Mapping and Visualizing Research Trend of Smart Farm with Internet of Things in the Last Ten Years using Bibliometric Analysis

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Abstract

With the introduction of the internet of things (IoT) in agriculture, the number of papers demonstrating a new path in agricultural research is increasing. The purpose of this research is to offer a detailed review of the interaction between IoT and agriculture. The purpose of bibliometric analysis is to synthesize and document the literature. The Scopus database was searched using keywords such as agricultural and IoT (internet of things). This analysis examines 489 papers published between 2012 and 2021. The research discovered that the literature on IoT and agriculture is rapidly expanding. The impact of the literature is examined using bibliometric analysis, which includes the most cited articles, the most productive journals, the most influential authors, the most productive institutions. There are three categories of collaborative researcher maps. A collection of knowledge generated from publications over the last decade, this study proposes a grouping of research themes Internert of things in Agriculture: temperature, Agriculture sector, communication, abbreviated as the TEASECTION research themes.

Keywords
Smart farm, internet of things, bibliometric, scientometric, research mapping

1. Introduction
The world's limited resources have to be shared by a population that keeps growing. The Food and Agriculture Organization (FAO) said that by 2050, there will be 9 billion people on Earth, and the number of people who need food will grow by 70% (Pivoto et al., 2018). But there isn't much land that can be used for farming, and climate change threatens crop yields. It is very important to deal with these dangers. In fact, one of the 17 Sustainable Development Goals (SDGs) (Opoku, 2019) in the UN 2030 Agenda is to get to sustainable food production systems through farming methods that increase productivity and adapt to climate change (J. & N., 2018). We used bibliometrics tools to describe the boundaries and dynamics of the IoT Based Agriculture research field. Quantitative analysis (Hosseini et al., 2019) and statistics are applied to published publications by bibliometrics in order to gauge their influence. The qualitative technique of a structured literature review and the quantitative approach of meta-analysis

have traditionally been the two main methodologies for synthesizing previous study findings (Tranfield et al., 2003). While the subjective biases of the researchers involved in the process of the qualitative approach are a problem, the quantitative approach is free of this problem.

Over the course of the past few years, the agricultural industry has made considerable strides in the development of smart farming and precision agriculture technology (Stafford, J 2019). With a total value of $5,084,800 million1, the agriculture industry is responsible for 6.4 percent of the total economic production around the world. The contribution of agriculture, food, and other related industries to the gross domestic product (GDP) of the United States in 20172 was $1.053 trillion. Consequently, making investments in the ecosystem of smart farming and embracing new technology will have a greater impact on the economy. In addition, the rapid expansion in the world's population has led to a substantial rise in the demand for agricultural and food-related goods. The traditional technologies that drive the agricultural sector are not able to meet this demand, and as a result, they are becoming extinct. Because of this, the agriculture and food production sector has also begun to implement data-driven and Internet of Things (IoT) technologies in an effort to boost the number as well as the quality of agricultural products. The implementation of smart farming practices has the potential to be a solution that increases productivity while preserving product quality. There is a wide variety of applications for smart farming (Vasisht, D., et al., 2017). (kamilaris, A, & Gao feng, 2016) (Hemavathi B Biradar & Laxmi Shabadi, 2017) present globally, such as a controlled water delivery and measuring soil moisture at different levels, in order to increase agricultural productivity. (Wolfert S, Lan ge, Verdouw C, 2017) The collecting of data from a variety of sensors, which can then be uploaded to the cloud, is possible. The data that was acquired not only enables a hands-off approach to smart farm monitoring but also gives useful information about the many environmental variables that were observed (Farooq S, Riaz S, Abid A, 2019).

2. Research Method

Bibliometric analysis was used in a comprehensive literature database for this study. The results of this survey have revealed relevant keywords related to IoT-based agriculture to search for and find connected items in the Scopus database around the world. Researchers have relied on the Scopus database, which is considered a reliable source of scientific publications by academics, as their primary source of information.

Using the keyword "IoT-based agriculture" as a search term in the Scopus database, this study was able to retrieve the necessary information. Data mining is restricted to yearly data in order to obtain complete yearly data. With respect to data mining in June 2021, we'll be using the following search query option: “TITLE-ABS-KEY” AND “PUBYEAR 2021. We’ve uncovered 236 publications dating back to 2010 through 2021 in this first step. As part of the investigation, At this point, the CSV dataset has been processed to extract the Scopus result metadata.

The Scopus website provides an analyze search results function that displays bibliometric information from selected publications. We have used this service to analyze and visualize the publication productivity of researchers, institutions, and countries. Besides, this feature is to measure the number of annual publications and publication citations, as well as the proportion of subject areas and source documents (Purnomo et al., 2021).

The researcher then used VOSviewer ver. 1.6.16 to perform co-occurrence and co-authorship analyses on the documents they had collected. One way that this study was able to compile a network of international researchers working together is by using VOSViewer in conjunction with author analysis units and the full computation systematic technique. A network of keyword maps for research topics is generated using a combination of a thorough co-occurrence analysis and a fully systematic computation technique based on VOSViewer (Purnomo et al., 2020; Soegoto et al., 2022; van Eck & Waltman, 2010). With the help of Microsoft Excel, we've compiled some basic statistics and tables. In the next step, the research findings were analyzed and correlated.

3. Result and Discussion

This section talks about the growing results of data based on the most common organizational affiliation, countries, individual studies, the most common subject areas, yearly source documents, annual documents and cited papers, publication of the map, and networks of authorship in the field exploration of IoT-based agriculture.

3.1 Most productive Organizational Affiliations in IoT-Based agriculture

There have been 858 affiliated organizations researching IoT-based farming. China Agricultural University (n = 14) was the most prestigious institution for IoT-based agriculture research. Following these institutions were Wegeningen

University & Research, the Netherlands (n = 11), Sunchon National University, South Korea (n = 9), Vellore Institute of Technology, India (n = 9), Purdue University, Indiana (n = 8), and China's Ministry of Agriculture (n = 8) (Figure 1).

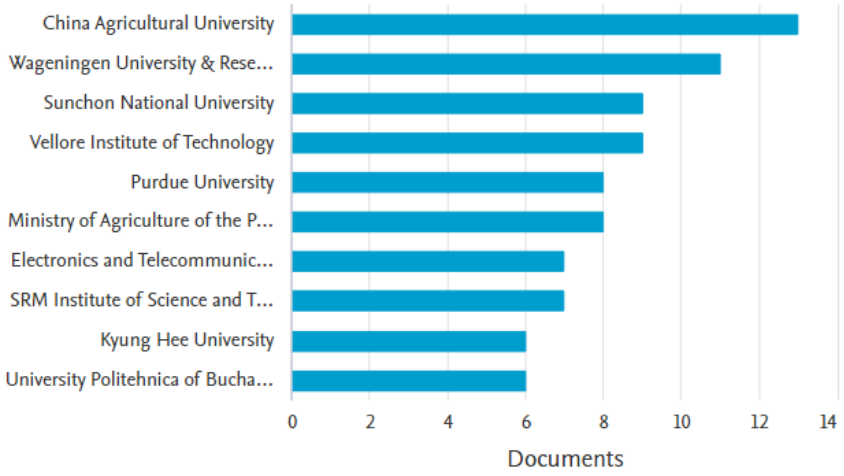

Figure 1. Affiliation with an Institution Annnual Publication Count of IoT Based Agriculture

China Agricultural University of China (n = 14) appears to have the most prominent and productive organizational affiliations. This is China, a country with a vast agricultural land and a fertile soil.

3.2 Most Individual Researcher in Hyperlocal Business Research

There was 159 individual researcher that has researched IoT Based agriculture. It is an expert on the subject of IoT and agriculture in the majority of writings was Cho Yongyun from Sunchin National University, South Korea (n = 5). And then Sarangi Sanat from TCS Research and Innovation, India (n = 5), Shin Chansun from Sunchon National University, South Korea (n = 5), Al Mhdawi Amar K from Edge Hill University, United Kingdom (n = 4), Attard Steven J from AgriTech Solution, Australia (n = 4), Byabazaire Jhon from University College Dublin, Ireland (n= 4), Davy Alan from South East Technological University from Ireland (n= 4), Everingham Yvette L from james Cook University, Australia (n= 4), Jain Prachin from TCS Research and Innovation, India (n= 4), Kamienski Carlos from Universidade Federal do ABC, Brazil (n= 4) (Figure 2).

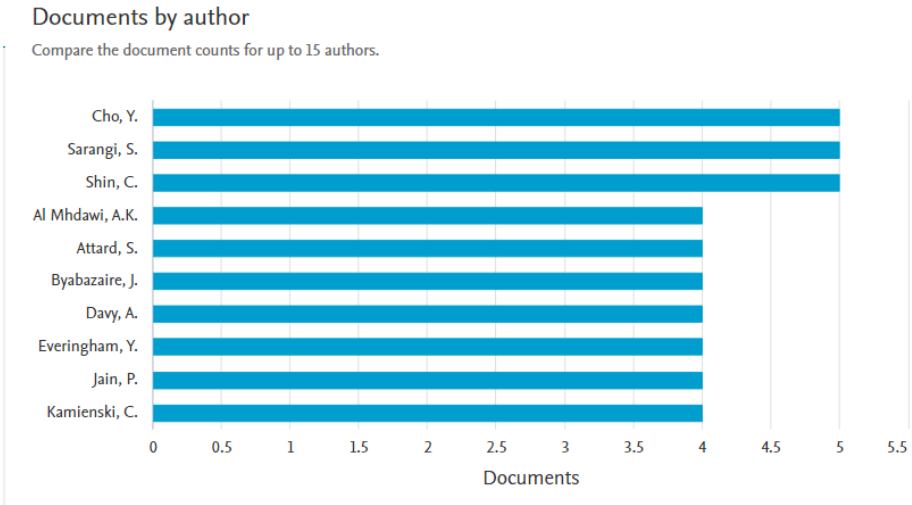

Figure 2. Most Individual IoT based Agriculture Publication researchers

The most productive individual researcher in IoT-based agriculture tends to be from South Korea. To date, Dmitry Namiot has published 89 papers, garnered a citation score of 89, and has an h-index of 11. (Scopus, 2022). In addition to 199 citations and an h-index of 8, Sarangi Sanat has published 36 papers (Scopus, 2022). The h-index of 10 of Chansung Shin's publications and his 577 citations speak for themselves (Scopus, 2022).

3.3 Most Productive nation's IoT base Agriculture Publication

There have been investigations into Internet of Things-based agriculture carried out in 93 different nations. India, with a total of one hundred and twenty (n =) scholarly documents, was the nation that had the most research published in IoT Agriculture publications. After that, China was covered in the next n = 121 articles. After that comes the United States with 69 people, South Korea with 59, Italy with 33, Thailand with 32, Taiwan with 31, Spain with 26, Australia with 24, and Malaysia with 23 (Figure 3).

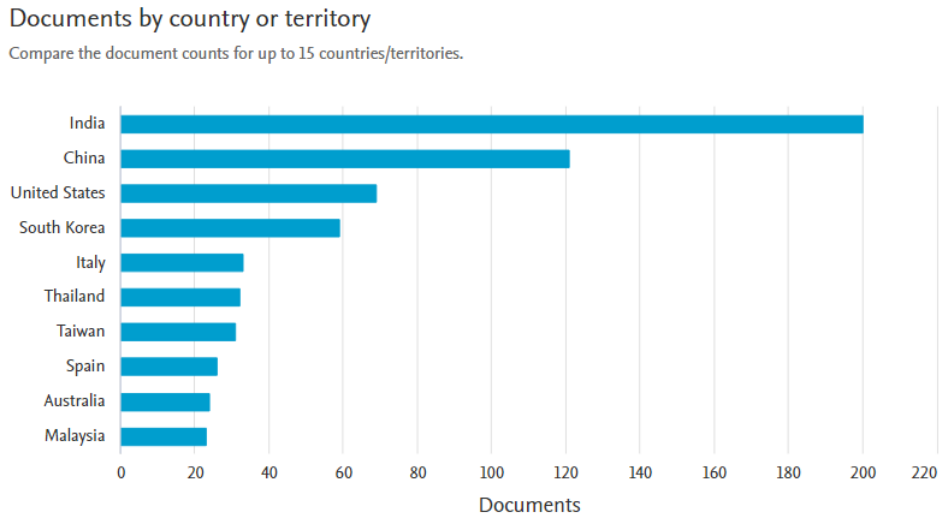

Figure 3. Nation Number of Annual Publication of IoT based Agriculture

India is mentioned in the most productive IoT-based agriculture publications. In 2022, India has an HDI ranking of 0.64 and a population of 1,405,848,848. China is included on the list of developed nations for 2022. China has an HDI ranking of 0.671 and a population of 1,448,471,000 in 2022. In 2022, the United States has an HDI ranking of 0.92 and a population of 334.805 million.

3.4 The Subject Area with the Highest Frequency of IoT based Agriculture Research

IoT-based research Agriculture has been studied in many different fields. Computer Science (n = 577, or 30%) is the field in which there are the most IoT-based agriculture studies published all over the world. This was followed by Engineering (n = 494 or 23.3%), Physics and Astronomy (n = 133 or 6.8%), Agricultural and Biological Sciences (n = 127 or 6.6%), Mathematics (n = 115 or 6%), Decision Sciences (n = 89 or 4.6%), Energy (n = 83 or 4.3%), and Social Sciences (n = 69 or 3.6%).

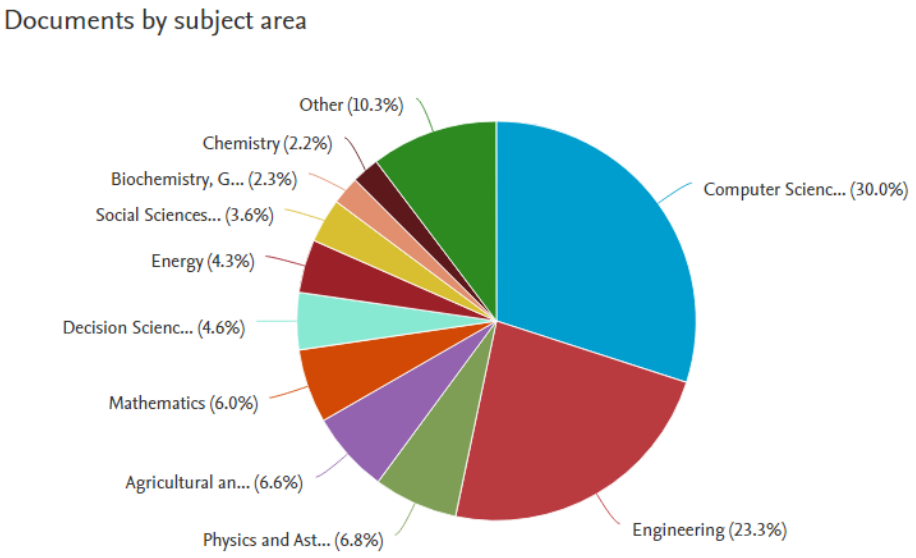

Figure 4. The Subject Area With the Highest Frequency of IoT based Agriculture Research

Computer science, engineering, physics and astronomy, agricultural and biological sciences, and mathematics are coming together to form what is known as Internet of Things (IoT) agriculture (Figure 4). This is one reason why research on Internet of Things applications in agriculture is so prevalent.

3.5 Publication Sources for IoT Based Agriculture Document by Year

Tabel 1. Number source of the hyperlocal business research

Scientific Source	SJR 2021	Article
Sensor Switzerland	0.803	30
ACM International Conference Proceeding Series	0.232	24
Advances In Intelligent Systems and Computing	0.215	23
Computers and Electronics in Agriculture	1.595	20
Nongye Gongcheng Xuebao Transactions of the Chinese Society of Agricultural Engineering	0.404	15
IEEE Access	0.927	12
Sensor Switzerland	0.803	30

339 publication sources have published IoT based agriculture research (Table 1). The highest number of articles per based on the year sources in the IoT based agriculture research was “Sensor Switzerland”, SJR 0.803 (n = 30); “ACM Intrnational Conference Proceding Series”, SJR 0.232 (n=24); “Advance In Intelligent System and Computing”, SJR 0.215 (n=23); “Computers and Electronics in Agriculture”, SJR 1.595 (n=20); “nongye Gongcheng Xuebao Transactions of the Chinese Society of Agricultural Engineering” SJR 0.404 (n=15); “IEEE Access” SJR 0.927 (n=12);.

3.3 IoT based Agriculture Sector’s Annual Publications

The number of articles about IoT-based agriculture studies that were published in other countries grew last year. This can be seen in Figure 5, which shows that 43 papers were published at the peak of 2016's writing. IoT-based agriculture has been the subject of research since 2010. Initiated In 2017, there will be 89 documents for product IoT-based agriculture studies. In 2018, there will be 148 documents, in 2019, there will be 234 documents, and in 2020, there will be 283 documents (Figure 5).

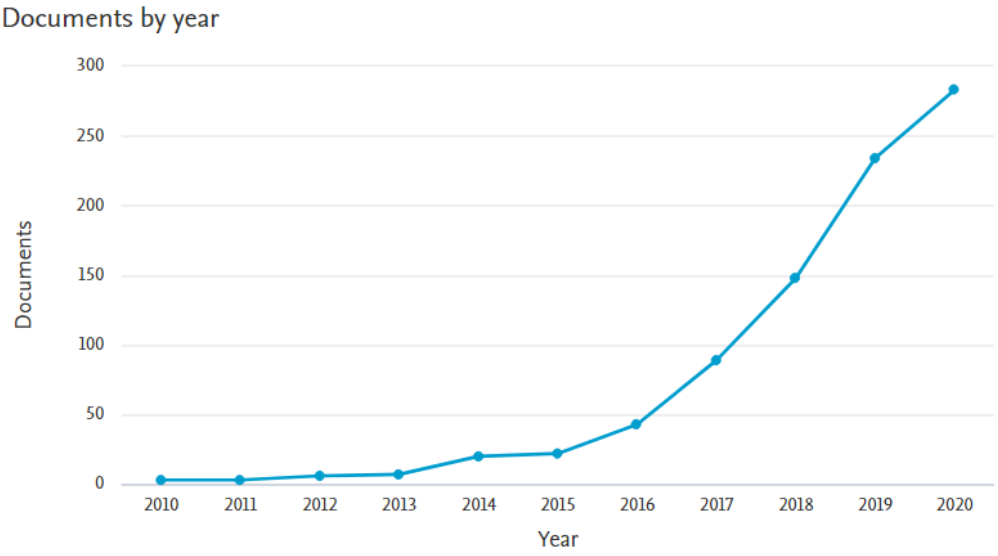

Figure 5. The IoT based Agriculture Sector's Annual Publications

3.6 Iot Based Agriculture Publication Documents Cited

Tabel 2. Document cited of iot based agriculture publication

Document Title	Author	Year	Source	Cited by
Big Data in Smart Farming	Wolfert, S., Ge, L.,Verdouw, C., Bogaardt,M.-J.	2017	Agricultural Systems 153, pp.69-80	961
Blockchain-based traceability in Agr-Food supply chian	Caro,M.P.,Ali,M.S.,Vecchio ,M.,Giaffreda,R.	2018	2018 IoT Vertical and Topical Summit on Agriculture-Tuscany, IOT Tuscany 2018 pp.1-4	287
IoT and agriculture data analysis for smart farm	Muangprathub, j., Boonnam, N., Kajornkasirat, S., (…), Wanichsombat,A., Nillaor,P.	2019	Computer and Electronics in Agriculture 156, pp. 467-474	258
A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda	Klerkx, L., Jakku, E., Labarthe, P.	2019	NJAS – Waginengen Journal of Life Sciences 90-91,100315	238
Farmbeats: An IoT platform for data driven agriculture	Vasisht, D., Kapetanovic, Z., Won, J, _H., (…), Sudarshan, M., Stratman, S.	2017	Proceedings of the 14th USENIX Symposium on Networked System Design and Implementation, NSDI 2017 pp. 515-529	203

Internet of Things (IoT) for Smart Precision Agriculture and Farming in Rural Areas	Ahmed, N., De, D., Hussain, I.	2018	IEEE Internet of Things Journal 5(6), 8521668, pp. 4890-4899	194

The study “Big Data in Smart Farming” by Wolfert, S., GE, L., Verdouw, C., Bogaardt, M.-j. was the highest documents based on the IoT Based (table 2) Agriculture cited Wolfert, Sjaak from Wageningen University & Research, Netherland, Ge lan from Wageningen University & Researchn Neztherland, Verdouw, Cor N. from Wageningen University & Research from Netherlands, Boogaardt, Marc Jeroen from Wageningen University & Research from Netherland.

3.7 Research Theme Map

The research theme map is a review that seeks to identify IoT Based Agriculture research based on keyword linkages between publications. The VOS Viewer software was used to evaluate and visualize the construction process. IoT based Agriculture for the keyword system IoT based Agriculture of publication theme map. Four the minimum condition criteria number of keyword-related documents was seven repetitions. Therefore, 2,655 among the main words 42 the thresholds for keywords have been surpassed.

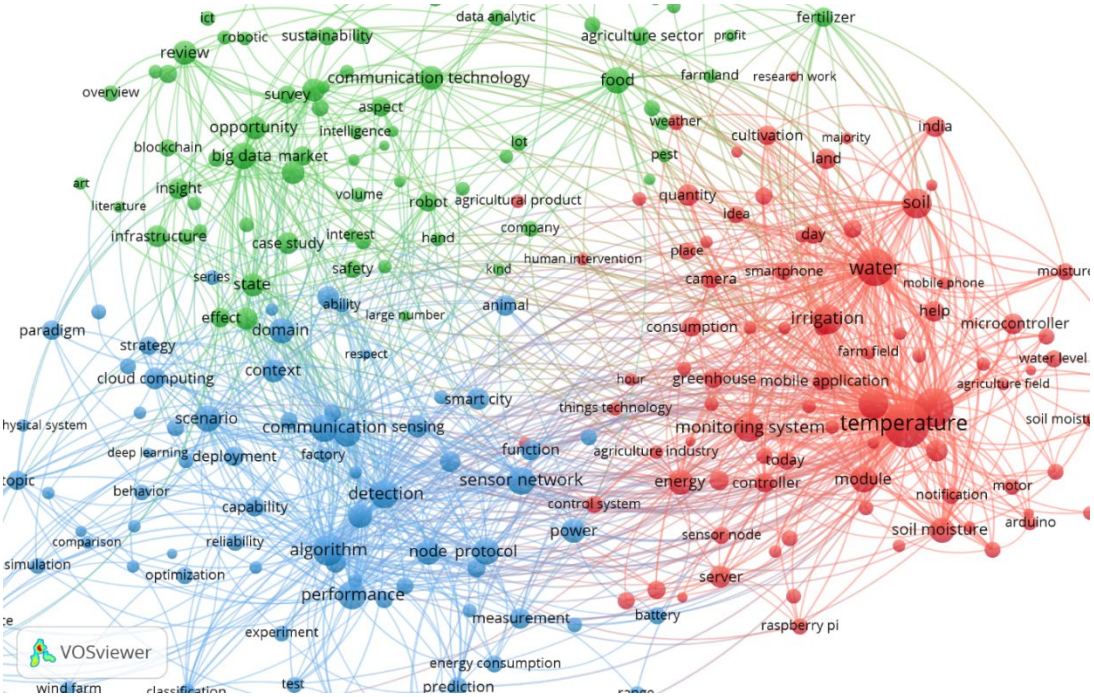

Figure 6. Map of Publication Themes

From figure 6. There is four Cluster In terms of international academic studies, theme groups are focused on study keywords. publication of hyperlocal business simplified as well as abbreviated as TEASECTION research themes

4. Conclusion

This study found that the number of persons who read foreign publications increases on a yearly basis. Maps and patterns in the visual were apparent in IoT-based agriculture. There were more than 200 IoT-based Agriculture studies published in publications from India. When the book was initially published, China Agriculture University was the most active research institution in the field of IoT-based Agriculture publications, with 13 journals. Cho Y was the academic researcher who published the most papers in the IoT-based Agriculture publication with a total of five. According to the IoT based Agriculture publication, the fields that received the most attention were Computer Science with 577 documents. IoT-based Agriculture was the focus of the "Sensors Switzerland," which had 30 members, according to the source. In 2016, hyperlocal business studies had the largest number of academic papers published

(43), making it the most prolific year for hyperlocal business studies publication. The publication entitled "Big Data in Smart farming" by S. Wolfert, L. GE, C. Verdouw, and M.-J. Bogaardt, with 961 citations, was the most widely cited in 201. There are two groups of researchers who are working together to publish articles on IoT-based agriculture.

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