Exploring Artificial Intelligence in Sustainability:
A Bibliometric Analysis

Sumit Mishra*
Dr. Gyanesh Kumar Sinha**

Abstract

The internet is becoming more and more important for both regular people and big companies. In 2019, online reports indicated that the global internet user count surpassed 4.13 billion, indicating that over half of the world's population was connected to the internet. There is a pressing need for innovative solutions to the increasing global challenges of degradation of the environment, climate change, depletion of resources, and social inequality. Recent research shows that the use of big data analytics and other AI technologies can improve sustainable development. In this paper, we explore the use of Artificial Intelligence in sustainability. We use bibliometric analysis using Secondary Scopus data and reviewed more than 428 research articles, book chapters, conference papers, we find that AI has the potential to improve sustainability results by providing more effective solutions to existing issues. The results suggest that AI can reduce energy consumption, improve resource utilization, improve production process efficiency, and provide better environmental management decision-making tools. We created a structured time frame and shown through graphical representation. We also suggest that further research should be conducted to develop strategies for incorporating AI into sustainable development efforts.

Keywords: Artificial Intelligence, Sustainability, Block chain, AI Technologies

Introduction

The internet is becoming more and more important for both regular people and big companies. In 2019, online reports indicated that the global internet user count surpassed 4.13 billion, indicating that over half of the world's population was connected to the internet. (Johnson, 2021). However, not everyone in the world has the same access to the internet. Because more people are using the internet, things like global connections, digital technology, and artificial intelligence are growing quickly. Artificial intelligence is a clear example of something that has already made a big difference in people's lives, and there are even more significant changes and major shifts are expected to happen in the near future (Grace et al., 2018). The increasing adoption of machine intelligence, driven by computing power and extensive data, is transforming various aspects of our everyday existence, such as business, entertainment, learning, healthcare, utilities, and environmental conservation (Soltau, 2016). In 1937, Alan Turing proposed the concept of the 'Turing Machine,' a smart machine. Since then, scientists and programmers worked on various phases of developing and employing machines with intelligence and computers at different levels. Currently, researchers are developing deep learning, that is, an artificial intelligence that is increasingly closer to the way humans think (Sharma et al., 2020). An enabler of AI is these dawning use of AI as a disruptive tool for sustainability through optimized resource utilization, prediction of environmental changes, and green technologies that show promise (Vinuesa et al., 2020). AI applications in sustainability reach across cities to include climate change mitigation, energy management, agriculture, and circular economy practices (Rolnick et al., 2019; Wang & Li, 2022; Sharma et al., 2022; Gai et al., 2023). Using the cutting-edge technologies of AI, including machine learning, deep learning, and big data analytics, allows for a real-time decision matrix that improves sustainability efforts (Ahmed et al., 2023). Sustainability is one of the contemporary and prominent applications of AI in its broadest

* Research Scholar, School of Management, Bennett University
** Professor, School of Management, Bennett University

sense, allowing us to meet present needs without compromising those of future generations. Sustainability has an in-built factor that alludes to the protection of nature and human interests with its broad views on the environment, economy, and with social ethical values in the principle form. AI has the offer of some excellent techniques and instruments for addressing problems related to sustainable development: reducing greenhouse gas emission and promoting the use of renewable energy, managing waste streams more efficiently, preserving biodiversity, and securing social equity and human well-being. This new charity sustainable development is highly controlled by the United Nations, accompanied by endless studies for its effective execution. Albeit a surge of publications in recent years, sustainable development is still conceived to be a rather new field of inquiry (Baumgartner, 2011). All five dimensions showed both positive and negative feedback, where value-oriented factors were taken as keys to sustainable development in the means of collaboration, shared responsibility, and ethics (Khakurel et al., 2018). Recent studies opine that the use of big data analytics and other artificial intelligence technologies will help boost sustainable development. The importance of innovation and putting people at the center of this effort has been emphasized by these studies (Zhang et al., 2020). Sustainable development is also considered to be an attitude of mind about development which brings into focus the imperative of enhancing the quality of life of human beings while at the same time assuring protection for the environment from menaces such as deforestation, pollution of water and air (Mensah, 2019)

Evolution of AI in Sustainability

Artificial intelligence is increasingly taking quite some active role in complementing sustainable development and globally handling the major issues. Researchers have begun to realize through analysis that the capabilities of artificial intelligence in analysing massive datasets and predicting situations may be used for possible solutions to some tough ecological and social problems like weather pattern prediction, energy optimization, and better resources management (Smith et al., 2020). The climate change problem is singled out as one of one hundred most critical sustainability issues. It's been shown an effective mechanism allowing to foresee and address hazardous threats posed by climate change. Machine learning algorithms organize both larger datasheets that they modelled from satellites weather stations and environmental sensors to provide for real-time tracking and an adequate response to the environment (Gandomi, 2015). In this way, they contribute to disaster response, early warning systems, and sustainable climate policy formulation. Sustainability, i.e., the consideration of water, electricity, and raw materials under the enlightened guidance of the available resources, integrates water-friendly artificial intelligence-based models, which strive to promote insights into the quality of water, leak detection, and better management of treatment processes of water.

Artificial intelligence supports energy-efficient distribution between supply and demand through smart grids by minimizing waste heaved against non-renewable sources (Nguyen et al., 2019). AI models predict water quality, detect leaks in pipelines, and allow for enhanced water treatment management (Smith, 2020).

AI technologies, such as precision farming, are changing the way food is produced. With a growing world population, sustainable agriculture is key to meeting that demand while preserving land and resources (Castelli and others 2019). AI tools enable farmers to make decisions that could influence planting, irrigation, and pest control all while reducing waste and impact on the environment (Talaviya and others 2020). Machine learning algorithms are being used to monitor endangered species and the methods with which poachers hunt them (Shivaprakash and others 2022). Drones and AI-enabled cameras also enable more effective and less intrusive observation of wildlife (Shivaprakash and others 2022). The technology, therefore, conserves biodiversity and protects ecosystems. With the expansion and diversification of AI, multiple possibilities can blossom towards positive change via enhanced sustainability. Circular economies may harness great promises through AI whereby items and resources are due for reusing and recycling and reused and recycles in an effective way for

them to gain great capacity (Breidt and others 2018). AI can also resolve the sociological issues of ethical labor practice, social equity, ideal consumption, and sustainable supply chain all significantly contributing to societal and environmental sustainability.

AI in Energy Efficiency and Renewable Energy

There have been great advances in renewable energy integration and smart grid management in the last decade, calling for an increasing presence or impact of AI in the energy sector. AI-based forecasting models assist by predicting fluctuations in energy output of solar panels and wind turbines, making them more efficient (Ahmed et al., 2023; Kouhestani & Farid, 2021).

AI enhanced smart grids deliver energy in real time, minimize losses during transmission, and improve grid reliability (Gielen et al., 2021). More importantly, AI-powered energy management systems optimally cut industrial energy consumption, reducing the carbon footprint at great length (Wang et al., 2022).

## AI in Circular Economy and Waste Management

Artificial Intelligence works through enhancing circular economy practices by efficient waste management, optimizing recycling processes, and improving material recovery systems (Gai et al., 2023). To optimize the sorting and classification of waste, AI-assisted technologies such as machine learning (ML), deep learning (DL), and computer vision are being deployed so as to really augment efficiency and reduce the volume of waste going into landfills (Zhao et al., 2021). AI makes its greatest impact on waste reduction by enhancing supply chain efficiency and reducing overproduction (Jabbour et al., 2020). AI-based predictive analytics allow firms to know their demand projections and to improve inventory management to minimize overproduction (Papetti et al., 2021). In doing so, this reduces the waste of material and supports the management of that product's sustainable life cycle by encouraging resource efficiency and circularity in manufacturing processes (Le Moigne et al., 2023). Besides, AI-infused blockchain solutions are investigated to enhance material tracking and transparency in the supply chain, thus assuring proper recycling and upcycling of waste materials (Treiblmaier, 2021).WE These AI-enhanced circular economy models energize closed-loop production cycles wherein products are designed for reuse, remanufacturing, and recycling, thereby reducing the reliance on virgin raw materials (Moreno et al., 2022).

Material and Methods

In this article, we explore the application of AI systems in the context of sustainable development and present a timeline of its evolution. We begin with an expert-driven literature review to uncover the historical development and interconnections between AI and sustainability. Subsequently, we utilize the Scopus database to gather the data that allows us to create a timeline showing when these terms started to become aligned and integrated, as depicted in the corresponding figures. Further we have used Vos-Viewer as tool to structure the data available.

Result & Analysis

The trend in publication of papers on AI in sustainability is shown in fig. 1. The period of publication has not been restricted to consider the time frame from when the integration of AI and Sustainability.
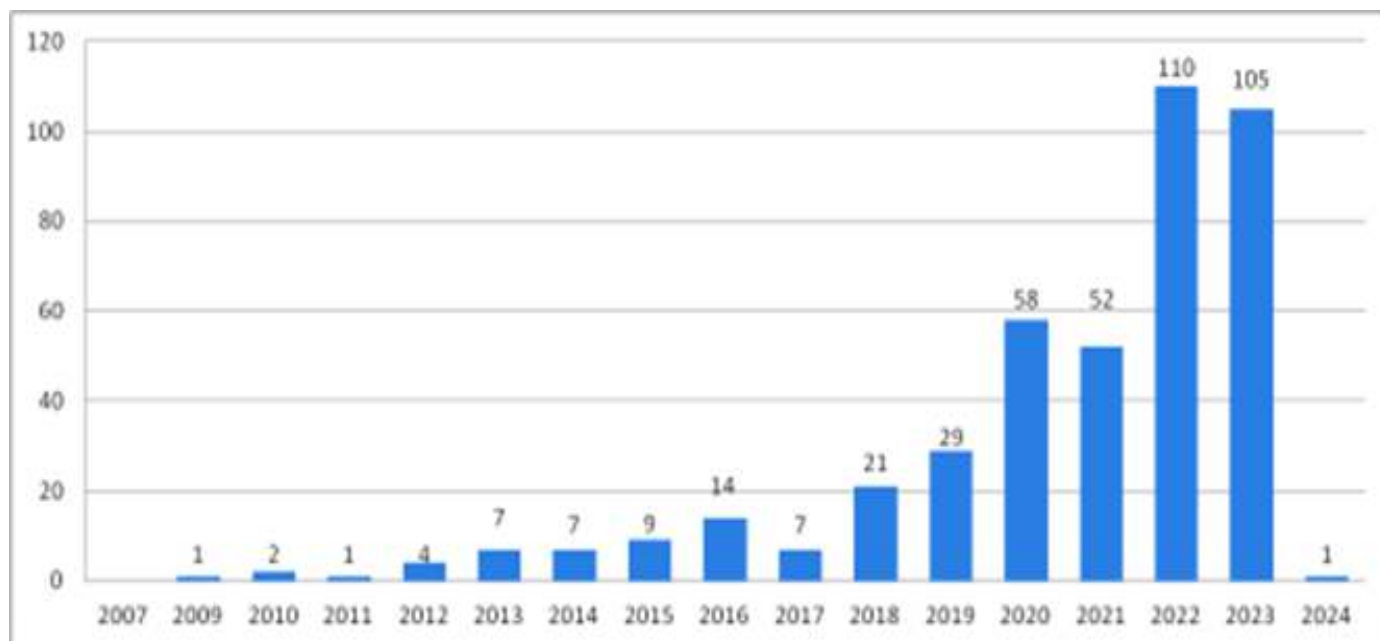
Fig.1 Year wise publication of AI in Sustainability

The very first relevant paper was published in year 2007 by (Goncalves et al., 2007) which deals with the decision support system in irrigation further from 2007 to 2017 only 52 papers have been published in the field. After, 2017 the publication trend in AI in sustainability in different sectors started increasing strongly. Especially in year 2022, there were the highest no of papers 110 had published which can be shown in Fig 1.

Eventually, the work in this area starts growing by academicians and industrialist. Covid-19 pandemic is one of major reasons for the growth of this integration. During the pandemic various paradoxes amid and been tackled by managers by using AI after which the focus in this integration took a growing phase.

In fig. 2.The type of publication is shown and which important to determining the success and impact of the work. Journal articles are typically peer-reviewed publications that provide detailed accounts of original research findings on specific topics and it can be seen in fig. 2. That there are 314 papers have been published which explore different industries including Sustainability in Artificial Intelligence. Books and book chapters can also be used to share research results but tend to have more general applications than journal articles or conference papers due to their length constraints and there are only 3 books published which include 18 book chapter and Conference papers present new ideas at conferences related to their field; they may be published in proceedings after being reviewed by experts in the field and thus, it also presents the current and future research trends in different field of research and there are 30 conference papers can be seen in the Fig. 2.
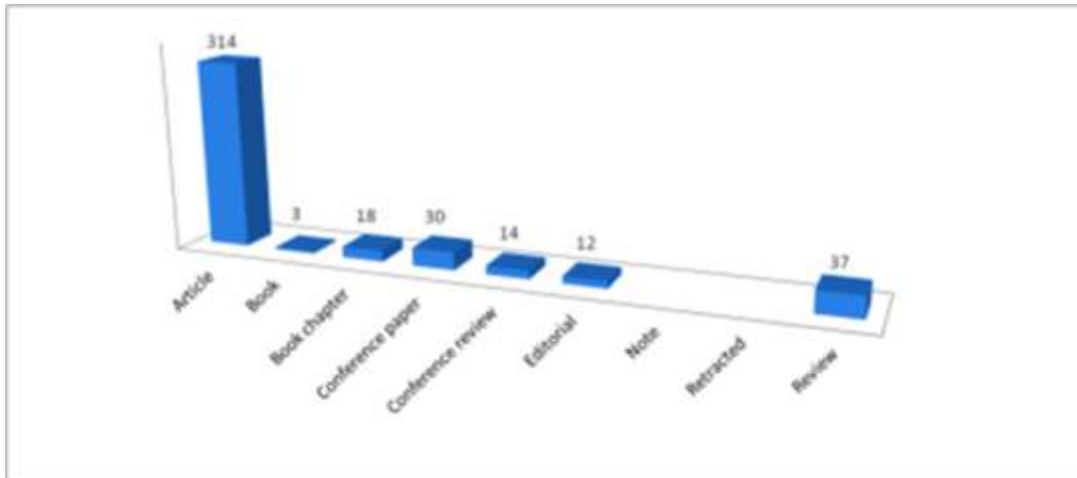
Fig. 2. Overview of type of publication on AI in sustainability

We have examined the journals that are publishing in the fields of sustainability and AI. Our findings indicate that there is an increase in publications in this subject over the past several years, there is now a rising interest in research pertaining to the integration of artificial intelligence with sustainable development. In this study various emerging journals have been identified which are publishing and participating in the field such as, "Journal of cleaner production" that has published higher number of research articles (79) and got (2640) citations which can be shown in Fig. 3. further, this journal has majorly focused on energy efficiency, renewable energy followed by "International journal of production research" with 16 publication and 1470 citations and covered the topics such as, environmental monitoring and climate change adaptation and cleaner production.
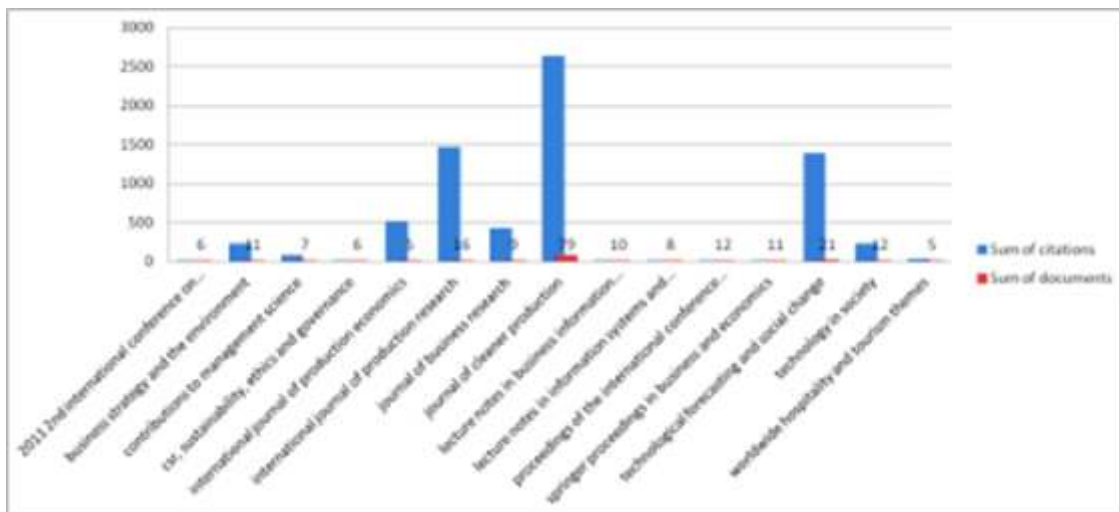
Fig. 3. Journals published in the field of AI in Sustainability

An growing awareness among researchers and policymakers about the potential benefits and challenges posed by employing AI for more sustainable results has led to this increased attention. There is a lot of need for more research in this field because the usage of AI technology may aid in addressing many global concerns including climate change, resource management, the generation of renewable energy, etc.

S. no	Journals	Documents	Citations
1	"2011 2nd international conference on artificial intelligence, management science and electronic commerce, aimsec 2011 – proceedings"	6	2
2	"Business strategy and the environment"	11	230
3	"Contributions to management science"	7	85
4	"CSR, sustainability, ethics and governance"	6	2
5	"International journal of production economics"	5	522
6	"International journal of production research"	16	1470
7	"Journal of business research"	9	427
8	"Journal of cleaner production"	79	2640
9	"Lecture notes in business information processing"	10	13
10	"Lecture notes in information systems and organization"	8	2
11	"Proceedings of the international conference on industrial engineering and operations management"	12	8
12	"Springer proceedings in business and economics"	11	4
13	"Technological forecasting and social change"	21	1386
14	"Technology in society"	12	228
15	"Worldwide hospitality and tourism themes"	5	33

Table.1. Journals published in the field of AI in Sustainability

Conclusion

Our study's findings demonstrate how AI has increasingly become a part of sustainability research in recent years. This is brought on by a variety of developments in AI technology, as well as a rise in awareness about the environment and knowledge, improved access to data sources for analysis, and more reasonably priced hardware options. As a result, over the years, AI has become increasingly used in a variety of sustainability-related fields, such as energy generation and management, agriculture optimisation and water conservation, artificial eco system modelling, analytics-enabled smart city planning, and climate change forecasts, among others. In the end, this shows that there may be room to incorporate AI technology into sustainable development further in the future.

Limitation and Future scope

The scope of exploration may be limited by using solely Scopus data. Further study is needed to get a complete picture of the industry because this dataset does not include all the data on AI and sustainability Further, Investigation is required to determine whether incorporating artificial intelligence into sustainable practices will have any long-term consequences on non-renewable resources or human wellbeing.

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