A Retrospective of International Research on IoT for Sustainability in Agricultural

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Abstract

Studies on the Internet of Things (IoT) for sustainability in agriculture continue to develop but are still limited to one particular field or one country. This study uses bibliometric analytic tools to graphically map scholarly publications and research trends in the IoT for Agricultural Sustainability sector throughout the world. The Scopus database is used to collect information for this study, and online analysis using the Scopus website and VOSViewer is used to exhibit bibliometric network mapping. We employ an article selection procedure that begins with the searched keywords and year limitations and then exports the database to RIS and CSV format files. We got 73 scientific publications published between 2012 and 2021 from the database. We also used VOSViewer to map the network. According to the database, researchers in India have the most published papers and are indexed by Scopus among the most prolific writers (N=20), with China coming in second (N=10) and Italy coming in the third (N=9). From 2018 to 2021, data analysis shows a substantial tendency of growing the number of IoT for Sustainability in Agricultural articles worldwide. This study recommends combining the research subjects of IoT for Sustainability in Agriculture: Artificial Intelligence, Blockchain, Agricultural Sustainability, IoT Application, abbreviated as AIBASIA research themes.

Keywords
Bibliometric, internet of things, sustainability, agriculture, research trend, research mapping

1. Introduction

In recent years, there has been an increase in research interest in IoT applications in the agricultural supply chain. Monitoring is the most common use of IoT in agriculture, followed by control and actuation (Talavera et al. 2017; C. Verdouw, Wolfert, and Tekinerdogan 2016). The Internet of Things (IoT) can enable real-time information sharing regarding agri-food items by monitoring the whole agriculture supply chain, decreasing losses and maintaining food safety. Furthermore, combining technologies such as IoT, Big Data, Blockchain, Machine Learning, and so on allows smart agriculture to meet various critical farming objectives such as boosting productivity, lowering water use, reducing pesticide usage, and so on. However, IoT applications in agriculture are still in their early stages and require seamless integration (Talavera et al. 2017; C. N. Verdouw et al. 2016). Thus, while IoT applications have the potential to improve total agricultural output, there is a need to investigate numerous issues such as interoperability, security, and so on (Tzounis et al. 2017; Villa-Henriksen et al. 2020).

Despite substantial research on IoT applications in agriculture by academics, the authors of this article identified major research gaps in the current literature. The majority of the content accessible focuses on the integration of IoT with breakthrough technologies and their applications in a number of sectors (Leng et al. 2019; Lezoche et al. 2020). Several agricultural studies have investigated the multiple potential applications of IoT as well as the challenges that may arise from its implementation (C. N. Verdouw et al. 2016). However, only a tiny amount of research work has been committed to building a thorough understanding of IoT adoption in agriculture, and it should be noted that existing literature focuses on technological issues rather than economic or social factors (Thibaud et al. 2018). No existing studies, to the best of the authors' knowledge, have done a complete review of the various types of research articles published on the subject of IoT applications in the agricultural supply chain. Furthermore, none of the prior studies compared the tools and techniques used, as well as the location of origin of the published publications. As a result, our contribution to the existing knowledge base is a thorough assessment of current literature in order to develop a detailed understanding of recent achievements in the agriculture and food industries.

In their research on technology adoption, (Chehbi-Gamoura et al. 2020) looked at four categories of evidence: literature reviews, surveys, theoretical/descriptive/conceptual, and empirical. When it comes to evaluating the case study's section, (Arunachalam, Kumar, and Kawalek 2018) looked at it in a similar area, while (Bhattacharya, Nand, and Castka 2019) employed simulation and mathematical modeling to Lean-Green integration. The fundamental objective of this article is to follow a comprehensive model of IoT applications in the case sector, thus these taxonomies cannot give an entire grid for the current research. As a result, the authors of this study categorized the selected studies to know the trend of this topic in the last ten years.

2. Research Method

A systematic and clear bibliometric review technique that focuses on the limitations of knowledge (Purnomo et al. 2021). For the purposes of bibliometric analysis, the search and selection criteria are shown in Figure 1. Scopus, one of the most extensively cited archives, was used to acquire the data. Search terms for this study were IoT for Sustainability in Agricultural to avoid picking papers that were irrelevant to the study’s purpose.

Only those terms are considered to maximize relevant search results. We used various specialty publications in the last ten years, from 2012 to 2021. On May 13, 2022, a search was conducted. Total retrieved documents were 107, but this was reduced to 95 when publications limit to 2012 until 2021 from the analysis. We restrict the source type to Journal, dan Conference Proceeding, then the result of the document reduces to 76. Then, we choose the language English only, and the documents reduce to 73. A total of 73 publications were studied for their bibliometric data. The procedure of selecting an article is shown in Figure 1.

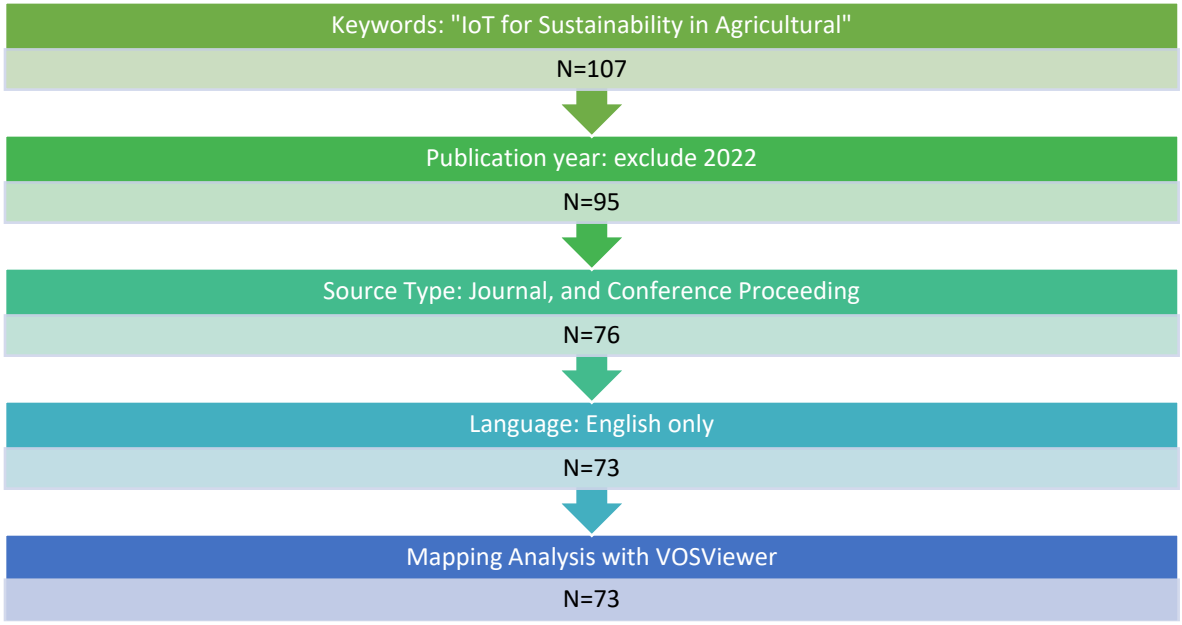


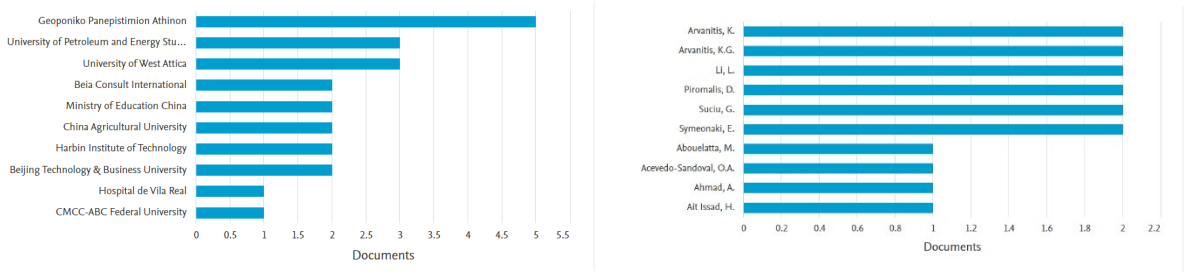
Figure 1. Research method to selection of the documents

3. Result and Discussion

From the search results using the keyword IoT for Sustainability in Agricultural on the Scopus website, it was found that 73 articles had been published during the last 10 years from 2012 to 2021. The data obtained was then processed based on several information needs such as Annual Publication, the highest citation based on journal sources, the most productive organization and author, Scientific Source with SJR, to map using VOSviewer software to map the theme network and author network.

3.1 The Most Productive Organizational Affiliations and Productive Author of IoT for Sustainability in Agricultural Research

In this research we get 199 affiliated organizations have researched IoT for Sustainability in Agricultural like in figure 2. The ten most prolific research affiliates in IoT for Sustainability in Agricultural research are Geoponiko Panepistimion Athinon (N = 5); University of Petroleum and Energy Studies (N = 3); University of West Attica (N = 3); Beia Consult International (N = 2); Ministry of Education China (N = 2); China Agricultural University (N = 2); Harbin Institute of Technology (N = 2); Beijing Technology & Business University (N=2); Hospital de Vila Real (N = 1); CMCC-ABC Federal University (N = 1) as shown in Figure 2 (a). They are all affiliates who have made a significant contribution to the researched IoT for Sustainability in Agricultural.



(a) (b)

Figure 2. The top ten lof Productive Organizational Affiliations (a) and ProductiveAuthor (b) of IoT for Sustainability in Agricultural Research

315 individual researchers have researched IoT for Sustainability in Agricultural. As shown in Figure 2 (b), the most prolific IoT for Sustainability in Agricultural author may be identified (Table 1).

Table 1. The author with the most publications in the field of IoT for Sustainability in Agricultural

No	Author	Affiliation	Documents
1	Arvanitis, K.	Geoponiko Panepistimion Athinon, Athens, Greece	2
2	Arvanitis, K.G.	Geoponiko Panepistimion Athinon, Athens, Greece	2
3	Li, L.	China Agricultural University, Beijing, China	2
4	Piromalis, D.	University of West Attica, Athens, Greece	2
5	Suciu, G.	Beia Consult International, Bucharest	2
6	Symeonaki, E.	University of West Attica, Athens, Greece	2
7	Abouelatta, M.	Ain Shams University, Cairo, Egypt	1
8	Acevedo-Sandoval, O.A.	Universidad Autónoma del Estado de Hidalgo, Pachuca, Mexico	1
9	Ahmad, A.	Universidad de Granada, Granada, Spain	1
10	Ait Issad, H.	Université Mouloud Mammeri de Tizi Ouzou, Tizi Ouzou, Algeria	1

3.2 The Most Document Cited of IoT for Sustainability in Agricultural Research

From the research topic IoT for Sustainability in Agricultural, we mapped the five highest document citations. From various sources along with the titles which we then attach in table 2.

Table 2. The Most Document Cited of IoT for Sustainability in Agricultural Research

No	Cites	Title	Source	Year
1	119	Precision agriculture techniques and practices: From considerations to applications (Shafi et al. 2019)	Sensors (Switzerland)	2019
2	52	Multi-stream hybrid architecture based on cross-level fusion strategy for fine-grained crop species recognition in precision agriculture (Kong et al. 2021)	Computers and Electronics in Agriculture	2021
3	45	Digital twins in smart farming (C. Verdouw et al. 2021)	Agricultural Systems	2021
4	43	Digital transformation priorities of India's discrete manufacturing SMEs – a conceptual study in perspective of Industry 4.0 (Dutta et al. 2020)	Competitiveness Review	2020
5	42	Big Data Analysis for Sustainable Agriculture on a Geospatial Cloud Framework (Delgado et al. 2019)	Frontiers in Sustainable Food Systems	2019

3.3 IoT for Sustainability in Agricultural Research Sector's Annual Publications

Figure 3 shows a graph of the annual trend of increasing publications in the last ten years, from 2012 to 2021. From the IoT for Sustainability in Agricultural publication database published in 2012, starting with 1 document, then in 2013 until 2016 there is 0 documents, or no one published. There was a significant increase in the number of publications year in years. In year 2017 (N=1), 2018 (N=2), 2019 (N=14), 2020 (N=22), until 2021 the publications have increase of up to 33 documents.

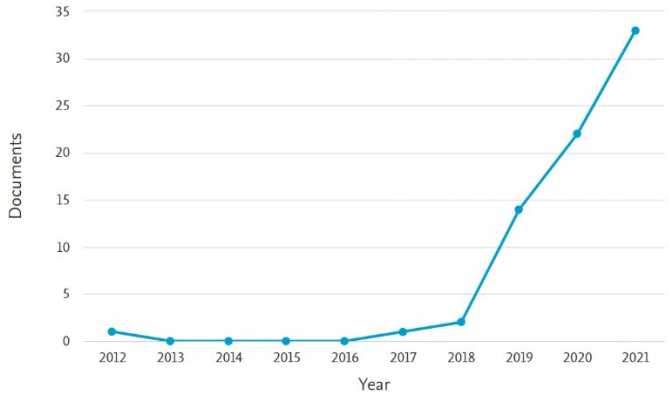


Figure 3. Chart documents per year on IoT for Sustainability in Agricultural literature

3.4 IoT for Sustainability in Agricultural Research from Scientific Source with SJR

A total of 73 sources of study have been published on the topic of IoT for Sustainability in Agricultural Research. The Applied Sciences Switzerland, SJR 2021 (N = 3) publishes the most articles each year in the field of IoT for Sustainability in Agricultural research. The details are shown in Table 3.

Table 3. The Most Document Cited of IoT for Sustainability in Agricultural Research

Scientific Source	SJR 2021	Article
Applied Sciences Switzerland	0.507	3
Computers And Electronics In Agriculture	1.595	3
IEEE Access	0.927	3
Ceur Workshop Proceedings	0.228	2
IOP Conference Series Earth And Environmental Science	0.202	2

Over a three-year period prior to the reporting year, each journal's SCImago Journal Rating (SJR) is determined by the average number of papers published in each journal during the reporting year that were referenced. SJR 2021 indicators ranging from 0.202 to 1.595 are found in the most prolific IoT for Sustainability in Agricultural research publications.

3.5 The Subject Area of IoT for Sustainability in Agricultural Research

Found 73 documents published by IoT for Sustainability in Agricultural in the last ten years, from 2012 to 2021. The most knowledge is in the field of Computer Science, with 22.0% academic documents (N=40). Then the second is Engineering with 17.6% academic documents (N=32, and the third is Agricultural and Biological Sciences with 11% academic documents (N=20). Then, Physics and Astronomy with 7.1% academic documents (N=13), Business, Management and Accounting with 6.0% academic documents (N=11), Mathematics with 5.5% academic documents (N=10), Environmental Science with 4.9% academic documents (N=9), and others with 14.8% academic documents such as images of IoT for Sustainability in Agricultural publication documents (Figure 4).

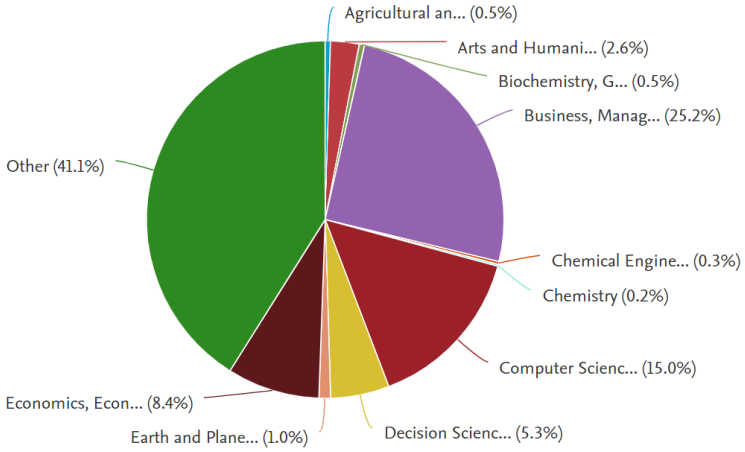


Figure 4. The Subject Area of IoT for Sustainability in Agricultural Research

3.7 Theme Map of IoT for Sustainability in Agricultural Research

Using the VOSViewer application, IoT for Sustainability in Agricultural on keyword mapping networks, the following subject map investigation was conducted. In this inquiry, we'll be looking at the titles and abstracts of articles. A binary representation of the result is used in the calculation. We can see from Figure 5.

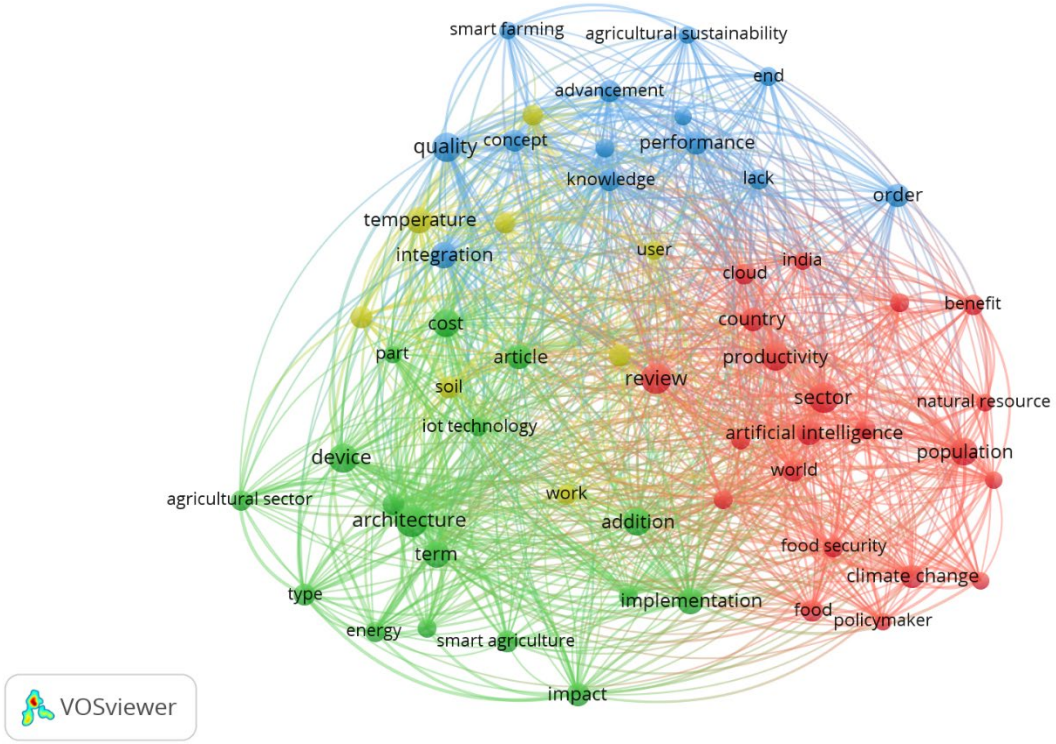


Figure 5. The coexistence of 99 of the most common terms (with at least four occurrences). The thickness of the lines reflects the severity of the link between terms, based on how often they appeared in articles together.

The data on the topic IoT for Sustainability in Agricultural was processed using VOSviewer software and obtained 2658 terms, with 99 terms meet the threshold. By default, from each of the 99 terms, 60% of the relevant terms will

be selected, making 99 terms selected. The 99 network terms will be mapped as in Figure 5 and divided into five clusters, Links is 1056, TLS (Total Link Strength) is 1677:

1. Cluster 1 has 21 items, which are red node color. In this network we choose terms Artificial Intelligence. This cluster with the word network like benefit, big data, climate change, cloud, country, food, food production, food security, government, productivity, researcher, review, sector, sustainable development, world.
2. Cluster 2 has 17 items, which are green node color. In this network we choose terms Blockchain. This cluster with the word network like addition, agricultural sector, architecture, article, device, case study, cost, energy, impact, implementation, iot technology, part, smart agriculture, state, term, type.
3. Cluster 3 has 13 items, which are blue node color. In this network we choose terms Agricultural Sustainability. This cluster with the word network like advancement, agricultural sector, concept, end, integration, knowledge, lack, order, performance, precision farming, quality, smart farming.
4. Cluster 4 has 8 items, which are yellow node color. In this network we choose terms IoT Application. This cluster with the word network like automation, irrigation, soil, temperature, user, wireless sensor network, work.

3.8 Authorship Network

A trend of collaborative research may be seen in figure 6 of a IoT for Sustainability in Agricultural article. There are 314 authors in the Authorship Network; 13 of them fulfill the criterion, the authors with the greatest total link strength (TLS) will be selected. There are three distinct research teams, each of which is related to the others.

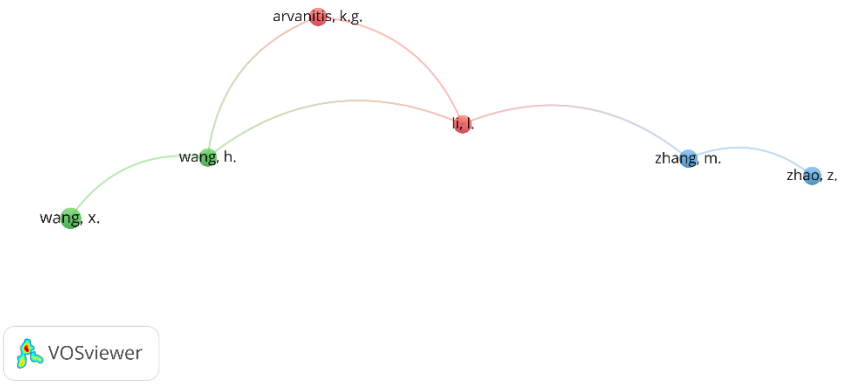


Figure 6. The network of 6 co-authors publishing in IoT for Sustainability in Agricultural. Each node presents an author

From figure 6, Arvanitis, K.G., and Li, L., are connected to each other with the red node color. The node green color is Wang, X., and Wang, H. The node with blue color is Zhang, M., and Zhao, Z. Every author in figure 6 show connected each other.

4. Conclusion

A rising number of Scopus-indexed worldwide articles on IoT for Sustainability in Agricultural is examined in this research. In this research we get 199 affiliated organizations have researched IoT for Sustainability in Agricultural like in figure 2. The ten most prolific research affiliates in IoT for Sustainability in Agricultural research are Geoponiko Panepistimion Athinon (N = 5); University of Petroleum and Energy Studies (N = 3); University of West Attica (N = 3). 315 individual researchers have researched IoT for Sustainability in Agricultural There was a significant increase in the number of publications year in years. In year 2017 (N=1), 2018 (N=2), 2019 (N=14), 2020 (N=22), until 2021 the publications have increase of up to 33 documents. A total of 73 sources of study have been published on the topic of IoT for Sustainability in Agricultural Research. The Applied Sciences Switzerland, SJR 2021 (N = 3) publishes the most articles each year in the field of IoT for Sustainability in Agricultural research. The most knowledge is in the field of Computer Science, with 22.0% academic documents (N=40). Then the second is Engineering with 17.6% academic documents (N=32, and the third is Agricultural and Biological Sciences with 11% academic documents (N=20). According to the contribution to knowledge, this study offers a categorization of the IoT for Sustainability in Agricultural study may have to wait several years to find the important themes. So, new

topics may be studied or researched in order to increase understanding in this area. Future evaluations of IoT for Sustainability in Agricultural's contribution and influence should be based on the combination of Scopus information, WoS, or another database. This study recommends combining the research subjects of IoT for Sustainability in Agriculture: Artificial Intelligence, Blockchain, Agricultural Sustainability, IoT Application, abbreviated as AIBASIA research themes.

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