infrastructures, data intensive operations and user centric service delivery. To give an example, the IoT, Cloud computing, Big Data and Analytics are the industry 4.0 technologies used in finance and supply chain services to improve visibility, connectivity and financial performance [1]. Similarly, the tourism and the hospitality sector is undergoing transformation with the use of AI, IoT, automation, and smart destination systems that are making travel more personalized and efficient while enriching the experience of visitors [2, 12]. Logistics and port services are also considered tertiary-sector activities because they are not directly involved in the production of goods but rather in the management of information, the flow of cargoes, forecasting and reliability of services [1, 29].

2.2 Sustainability in tertiary industries

The sustainability of tertiary industries involves environmental, economic and social aspects [13]. Environmental sustainability is about minimizing energy consumption, emissions, waste, resource stress, and environmental harm in service systems [14, 15]. Economic sustainability relates to efficiency, cost reduction, competitiveness, resilience and long-term service performance [16, 17]. Social sustainability encompasses access, health, safety, education, inclusion, and quality of life [18, 19]. These dimensions are particularly relevant for service sectors, as many digital services use energy, and can also help to reduce environmental impact. For instance, digital monitoring and analytics can support urban sustainability and resource-efficiency strategies [6, 9]. Sustainability in healthcare and smart buildings is related to low-power systems, a healthy environment, and reduced operational waste [7, 20].

2.3 Internet of Things for sustainability

The Internet of Things (IoT) is the sensing and connectivity layer that makes physical service environments measurable, traceable, and responsive [21]. In IoT-enabled service systems, data are collected from users, assets, buildings, vehicles, medical devices, and environmental data through sensors, connectivity devices, gateways, and communication networks [22]. This capability is essential in the context of sustainability, enabling service providers to monitor energy use, find

opportunities for energy savings, automate energy management and facilitate real time decision making. It is evident that IoT-enabled electric vehicles, charging stations, smart meters, and grid devices can generate data that can be leveraged to improve charging plans, energy efficiency, and opportunities for vehicle-to-grid integration in Green smart cities [3]. In healthcare, IoT devices and medical sensors are used for remote monitoring, diagnosis, and energy-aware service delivery; however, they can raise issues related to power consumption, latency, privacy, and security [23, 24, 25]. In the hospitality and transport sectors, IoT is utilized in resource optimization, smart service robots, visitor management, and sustainable network design [2, 3, 20].

2.4 Big Data Analytics for sustainability

Big Data Analytics involves acquiring and analyzing massive volumes of data to discover market trends, insights, and patterns that help firms make better business decisions [26]. For this review, BDA is framed as data mining, artificial intelligence, machine learning, business intelligence, predictive analytics, and other computational methods. The tools are conceptually important because IoT data has limited value unless it is analysed and converted into actionable decision insights. Data mining and bibliometric methods have been employed in financial services to identify research areas and forecast trends in blockchain-finance applications [27]. In cloud-centric healthcare, machine learning can play a role in the analysis of the IoT produced data, and optimize the design of energy-efficient healthcare services supporting sustainable smart healthcare [28]. AI, business intelligence, digital transformation and predictive analytics enhance efficiency, competitiveness and cost-effectiveness within logistics and supply chain services [1, 29]. In tourism, analytics and smart platforms can support destination management, visitor services, and sustainability-oriented decision-making [2, 34, 52]. But BDA is more than just a technical solution. Its value depends on data quality, organizational readiness, human expertise, and the ability to translate predictions into responsible managerial action [29].

2.5 Integration of IoT and BDA in service industries

The integration of IoT and BDA can be considered as a data-to-action mechanism. IoT collects real-time data from service environments, and BDA, AI, cloud, edge, fog computing, blockchain, and predictive models convert those data into actionable insights, automation, and strategic decisions [30]. This integration comes that much timelier for this review, since the success of sustainability, as often is the case, depends on both the sense and the analytics – a factor considered separately will not suffice. In the context of smart cities, security, privacy, scalability and trust are key concerns, however, AI, blockchain and IoT can contribute to the development of secure, decentralized and intelligent service ecosystems [31]. Blockchain and AI models can be used in the healthcare industry to enable healthcare IoT systems, interoperability and data sharing security, disease prediction, and energy-efficient options [32, 59, 60]. Beyond these sustainability benefits, edge, fog, and cloud computing can also improve healthcare services, by decreasing the latency and energy use in time-constrained use cases [33]. Moreover, generative AI, natural language processing and IoT can be used to offer personalised recommendations, multilingual communication, accessibility and sustainable smart destination management in the tourism sector [34]. The conceptual approach of this work is that IoT and BDA should not be considered as stand-alone technologies. With the appropriate infrastructure, governance, skills and ethical safeguards, they can be integrated to form a comprehensive digital capability that can then improve sustainability in tertiary industries.

3. METHODOLOGY

A systematic literature review was conducted with bibliometric analysis, science mapping and qualitative synthesis. The design was appropriate because research on IoT, big data analytics and sustainability in tertiary industries is dispersed across service sectors, technologies and sustainability outcomes [35, 36, 37]. Bibliometric analysis mapped publication patterns and intellectual structures, while qualitative synthesis interpreted applications, mechanisms, outcomes, drivers, barriers and future research directions [38, 39]. The review followed PRISMA-related steps: identification, screening, eligibility and inclusion [40].

3.1 Identification of the data

The data were collected from Scopus and Web of Science due to their ability to deliver structured bibliographic information, which is essential for interdisciplinary technology and sustainability research [41, 42]. The search strategy was structured into four keyword groups, each corresponding to the research questions: tertiary or service industries, sustainability, IoT, and Big Data Analytics. The service-sector terms covered healthcare, education, higher education, finance, hospitality, tourism, transport, logistics, IT services and telecommunication services. Sustainability terms included sustainable development, environmental, social and economic sustainability, energy efficiency, resource efficiency, carbon emissions, circular economy, ESG and SDGs. The technology and analytics terms included IoT, Internet of Things, smart sensors, big data, data analytics, business intelligence, data mining, machine learning, artificial intelligence and data science.

In Scopus, the search was applied to title, abstract and keywords and produced 1,818 records. Web of Science topic searches produced 151 records, giving an initial pool of 1,969 records. The search was then refined by applying the four keyword blocks, the 2015–28 February 2025 date limit, English-language preference and document-type criteria. Broad records that matched isolated keywords but did not combine service-sector, sustainability and IoT/BDA concepts were removed before screening. This refinement removed 1,418 records and produced the 551-record dataset used for bibliometric and metadata analysis [1, 4, 8].

3.2 Screening initial data

The 551 records were then screened by title, abstract, keywords and publication details. Records were retained when they addressed sustainability together with IoT, BDA, AI, machine learning, business intelligence or data-driven decision-making in a tertiary or service-sector context. Records were excluded when the link among the service sector, the technology and sustainability was absent or only incidental, because broad interdisciplinary searches can retrieve papers that share

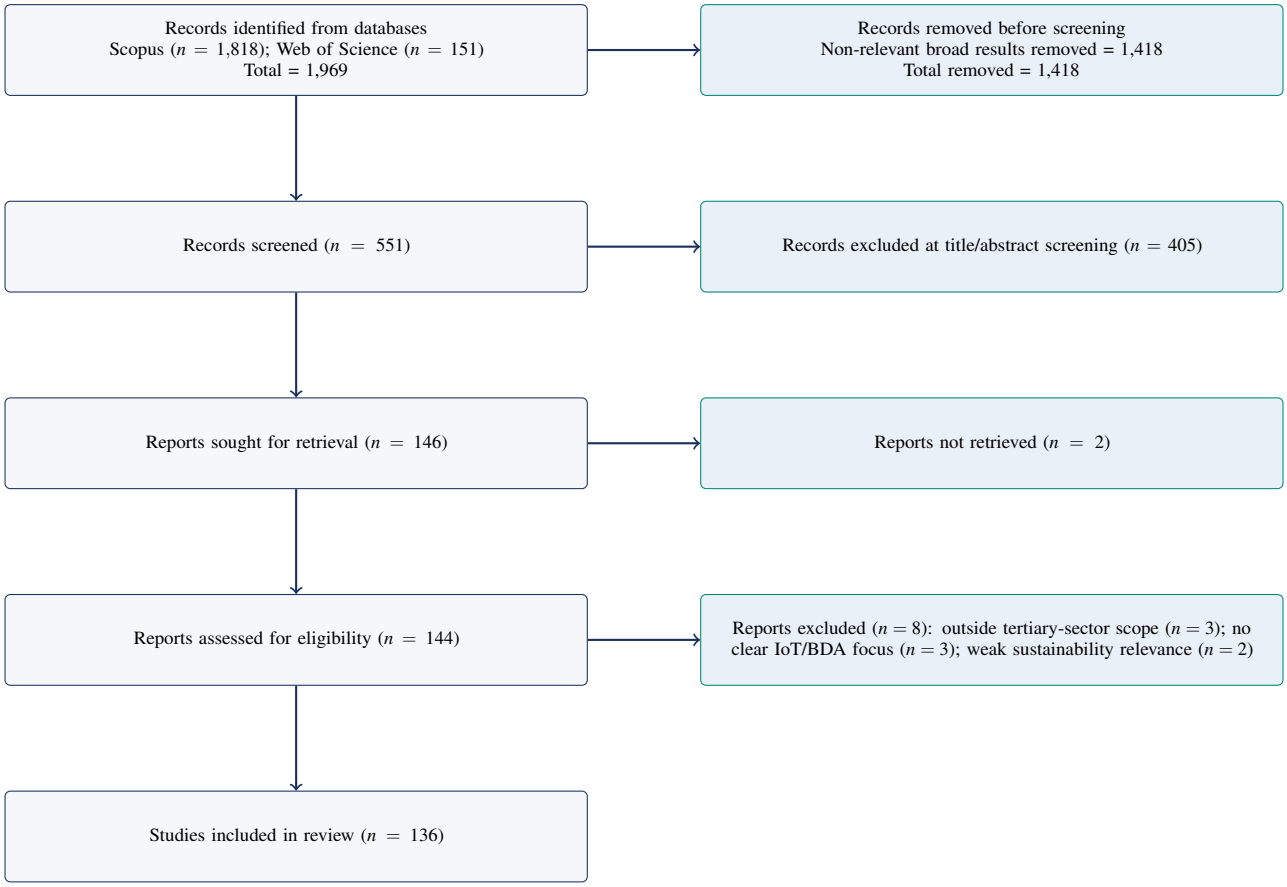


Figure 1. PRISMA 2020 Flow Diagram for Study Selection (2015–28 February 2025)

Table 1. Search strategy and keyword blocks used for source identification

Database	Search field	Concept	Search terms used	Limits and search outcome
Scopus	TITLE-ABS-KEY	Tertiary-industry service domains	"tertiary industr*", "tertiary sector", "service industr*", "service sector*", banking or financial services, healthcare or health care services, education or higher education, retail, hospitality, tourism, transportation, logistics, software or IT services, telecommunication or communications services	Combined with the other three blocks using AND. Refined search produced 551 records; final English-language article set reported in the search log: n = 136.
Scopus	TITLE-ABS-KEY	Sustainability	sustainab*, "sustainable development", "sustainable performance", environmental, social or economic sustainability, "green innovation", "green computing", "energy efficien*", "resource efficien*", "carbon emission*", "carbon footprint", "circular economy", ESG, SDG*	Publication coverage was restricted to records dated from 2015 through 28 February 2025.
Scopus	TITLE-ABS-KEY	IoT and sensing	IoT, "Internet of Things", "Web of Things", "smart sensor*", "sensor network*"	Document type and language filters were applied after the refined search.
Scopus	TITLE-ABS-KEY	Big Data Analytics and AI	"big data", "big data analy*", "data analytics", "business analytics", "business intelligence", "data mining", "machine learning", "artificial intelligence", "data science"	The final search logic required all four blocks to be present.
Web of Science	Topic search (TS)	Tertiary-industry service domains	Same service-domain terms as Scopus, translated into TS syntax.	Web of Science search log recorded 151 records.
Web of Science	Topic search (TS)	Sustainability	Same sustainability terms as Scopus, translated into TS syntax.	Publication coverage was restricted to records dated from 2015 through 28 February 2025.
Web of Science	Topic search (TS)	IoT and sensing	IoT, "Internet of Things", "Web of Things", "smart sensor*", "sensor network*".	The Web of Science syntax followed the same four-block AND structure.
Web of Science	Topic search (TS)	Big Data Analytics and AI	"big data", "big data analy*", "data analytics", "business analytics", "business intelligence", "data mining", "machine learning", "artificial intelligence", "data science".	Records were screened with the Scopus results during eligibility assessment.

keywords but not the review problem [43]. For the retrieval phase, 405 records were excluded and 146 reports remained because the excluded records did not focus on sustainability, did not have a clear IoT or analytics component, or were not in the service industries. A total of 144 reports were evaluated for eligibility, with two full texts that could not be retrieved. These 551 records were kept separately for bibliometric mapping as they contained sufficient metadata to analyse the subject areas, keywords, countries, authors and authors' keyword structures of publications and the growth of publications [38].

3.3 Determining eligibility

The eligibility step selected studies for qualitative synthesis from 144 retrieved papers. Each was evaluated in terms of the three research questions. Studies were considered if they focused on the IoT and BDA/related analytical techniques in the context of sustainability in tertiary sectors. Eligible contexts included healthcare, education, tourism, hospitality, finance, transport, logistics, smart cities and digital service

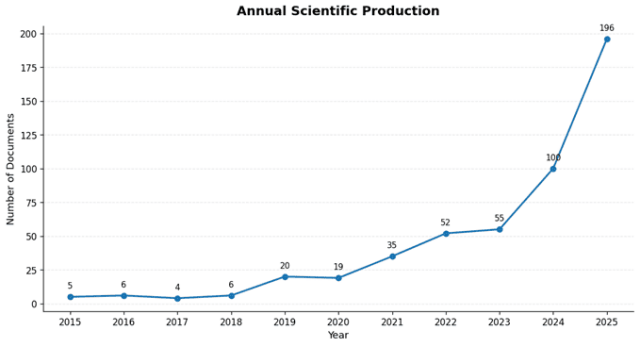


Figure 2. Annual publication trend (2025 data through 28 February)

systems. Papers were also required to cover applications, integrated IoT-BDA mechanisms, environmental, economic, or social outcomes, implementation drivers, barriers, risks, or future directions for research. The assessment used structured review judgement and critical-appraisal principles [44, 45]. Sector-specific papers were not discounted because the review was conducted to provide a comparison of evidence from the broader tertiary sector. At eligibility, 8 reports were excluded: three were not in the scope of the tertiary sector, three did not have a clear focus on IoT/BDA, and two had low sustainability relevance. This resulted in the final qualitative synthesis sample of 136 studies.

3.4 Data Inclusion and Analysis Procedures

Two related datasets were thus used for the final review: 551 records for bibliometric and metadata analysis and 136 studies for qualitative synthesis. This two-stage structure preserved breadth for field mapping and depth for interpretation [36]. The bibliometric analysis was performed using Bibliometrix and Biblioshiny, an open-source R package [38]supported by Excel for cleaning and tabulation and Python in Google Colab for visualisation. The analysis covered year, source, author, cited papers, country, institution, keywords, subject area and document type. VOSviewer and Biblioshiny were used for keyword co-occurrence, country collaboration, co-citation or bibliographic coupling, thematic mapping and three-field relationships. The 136 studies were then synthesized around conceptual development, applications, integrated mechanisms, sustainability outcomes, drivers, barriers and risks.

4. BIBLIOMETRIC AND METADATA ANALYSIS

4.1 Metadata analysis

4.1.1 Annual publication trend

The dataset of 551 studies clearly depicts an increase in the number of publications related to IoT, Big Data Analytics (BDA) and sustainability in the tertiary industries during the last decade. The number of articles in this field has been growing since 2016, with a significant increase after 2019 and reaching 101 in 2024; the 2025 value of 196 includes only records available up to 28 February 2025 (Figure 2) and should be interpreted as partial-year indexing rather than a complete annual total. This evolution aligns with the growing interest in smart healthcare solutions, Industry 4.0 frameworks, and smart city applications, evident in the research activity across the globe to integrate digital technologies for environmental, economic, and social sustainability [9, 46]. The observed growth also aligns with the development of policy and industry initiatives, including smart-city frameworks and healthcare and education digital-transformation strategies.

Table 2. Most relevant sources

Source	Documents
Lecture Notes in Networks and Systems	51
Sustainability Switzerland	21
Smart Innovation Systems and Technologies	11
IEEE Access	7
Lecture Notes in Electrical Engineering	7
Advances in Intelligent Systems and Computing	6
Communications in Computer and Information Science	6
AIP Conference Proceedings	4
Applied Sciences Switzerland	3
Proceedings of the LACCEI International Multi Conference for Engineering Education and Technology	3
Studies in Computational Intelligence	3

4.1.2 Most productive journals

As shown in Table 2, there is moderate concentration in technology oriented and conference-based outlets. Lecture Notes in Networks and Systems is the leading source with the largest number of documents (51), about 9.3% of the 551-record corpus. Sustainability Switzerland follows with 21 documents, or 3.8%, while Smart Innovation Systems and Technologies contribute 11 documents, or 2.0%. IEEE Access and Lecture Notes in Electrical Engineering each provide 7 papers. This is a continuation of the strong influence of computer science, engineering and applied technology venues. The visibility of Sustainability Switzerland, however, also shows that the subject is slowly shifting from technical implementation to service transformation towards sustainability.

4.1.3 Most productive authors

The data in Table 3 indicate a diffuse authorship pattern. Bento, Sharma and Talukder had written 5 papers each while Singh had written 4 papers. In contrast the number of documents contributed by top 10 authors in Scopus is 34 (representing about 6.2% of the total documents) and 36 in Web of Science. This is a relatively small percentage, meaning that there are not a few authors dominating the field. Rather, it is distributed among numerous researchers in various fields such as healthcare, logistics, education, tourism, and smart cities. Such a diversity confirms the interdisciplinary character of the sector, and at the same time, it is a sign that the theory building processes of tertiary industries are still scattered.

4.1.4 Most cited Papers

Note: CPY = citations per year.

Table 4 indicates that the influence of citations is more concentrated than that of authors. The top 3 papers were cited 1,568 times, accounting for 47.5% of the citations in the top 10 papers, which were cited a total of 3,303 times. The most recent influence of AI and education for sustainable development is led by Abulibdeh et al. [8] with 541 citations and the highest citation-per-year value (180.3). Ghazal et al. [48] comes next with 521 citations, which reinforces the idea that IoT and machine learning are at the heart of smart healthcare. Singh et al. [6] has 506 citations, indicating the significance of

Table 3. Top ten authors appeared in Scopus and Web of Science.

Rank	Scopus	No. of Papers	Web of Science	No. of Papers
1	Bento, A.C.	5	BENTO, ANTONIO CARLOS	5
2	Sharma, A.K.	5	SHARMA, ARVIND K.	5
3	Talukder, M.B.	5	TALUKDER, MOHAMMAD BADRUDDOZA	5
4	Singh, Y.	4	SINGH, YASHWANT	4
5	Jain, V.	3	JAIN, VISHAL	3
6	Mitra, A.	3	KISHOR KUMAR REDDY, C.	3
7	Tyagi, P.K.	3	MITRA, ARC HAN	3
8	Afchar, M.N.	2	SINGH, PRABH DEEP	3
9	Ali, F.I.	2	TYAGI, PANKAJ KUMAR	3
10	Ali, T.E.	2	AFCHAR, MOHAMMAD NURUL	2

Table 4. Top ten cited papers.

Rank	Authors	Title	Cites	Year	CPY
1	Abulibdeh, A.; Zaidan, E.; Abulibdeh, R.	Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions	541	2024	180.3
2	Ghazal, T.M.; Hasan, M.K.; Alshurideh, M.T.; Alzoubi, H.M.; Ahmad, M.; Akbar, S.S.; Al Kurdi, B.; Akour, I.A.	IoT for Smart Cities: Machine Learning Approaches in Smart Healthcare-A Review	521	2021	86.8
3	Singh, S.; Sharma, P.K.; Yoon, B.; Shojafar, M.; Cho, G.H.; Ra, I.-H.	Convergence of blockchain and artificial intelligence in IoT network for the sustainable smart city	506	2020	72.3
4	Tijan, E.; Aksentijević, S.; Ivanić, K.; Jardas, M.	Blockchain technology implementation in logistics	399	2019	49.9
5	Akpan, I.J.; Udoh, E.A.P.; Adebisi, B.	Small business awareness and adoption of state-of-the-art technologies in emerging and developing markets, and lessons from the COVID-19 pandemic	302	2022	60.4
6	Mbunge, E.; Muchemwa, B.; Jiyane, S.; Batani, J.	Sensors and healthcare 5.0: transformative shift in virtual care through emerging digital health technologies	298	2021	49.7
7	Soni, G.; Kumar, S.; Mahto, R.V.; Mangla, S.K.; Mittal, M.L.; Lim, W.M.	A decision-making framework for Industry 4.0 technology implementation: The case of FinTech and sustainable supply chain finance for SMEs	257	2022	51.4
8	Kumar, M.; Kumar, A.; Verma, S.; Bhattacharya, P.; Ghimire, D.; Kim, S.-h.; Hosen, A.S.M.S.	Healthcare Internet of Things (H-IoT): Current Trends, Future Prospects, Applications, Challenges, and Security Issues	176	2023	44.0
9	Alharbi, H.A.; Aldossary, M.	Energy-Efficient Edge-Fog-Cloud Architecture for IoT-Based Smart Agriculture Environment	166	2021	27.7
10	Taimoor, N.; Rehman, S.	Reliable and Resilient AI and IoT-Based Personalised Healthcare Services: A Survey	137	2022	27.4

Table 5. Top 10 contributing countries

Rank	Country	Number of documents	Percentage
1	India	180	32.2%
2	China	51	9.1%
3	United States	37	6.6%
4	Saudi Arabia	29	5.2%
5	Malaysia	28	5.0%
6	United Kingdom	23	4.1%
7	Pakistan	17	3.0%
8	Italy	15	2.7%
9	Australia	15	2.7%
10	Turkey	14	2.5%

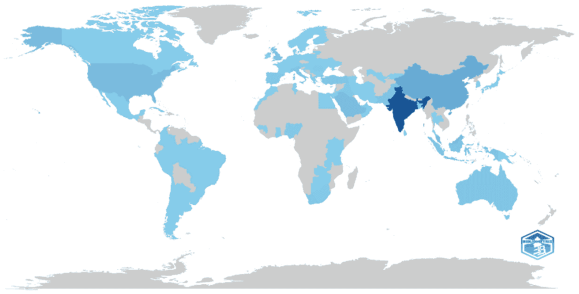


Figure 3. Country contribution mapping

blockchain-AI-IoT convergence for sustainable smart cities. Other highly cited works expand the knowledge base to logistics, Healthcare 5.0, FinTech and sustainable supply chain finance [1, 47]. In general, the citation pattern reveals that the key intellectual foci of the field are smart healthcare, smart cities, education and digitally enabled supply chains.

4.1.5 Country contribution

The trend indicates that the Asian and emerging digital economies are having a strong influence on the field. This is also consistent with the institutional trend in Table 6, where several Indian universities appear among the top affiliations. Meanwhile, research in the selected articles from Oman, Thailand, Korea, Serbia, Romania and the UAE reveals a growing geographical diversity of applications.

4.1.6 Institutional contribution

Table 6 indicates that institutional contribution is less focused than country contribution. Lovely Professional University and Chandigarh University each provided ten documents, and Tecnológico de Monterrey and Shoolini University each provided seven documents. King Saud University, Universiti Malaya, Amity University and Chitkara University each contributed six papers. The top institutions are mainly located in India, Malaysia, Saudi Arabia and Mexico. This distribution is confirmation of the fact that the field is not only dominated by high income Western institutions. Rather, universities in emerging and middle-income economies are significantly contributing to shaping the IoT-BDA sustainability research.

4.1.7 Most frequent keywords

Figures 4 and 5 illustrate that the field is structured around a few powerful digital concepts. The most common is the

Table 6. Top 10 Institutions by contribution

Rank	Affiliation	Documents
1	Lovely Professional University	10
2	Chandigarh University	10
3	Tecnológico de Monterrey	7
4	Shoolini University	7
5	King Saud University	6
6	Universiti Malaya	6
7	Amity University	6
8	Chitkara University, Punjab	6
9	Universiti Kebangsaan Malaysia	5
10	JAIN Deemed-to-be University	5



Figure 4. Most frequent keywords

keyword Internet of Things, which has 189 occurrences and represents 10% of the keyword map. Artificial intelligence appears 154 times, or 8%, while sustainable development appears 98 times, or 5%. The terms big data are mentioned 86 times, health care 63 times, and IoT 63 times. Machine learning is mentioned 60 times and blockchain is mentioned 54 times.

These values indicate that the focus of the field is IoT-AI-BDA integration. However, literature also indicates the presence of health care, energy efficiency, green computing, smart city, data privacy, and cloud computing, which indicates that the focus is not only on adoption but also an indicator of resource efficiency, quality of service, security, and sustainability results.

4.1.8 Contribution by subject area

Table 7 shows that the subject-area distribution is dominated by technical disciplines. The percentages are 28.9% for Computer Science and 20.3% for Engineering. The two areas combine to account for nearly 50% of the subject distribution mapped. Business, Management and Accounting make up 10.3%, Social Sciences 8.8%, Energy 6.5%, Decision Sciences 6.4%, Economics, Econometrics and Finance 6.0%. Environmental Science and Medicine are at lower levels, at 4.9% and 3.3%. This distribution is significant as it illustrates strength and weakness. The technical base is good, but the social sciences, environmental science and medicine are comparatively less well represented, indicating that sustainability outcomes, adoption behaviour and impacts in specific sectors require further study.

4.2 Science mapping and network analysis

4.2.1 Keyword co-occurrence network

Figure 6 indicates that the keyword structure is focused on Internet of Things, artificial intelligence, machine learning, and sustainability. This indicates that IoT is not solely being

Table 7. Contribution by subject area

Rank	Subject area	Number of documents	Percentage
1	Computer Science	358	28.9%
2	Engineering	252	20.3%
3	Business, Management and Accounting	128	10.3%
4	Social Sciences	109	8.8%
5	Energy	81	6.5%
6	Decision Sciences	79	6.4%
7	Economics, Econometrics and Finance	74	6.0%
8	Environmental Science	61	4.9%
9	Mathematics	57	4.6%
10	Medicine	41	3.3%

viewed as a separate infrastructure and more as part of a sustainability agenda driven by analytics. The cluster of healthcare is highly noticeable in confirming that the field of digital health is the most developed tertiary-sector application through healthcare, diagnosis, and telemedicine, as well as the Internet of Medical Things and wearables [4, 48]. Another cluster relates energy efficiency to fog computing and edge computing, telecommunication services, thereby relating the review to low power digital infrastructure and sustainable energy issues [7, 49]. Tourism, finance, logistics and smart campus seem to be situated more towards the periphery, with somewhat more distributed and slightly less-central service-sector.

4.2.2 Country collaboration network

Figure 7 indicates that India is the main collaboration hub, with strong links to China, Malaysia, Saudi Arabia, the United States and the United Kingdom. In recent years, new connections have been established to the United Arab Emirates, Indonesia, Iraq, Bangladesh and Pakistan, where the policy focus is on smart healthcare, logistics and digital public services, and IoT-BDA sustainability research is growing in these areas; the distribution of density across the network however indicates that knowledge production is still geographically focused. This matters because sustainability outcomes are dependent on local infrastructure, regulation, skills and organizational readiness [29, 34].

4.2.3 Co-citation or bibliographic coupling network

Figure 8 demonstrates that there is no one preeminent school, but rather a chain of several interconnected groups of authors that form the foundation of the intellectual movement. There is a dense red cluster related to IoT, machine learning and healthcare. The green cluster relates to sustainability, smart city, logistics and adoption of technologies. The smaller blue group acts as a liaison between digital transformation and applied analytics. This helps to confirm the argument that the field has evolved along parallel sectoral streams. The technical maturity of healthcare, as well as the maturation of shared foundations in logistics, tourism, education and circular systems were highlighted [1, 2, 12].

4.2.4 Three-field plot

Figure 9 is the relationship between cited references, authors and merged keywords. Rogers' diffusion of innovations [50] is presented as a seminal reference, and that adoption and diffusion continue to be theoretical issues. On the author side, Sharma, Bento, Singh and Talukder are dominating,

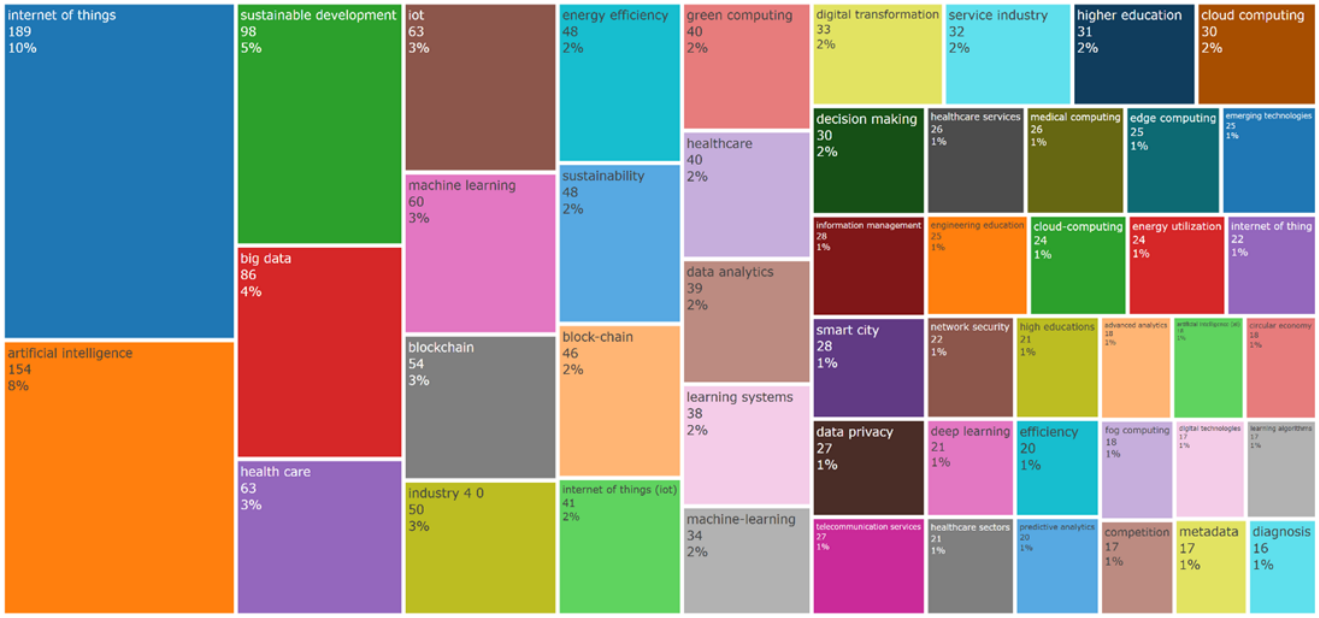


Figure 5. The word cluster presenting the most frequently used words

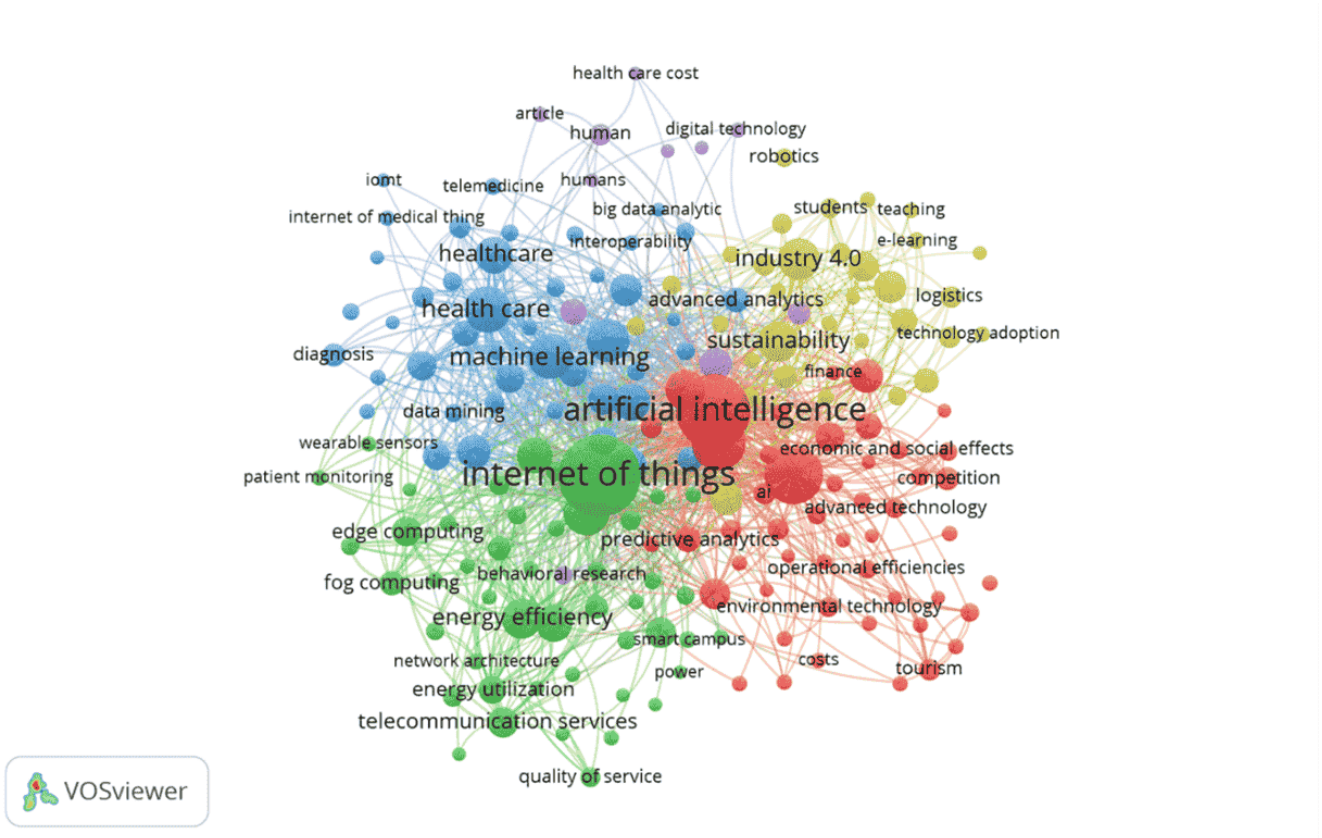


Figure 6. Keyword co-occurrence network

and on the keyword side, the dominating keywords are internet of things, artificial intelligence, machine learning, health care, data analytics, energy efficiency, blockchain and sustainability. This validates the link between technology adoption, analytics capability and sustainability outcomes, while a more explicit tertiary-industry framework is needed to fully capture this phenomenon.

5. DISCUSSION AND SYNTHESIS

5.1 Conceptual development

The discussion shows a clear but uneven shift from technology-specific studies to integrated digital sustainability systems. First, IoT and BDA are often now described as complementary capabilities: IoT is used to collect service data, while analytics, AI, cloud-edge systems and blockchain provide monitoring, prediction, optimization and governance support [4, 6, 25]. This answers the first research question, that the field is oriented towards smart healthcare, smart cities, towards logistics and digitally enabled service transformation

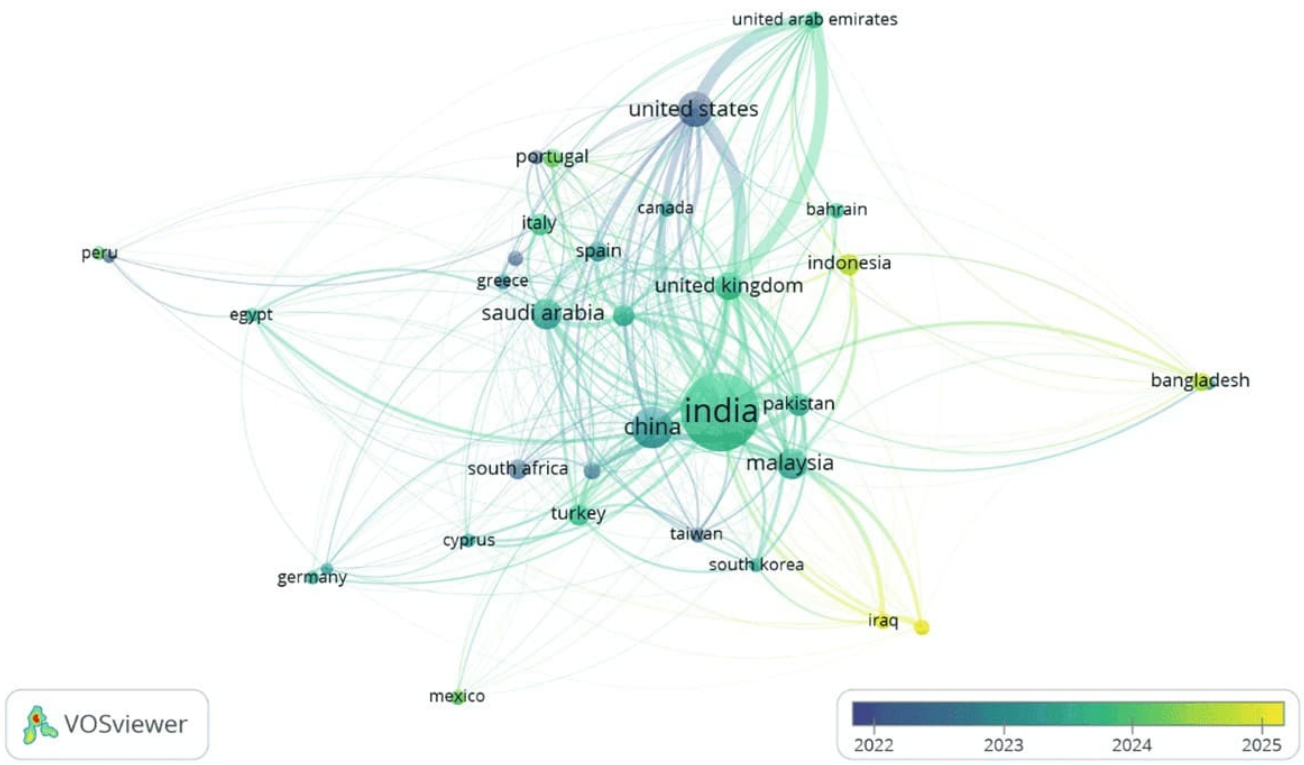


Figure 7. Country collaboration network

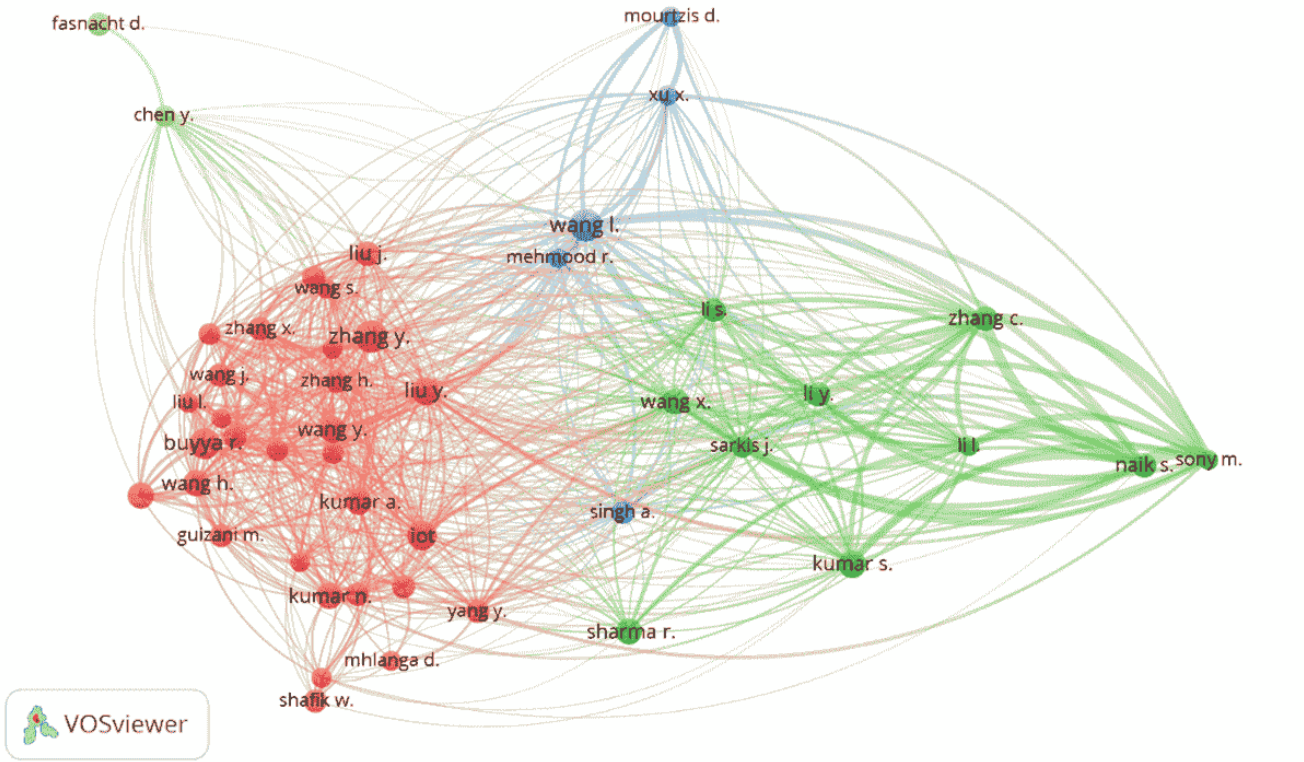


Figure 8. Co-citation or bibliographic coupling network

and not towards one disciplinary tradition.

The key difference lies in the fact that things are claimed at a higher level than they would be when evidence is provided in many service industries. The most advanced architectures come from the healthcare sector and from smart-city studies, while in the tourism, hospital and education sectors, researchers are shifting from smart tools towards smart service ecosystems involving users, institutions and stakeholders

[2, 8, 34]. However, many papers still explain what digital systems could enable rather than measuring long-term sustainability effects in organizations or communities. Therefore, the conceptual contribution of this review is to treat IoT-BDA sustainability as a layered socio-technical capability rather than as a technology adoption issue. Future research should test these layers in sector-specific settings and examine which combinations of sensing, analytics, governance and readiness generate measurable environmental, economic and social value [9, 29].

5.2 Sectoral applications in tertiary industries

Evidence is not consistent across sectors. Healthcare is the most mature domain because studies link IoT sensors, wearables and analytics with patient monitoring, routing, sleep monitoring, chronic disease support, prediction and decision support [23, 24, 48, 51]. Some healthcare studies measure technical performance, such as energy-aware routing or detection accuracy, but fewer show sustained clinical, organizational or social sustainability impacts [4, 25]. In tourism and hospitality, the evidence is more mixed and often more expectation-based. Studies describe how big data, IoT, AI and smart platforms can improve visitor experience, destination management, accessibility and resource use [2, 34, 52]. Most of these outcomes are conceptual, survey-based or model-based, and more longitudinal evidence is required to investigate whether smart tourism can lead to a reduction in ecological pressure, and to increased inclusion and competitiveness.

Education is not so prominent in the corpus but it is an important aspect for social sustainability. Existing studies connect AI, IoT, blockchain and digital platforms to transversal skills, ethical awareness, digital readiness and institutional transformation [8, 53]. The gap is the limited evidence on measured learning inclusion, long-term skills development and institutional sustainability. Moreover, the dominant themes in logistics, transport, finance and smart-city services are visibility, prediction, optimization and efficiency. Although some studies report or model improvements in travel time, energy metrics, supply-chain efficiency and cost reduction, the realized effect is dependent on organizational readiness, data integration and governance capacity [1, 3, 29]. Future research should be based on common sustainability indicators for comparison between sectors.

5.3 Integrated IoT-BDA mechanisms and enabling architectures

The second main finding is that sustainability depends less on the presence of IoT devices than on the conversion of data into accountable decisions. The common mechanism in all the studies reviewed is sensing, data transmission, cloud-edge-fog processing, analytics, secure governance and decision support [30, 54]. This mechanism offers an understanding of how value can be generated by IoT-BDA systems, but it does not itself prove sustainability impact. However, the mechanism is best exemplified in the healthcare industry. The use of sensors for monitoring, cloud analytics, AI diagnosis, secure transmission and alerts can enhance reliability, security and energy efficiency and reduce latency [55, 56, 57]. Most of these are technical or system-performance outcomes and need further empirical verification to translate into lower cost, better access and sustainable healthcare [4, 57].

The difference between measured and expected value is also shown for privacy preserving and low power architectures. Federated learning, blockchain and energy-aware clustering can help to reduce the communication load, improve access control and auditability [58, 59, 60, 61, 62]. However, their broader sustainability contribution remains conditional on implementation cost, regulatory fit and user trust. In addition to healthcare, the same sensing-and-analytics mechanism is used in smart tourism and logistics, where connected data can support service monitoring, traceability and decision support [2, 3, 34, 63]. Future research should therefore separate technical accuracy, operational efficiency and verified sustainability outcomes.

5.4 Sustainability outcomes: environmental, economic and social value

The third key finding is that the sustainability outcomes vary between the types of evidence. Measured outcomes are supported by empirical, experimental, quasi-experimental or performance data, such as energy use, carbon-emission intensity, material-recognition accuracy, travel-time improvement or system latency. Other outcomes are expected or conceptual and are based on frameworks, simulations, models or perceptions. This is important given that many of the publications are about potential value, not proven sustainability impact. Measured environmental evidence appears in selected studies. Duhirwe et al. [7] present a measurable environmental result in terms of ventilation-energy savings while maintaining acceptable indoor CO2 levels. In contrast, studies on smart-mobility and ice-snow-tourism tend to offer conceptual or model-based expectations of the environment [3, 20, 64].

Economic outcomes are also uneven. Industry 4.0, AI, BI and predictive analytics are connected to efficiency, competitiveness and cost reduction in supply-chain finance, studies in hotel management and logistics [1, 2, 29]. These findings are more robust if derived from organizational data, but less so if derived from only perceptions or proposed frameworks. Future studies should include base costs and changes and sector-specific productivity measures after implementation. The majority of the reporting about social sustainability is through access, safety, inclusion, digital learning, and service quality and user experience. Healthcare studies relate IoT and analytics to remote monitoring and early warning and personalized care, and education and tourism studies to digital skills, accessibility and inclusive service design [4, 8, 25, 34, 51]. However, many of these are expected outcomes. Over time, more nuanced evidence is needed regarding health equity, learning outcomes and accessibility use and service quality.

5.5 Drivers, barriers, risks and governance conditions

The fourth key finding is that governance and readiness make the difference between digital capability and sustainability value. Implementation relies on infrastructure, skills, leadership, data governance, acceptance and policy support [1, 29]. This explains why technically feasible systems may fail to produce measurable sustainability gains when organizations lack data quality, staff capability or decision routines [4, 29]. Digital readiness is thus a driver and research gap. Previous studies in supply chain show that the performance of analytics is influenced by the capacity of the organization, data quality and data integration [1, 29]. Future research should

include an analysis of the extent of adoption maturity as a mediator between technology investment and the sustainability outcomes measured.

In healthcare and other critical sectors, barriers to interoperability, cyber security and privacy continue to be key obstacles. Access control can be improved by means of blockchain, federated learning and intrusion-detection approaches, which also improve auditability and decentralized data handling [58, 59, 61, 65]. Their sustainability value should not be assumed based on technical security but should be assessed in conjunction with energy demand, cost, regulatory compliance, and user trust. Human acceptance is another gap. Hospitality service robots, educational AI and smart tourism platforms can improve service efficiency and accessibility, but their benefits depend on employee trust, self-efficacy, fairness, ethical oversight and inclusive design [2, 8, 34]. Future studies are needed to relate user acceptance to the service performance and social sustainability indicators. Energy awareness should also be considered a governance condition. Battery saving, latency, processing requirements and security are all technical options that must be considered in real-time healthcare IoT; they are also sustainability constraints [57, 61]. Without these safeguards, IoT and BDA may increase complexity, cost and vulnerability rather than sustainable value.

5.6 Sustainability Outcomes and Service Performance

Figure 11 integrates the focused discussion into a layered framework. The framework is a roadmap from service pressures to sustainability outcomes and not evidence that technology is a path to sustainability. The policy pressure, resources, leadership, organizational preparedness and digital skills are included at the beginning as these factors influence whether tertiary-sector organizations transform from simple digitization to data-intensive transformation [1, 29].

The evidence distinction is also clarified in the framework. Prediction, optimization, personalization, anomaly detection and risk insights are intermediate capabilities that can be derived from IoT data capture and BDA-AI intelligence, but are not final sustainability capabilities [2, 4, 9, 25]. Only claim sustainability where such capabilities are connected to measurable environmental, economic or social indicators.

The final layer therefore separates verified and expected value. Verified value is the value that is found to be correct with the help of experiments, e.g. reported energy savings or monitored transport performance [7, 20]. Expected value incorporates modeled, simulated or perception-based claims that need to be validated. The feedback loop shows a research trajectory for the future: learning from the performance of IoT-BDA systems and updating analytics models, governance rules, cybersecurity practices and interoperability standards to make IoT-BDA systems adaptive, accountable and evidence-based.

6. CONCLUSIONS, LIMITATIONS AND FUTURE RESEARCH AGENDA

6.1 Conclusions

In this review, the influence of IoT and BDA on the sustainability of tertiary industries was examined through a systematic literature review (SLR) and bibliometric analysis. The results reveal the shift from individual studies on technology to integrated digital sustainability systems in the field. Earlier studies often treated IoT as the sensing and connectivity layer and BDA as a separate analytical capability, while more recent work presents IoT, AI, analytics, blockchain, cloud-edge architectures and organizational readiness as interconnected elements of service transformation [6, 48]. This change reflects the focus of the study, which was to gain an understanding of the where and how of these technologies and to understand how these technologies are mutually supporting in the service-dominant sectors in relation to sustainability.

According to bibliometric and synthesis results, the most visible knowledge areas are healthcare, smart cities, tourism, logistics and transport and supply chains. The healthcare industry is the most advanced, especially regarding remote monitoring, predictive diagnosis, patient security, privacy and personalized care [48]. Smart destinations, service automation, visitor experience and resource management are becoming more important in the field of tourism and hospitality studies. Logistics and supply-chains are more about predictive analytics and cost reduction, competitiveness and resilience. Research on education is underrepresented, although it is a vital point of contact for digital sustainability and skills, ethics, institutional readiness and long-term learning capacity.

The review further illustrates sustainability outcomes can be thought of as environmental, economic and social value. Environmental effects comprise energy saving, emissions reduction, ecological monitoring and waste recovery. Economic impacts include efficiency, cost reduction, competitiveness and resilience. Social outcomes include access to healthcare, safety, inclusion, quality and user experience of digital learning and services. There is a mix of evidence strength. Some studies report measured energy or system-performance outcomes [7, 20]whereas others rely on simulations, conceptual frameworks, or perception-based surveys. Prior research on Industry 4.0 and BDA in supply chains indicates that digital tools can support performance, but organizational readiness and data capabilities remain necessary to translate investment into tangible results [1, 29].

6.2 Limitations

This study has a number of limitations. Firstly, the review is dependent on the databases selected, search terms selected and inclusion criteria adopted and may not capture some relevant studies that use different search terms. Secondly, the literature is different in tertiary sectors; the research on healthcare and smart city are more advanced than in education or some professional service sectors and finance. Third, there is a methodologically mixed evidence base. Technical and simulation studies can help to identify mechanisms, but do not necessarily show sustainability impact in practice. Fourth, the AI, IoT, blockchain, federated learning and cybersecurity technologies are progressing so rapidly that some results may need to be updated regularly.

6.3 Future research agenda

Future studies should not only be technically possible, but also be aimed at quantifiable sustainability effects throughout the course of time. Longitudinal and comparative studies will

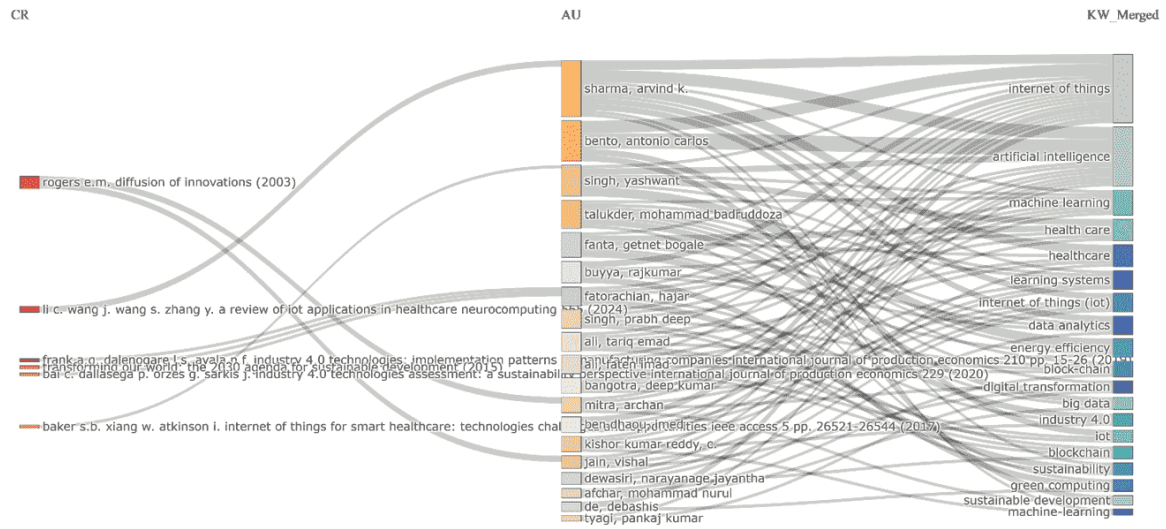


Figure 9. Three-field plot

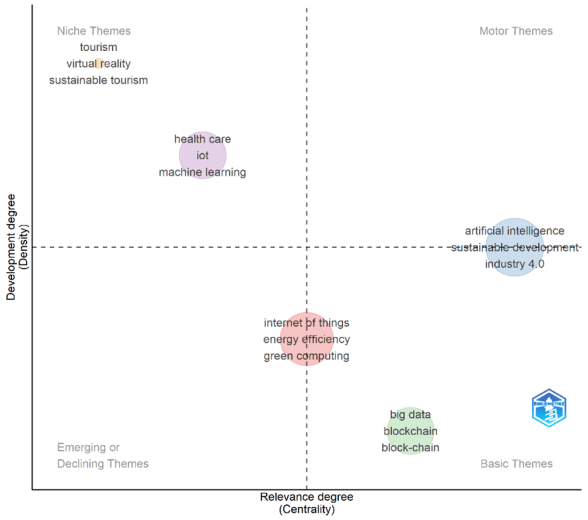


Figure 10. Thematic map of conceptual development

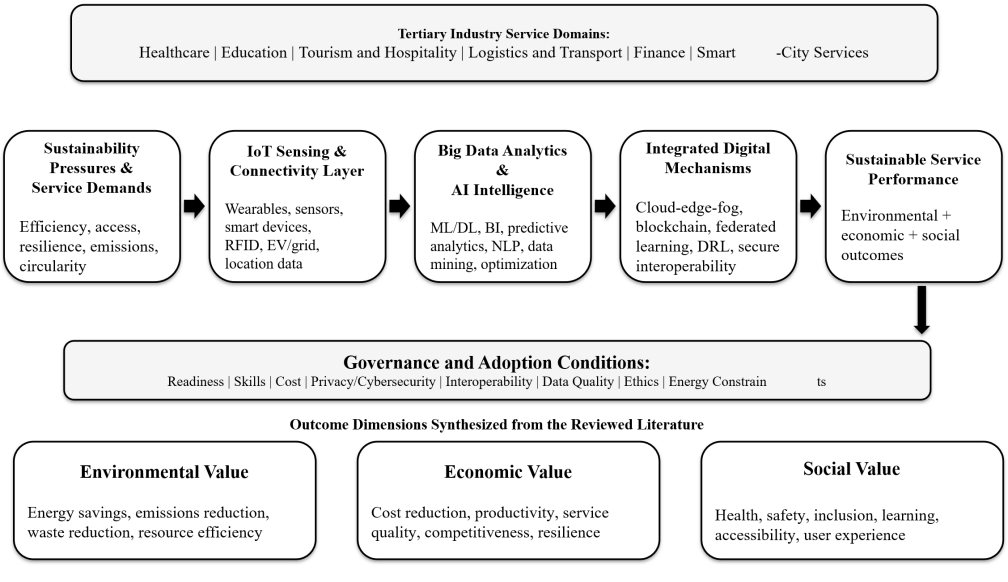


Figure 11. Conceptual framework for sustainability through IoT and Big Data Analytics in tertiary industries
Source: Authors' own illustration based on the systematic literature review (data cutoff: 28 February 2025)

be needed to confirm whether or not IoT-BDA systems lead to sustainable energy savings, as well as to a reduction in emissions, waste, cost, and/or inequality in various service sectors. Additionally, more research is needed on governance issues, including privacy, cybersecurity, interoperability, data quality, algorithmic accountability and the ethical application of AI. Future studies on digital skills and learning inclusion and sustainable institutional transformation are needed in the field of higher education research. In the field of energy and sustainability research, the research areas of future studies should focus on energy-aware architectures, circular economy applications, emissions monitoring and solid technology assessment. In general, IoT and BDA need to be understood as socio-technical systems that can only be sustainable when integrated, governed, and placed in a sectoral context.

REFERENCES

[1] G. Soni, S. Kumar, R. V. Mahto, S. K. Mangla, M. L. Mittal, and W. M. Lim, "A decision-making framework for Industry 4.0 technology implementation: The case of FinTech and sustainable supply chain finance for SMEs," Technological Forecasting and Social Change, vol. 180, article 121686, 2022.

[2] T. Gajić, M. D. Petrović, A. M. Pešić, M. Conić, and N. Gligorijević, "Innovative approaches in hotel management: Integrating artificial intelligence (AI) and the Internet of Things (IoT) to enhance operational efficiency and sustainability," Sustainability, vol. 16, no. 17, article 7279, 2024.

[3] B. Li, M. C. Kisacikoglu, C. Liu, N. Singh, and M. Erol-Kantarci, "Big data analytics for electric vehicle integration in green smart cities," IEEE Communications Magazine, vol. 55, no. 11, pp. 19–25, 2017.

[4] M. Kumar, A. Kumar, S. Verma, P. Bhattacharya, D. Ghimire, S.-H. Kim, and A. S. M. S. Hosen, "Healthcare Internet of Things (H-IoT): Current trends, future prospects, applications, challenges, and security issues," Electronics, vol. 12, no. 9, article 2050, 2023.

[5] A. Faridoon and M. Imran, "Big Data Storage Tools Using NoSQL Databases and Their Applications in Various Domains: A Systematic Review," Computing and Informatics, vol. 40, no. 3, pp. 489–521, 2021.

[6] S. Singh, P. K. Sharma, B. Yoon, M. Shojafar, G. H. Cho, and I.-H. Ra, "Convergence of blockchain and artificial intelligence in IoT network for the sustainable smart city," Sustainable Cities and Society, vol. 63, article 102364, 2020.

[7] P. N. Duhirwe, J. Ngarambe, and G. Y. Yun, "Energy-efficient virtual sensor-based deep reinforcement learning control of indoor CO2 in a kindergarten," Frontiers of Architectural Research, vol. 12, no. 2, pp. 394–409, 2023.

[8] A. Abulibdeh, E. Zaidan, and R. Abulibdeh, "Navigating the confluence of artificial intelligence and education for sustainable development in the era of Industry 4.0: Challenges, opportunities, and ethical dimensions," Journal of Cleaner Production, vol. 437, article 140527, 2024.

[9] S. E. Bibri, A. Alahi, A. Sharifi, and J. Krogstie, "Environmentally sustainable smart cities and their converging AI, IoT, and big data technologies and solutions: An integrated approach to an extensive literature review," Energy Informatics, vol. 6, article 9, 2023.

[10] A. T. Rosário and J. C. Dias, "Sustainability and the Digital Transition: A Literature Review," Sustainability, vol. 14, no. 7, article 4072, 2022.

[11] C. Ishizuka, K.-C. Tseng, and Y. Kishi, "Reviving tradition-bound products: a case of value co-creation using rhetorical history," Service Business, vol. 16, no. 4, pp. 1015–1033, 2022.

[12] L. Tong, W. Yan, and O. Manta, "Artificial intelligence influences intelligent automation in tourism: A mediating role of Internet of Things and environmental, social, and governance investment," Frontiers in Environmental Science, vol. 10, article 853302, 2022.

[13] U. Sivarajah, Z. Irani, S. Gupta, and K. Mahroof, "Role of big data and social media analytics for business to business sustainability: A participatory web context," Industrial Marketing Management, vol. 86, pp. 163–179, 2019.

[14] A. M. Fathollahi-Fard, L. A. Woodward, and O. Akhrif, "Sustainable distributed permutation flow-shop scheduling model based on a triple bottom line concept," Journal of Industrial Information Integration, vol. 24, article 100233, 2021.

[15] C. Martin-Rios, C. Poretti, and G. B. Derchi, "Three Anchoring Managerial Mechanisms to Embed Sustainability in Service Organizations," Sustainability, vol. 14, no. 1, article 265, 2022.

[16] N. A. Ochuba, D. O. Olutimehin, O. G. Odunaiya, and O. T. Soyombo, "Sustainable business models in satellite telecommunications," Engineering Science & Technology Journal, vol. 5, no. 3, pp. 1047–1059, 2024.

[17] S. Shankar, S. Rai, and N. K. Singh, "Organizational resilience and socioeconomic sustainability: COVID-19 perspective," Environment Development and Sustainability, vol. 23, no. 8, pp. 12006–12023, 2021.

[18] D. K. Grum and K. Babnik, "The psychological concept of social sustainability in the workplace from the perspective of sustainable goals: A systematic review," Frontiers in Psychology, vol. 13, article 942204, 2022.

[19] M. Lu and P. Chen, "Sustainable total factor productivity of transport: considering safety issues and environmental impacts," Environmental Science and Pollution Research, vol. 30, no. 19, pp. 56094–56107, 2023.

[20] A. Rauniyar, T. Berge, A. Kuijpers, P. Litzinger, B. Peeters, E. V. Gils, N. Kirchhoff, and J. E. Hakegard, "NEMO: Real-time noise and exhaust emissions monitoring for sustainable and intelligent transportation systems," IEEE Sensors Journal, vol. 23, no. 20, pp. 25497–25517, 2023.

[21] L. Atzori, A. Iera, and G. Morabito, "Understanding the Internet of Things: definition, potentials, and societal role of a fast evolving paradigm," Ad Hoc Networks, vol. 56, pp. 122–140, 2016.

[22] A. Papa, M. Mital, P. Pisano, and M. D. Giudice, "E-health and wellbeing monitoring using smart healthcare devices: An empirical investigation," Technological Forecasting and Social Change, vol. 153, article 119226, 2020.

[23] D. K. Bangotra, Y. Singh, A. Selwal, N. Kumar, P. K. Singh, and W.-C. Hong, "An intelligent opportunistic routing algorithm for wireless sensor networks and its application towards e-healthcare," Sensors, vol. 20, no. 14, article 3887, 2020.

[24] F. Yang, Q. Wu, X. Hu, J. Ye, Y. Yang, H. Rao, R. Ma, and B. Hu, "Internet-of-Things-enabled data fusion method for sleep healthcare applications," IEEE Internet of Things Journal, vol. 8, no. 21, pp. 15892–15905, 2021.

[25] P. Mishra and G. Singh, "Internet of Medical Things healthcare for sustainable smart cities: Current status and future prospects," Applied Sciences, vol. 13, no. 15, article 8869, 2023.

[26] D. Darwish, "Introduction to Big Data Analytics," in Advances in Business Information Systems and Analytics Book Series. Hershey, PA, USA: IGI Global, pp. 1–48, 2024.

[27] Y. Liu, S. Zhang, M. Chen, Y. Wu, and Z. Chen, "The sustainable development of financial topic detection and trend prediction by data mining," Sustainability, vol. 13, no. 14, article 7585, 2021.

[28] V. Bhole, H. N. Bhor, J. V. Terdale, V. Pinjarkar, R. Malvankar, and N. Zade, "Machine learning approach for intelligent and sustainable smart healthcare in cloud-centric IoT," International Journal of Intelligent Systems and Applications in Engineering, vol. 11, no. 10s, pp. 36–48, 2023.

[29] M. Hussain, M. Ajmal, G. Subramanian, M. Khan, and S. Anas, "Challenges of big data analytics for sustainable supply chains in healthcare: A resource-based view," Benchmarking: An International Journal, vol. 31, no. 9, pp. 2897–2918, 2024.

[30] N. Côrte-Real, P. Ruivo, and T. Oliveira, "Leveraging Internet of Things and big data analytics initiatives in European and American firms: Is data quality a way to extract business value?" Information & Management, vol. 57, no. 1, article 103141, 2019.

[31] I. Ahmed, Y. Zhang, G. Jeon, W. Lin, M. R. Khosravi, and L. Qi, "A blockchain- and artificial intelligence-enabled smart IoT framework for sustainable city," International Journal of Intelligent Systems, vol. 37, no. 9, pp. 6493–6507, 2022.

[32] A. Bathula, S. K. Gupta, S. Merugu, L. Saba, N. N. Khanna, J. R. Laird, S. S. Sanagala, R. K. Singh, D. Garg, M. M. Fouda, and J. S. Suri, "Blockchain, artificial intelligence, and healthcare: The tripod of future - a narrative review," Artificial Intelligence Review, vol. 57, article 238, 2024.

[33] H. A. Alharbi, B. A. Yosuf, M. Aldossary, and J. Almutairi, "Energy and Latency Optimization in Edge-Fog-Cloud Computing for the Internet of Medical Things," Computer Systems Science and Engineering, vol. 47, no. 1, pp. 1299–1319, 2023.

[34] P. Suanpang and P. Pothipassa, "Integrating generative AI and IoT for sustainable smart tourism destinations," Sustainability, vol. 16, no. 17, article 7435, 2024.

[35] D. Tranfield, D. Denyer, and P. Smart, "Towards a methodology for developing evidence-informed management knowledge by means of systematic review," British Journal of Management, vol. 14, no. 3, pp. 207–222, 2003.

[36] D. Denyer and D. Tranfield, "Producing a systematic review," in The SAGE Handbook of Organisational Research Methods. Los Angeles, CA, USA: SAGE, pp. 671–689, 2009.

[37] N. Jahan, S. Naveed, M. Zeshan, and M. A. Tahir, "How to conduct a systematic review: A narrative literature review," Cureus, vol. 8, no. 11, article e864, 2016.

[38] M. Aria and C. Cuccurullo, "bibliometrix: An R-tool for comprehensive science mapping analysis," Journal of Informetrics, vol. 11, no. 4, pp. 959–975, 2017.

[39] V. Clarke and V. Braun, "Thematic analysis," The Journal of Positive Psychology, vol. 12, no. 3, pp. 297–298, 2017.

[40] M. J. Page, J. E. McKenzie, P. M. Bossuyt, I. Boutron, T. C. Hoffmann, C. D. Mulrow, and D. Moher, "The PRISMA 2020 statement: An updated guideline for reporting systematic reviews," BMJ, vol. 372, article n71, 2021.

[41] E. Bell, A. Bryman, and B. Harley, Business Research Methods, 6th ed. Oxford, U.K.: Oxford University Press, 2022.

[42] M. Saunders, P. Lewis, and A. Thornhill, Research Methods for Business Students, 8th ed. Harlow, U.K.: Pearson, 2019.

[43] A. M. T. Thomé, L. F. Scavarda, and A. J. Scavarda, "Conducting systematic literature review in operations management," Production Planning & Control, vol. 27, no. 5, pp. 408–420, 2016.

[44] CASP, "CASP checklists," Critical Appraisal Skills Programme, 2018.

[45] H. A. Mohamed Shaffril, S. F. Samsuddin, and A. Abu Samah, "The ABC of systematic literature review: The basic methodological guidance for beginners," Quality & Quantity, vol. 55, no. 4, pp. 1319–1346, 2021.

[46] R. Chataut, A. Phoummalayvane, and R. Akl, "Unleashing the Power of IoT: A Comprehensive Review of IoT Applications and Future Prospects in Healthcare, Agriculture, Smart Homes, Smart Cities, and Industry 4.0," Sensors, vol. 23, no. 16, article 7194, 2023.

[47] N. Taimoor and S. Rehman, "Reliable and resilient AI and IoT-based personalized healthcare services: A survey," IEEE Access, vol. 10, pp. 535–563, 2022.

[48] T. M. Ghazal, M. K. Hasan, M. T. Alshurideh, H. M. Alzoubi, M. Ahmad, S. S. Akbar, B. Al Kurdi, and I. A. Akour, "IoT for smart cities: Machine learning approaches in smart healthcare: A review," Future Internet, vol. 13, no. 8, article 218, 2021.

[49] J. Das, S. Ghosh, A. Mukherjee, S. K. Ghosh, and R. Buyya, "RESCUE: Enabling green healthcare services using integrated IoT–edge–fog–cloud computing environments," Software: Practice and Experience, vol. 52, no. 7, pp. 1615–1642, 2022.

[50] E. M. Rogers, Diffusion of Innovations, 5th ed. New York, NY, USA: Free Press, 2003.

[51] G. Singh, "Wearable IoT (w-IoT) artificial intelligence (AI) solution for sustainable smart healthcare," International Journal of Information Management Data Insights, vol. 5, no. 1, article 100291, (published online 2024), 2025.

[52] D. Li, P. Du, and H. He, "Artificial intelligence-based sustainable development of smart heritage tourism," Wireless Communications and Mobile Computing, vol. 2022, article 5441170, 2022.

[53] R. Bucea-Manea-ţoniş, V. Kuleto, S. C. D. Gudei, C. Lianu, C. Lianu, M. P. Ilić, and D. Păun, "Artificial intelligence potential in higher education institutions enhanced learning environment in Romania and Serbia," Sustainability, vol. 14, no. 10, article 5842, 2022.

[54] M. Goudarzi, M. Palaniswami, and R. Buyya, "Scheduling IoT Applications in Edge and Fog Computing Environments: A Taxonomy and Future Directions," ACM Computing Surveys, vol. 55, no. 7, article 152, 2022.

[55] P. K. Gupta, B. T. Maharaj, and R. Malekian, "A novel and secure IoT based cloud centric architecture to perform predictive analysis of users activities in sustainable health centres," Multimedia Tools and Applications, vol. 76, pp. 18489–18512, 2017.

[56] M. Izhar, S. A. A. Naqvi, A. Ahmed, S. Abdullah, N. Alturki, and L. Jamel, "Enhancing Healthcare Efficacy Through IoT-Edge Fusion: A Novel Approach for Smart Health Monitoring and Diagnosis," IEEE Access, vol. 11, pp. 136456–136467, 2023.

[57] V. Hayyolalam, M. Aloqaily, O. Ozkasap, and M. Guizani, "Edge intelligence for empowering IoT-based healthcare systems," IEEE Wireless Communications, vol. 28, no. 3, pp. 6–14, 2021.

[58] I. Ioannou, P. Nagaradjane, P. Angin, P. Balasubramanian, K. J. Kavitha, P. Murugan, and V. Vassiliou, "GEMLIDS-MIOT: A green effective machine learning intrusion detection system based on federated learning for medical IoT network security hardening," Computer Communications, vol. 218, pp. 209–239, 2024.

[59] S. K. Rana, S. K. Rana, K. Nisar, A. A. Ag Ibrahim, A. K. Rana, N. Goyal, and P. Chawla, "Blockchain technology and artificial intelligence-based decentralized access control model to enable secure interoperability for healthcare," Sustainability, vol. 14, no. 15, article 9471, 2022.

[60] O. A. Alzubi, J. A. Alzubi, K. Shankar, and D. Gupta, "Blockchain and artificial intelligence enabled privacy-preserving medical data transmission in Internet of Things," Transactions on Emerging Telecommunications Technologies, vol. 32, no. 12, article e4360, 2021.

[61] L. Liu and Z. Li, "Permissioned blockchain and deep reinforcement learning enabled security and energy efficient healthcare Internet of Things," IEEE Access, vol. 10, pp. 53640–53651, 2022.

[62] J. Escorcia-Gutierrez, R. F. Mansour, E. Leal, J. Villanueva, J. Jimenez-Cabas, C. Soto, and R. Soto-Díaz, "Privacy preserving blockchain with energy aware clustering scheme for IoT healthcare systems," Mobile Networks and Applications, vol. 29, no. 1, pp. 1–12, 2024.

[63] A. Kaushik, R. Singh, M. Li, H. Luo, S. Dayarathna, R. Senanayake, X. An, R. A. Stirling-Gallacher, W. Shin, and M. D. Renzo, "Integrated Sensing and Communications for IoT: Synergies with Key 6G Technology Enablers," IEEE Internet of Things Magazine, vol. 7, no. 5, pp. 136–143, 2024.

[64] J. Cao, "The ecological safety assessment and brand communication of ice-snow tourism under the Internet of Things and deep learning," IEEE Access, vol. 11, pp. 128235–128244, 2023.

[65] T. E. Ali, F. I. Ali, P. Dakić, and A. D. Zoltan, "Trends, prospects, challenges, and security in the healthcare Internet of Things," Computing, vol. 107, article 28, (published online Dec. 16, 2024), 2025.