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

Fairuz Iqbal Maulana
Computer Science Department, School of Computer Science, Bina Nusantara University
Jakarta 11480, Indonesia
fairuz.maulana@binus.edu

Agung Purnomo and Febby Candra Pratama
Entrepreneurship Department, BINUS Business School Undergraduate Program
Bina Nusantara University
Jakarta 11480, Indonesia
agung.purnomo@binus.ac.id, febby.pratama@binus.edu

Faizal Ardiansyah
Informatics Engineering Study Program, Faculty of Computer Science, Universitas Brawijaya
Malang, Indonesia
faizzalardiansyah11@gmail.com

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 Internet 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).

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), Byabzaare 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).
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).

![Graph of IoT based Agriculture publications by country](image)

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

Table 1. Number source of the hyperlocal business research

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

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 Proceeding 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).
### 3.6 IoT Based Agriculture Publication Documents Cited

**Figure 5. The IoT based Agriculture Sector’s Annual Publications**

<table>
<thead>
<tr>
<th>Document Title</th>
<th>Author</th>
<th>Year</th>
<th>Source</th>
<th>Cited by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Big Data in Smart Farming</td>
<td>Wolfert, S., Ge, L., Verdouw, C., Bogaardt, M.-J.</td>
<td>2017</td>
<td>Agricultural Systems 153, pp.69-80</td>
<td>961</td>
</tr>
</tbody>
</table>
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 & Research 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.

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

| 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 |
(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.

References


Biographies

Fairuz Iqbal Maulana Fairuz Iqbal Maulana, S.T., M.Eng., M.T. is a lecturer at the College of Computer Science, Bina Nusantara University, Indonesia. He earned two Master's degrees, the first in the field of Interdisciplinary Program of Information System, Pukyong National University (PKNU), Busan - South Korea, and the second in the School of Electrical Engineering and Informatics (STEI), Institut Teknologi Bandung (ITB), Indonesia with specializes in Multimedia and Games. His research fields are Game programming, Computer Vision, Facial Recognition, Augmented Reality, Virtual Reality for education, Internet of Things. He is the head of the Digital Technopreneur Laboratory in Malang campus. He can be contacted by email: fairuz.maulana@binus.edu

Agung Purnomo is a researcher and faculty member of the Entrepreneurship Department, BINUS Business School Undergraduate Program at the Bina Nusantara University, Malang Campus, Malang, Indonesia. He earned a Bachelor
of Agriculture in Horticulture from Brawijaya University, Indonesia; and a Master of Business Administration in Creative and Cultural Entrepreneurship from Institut Teknologi Bandung, Indonesia. Mr. Agung is currently pursuing a Ph.D. in Management Science at Universitas Airlangga, Indonesia. He has published several journals and conference papers using bibliometric methods in collaboration with multidisciplinary researchers.

Febby Candra Pratama is a researcher and faculty member of the Entrepreneurship Department, BINUS Business School Undergraduate Program at the Bina Nusantara University, Malang Campus, Malang, Indonesia. He earned a Bachelor of Economics from Universitas Negeri Malang, Indonesia; and a Master of Management from Brawijaya University, Indonesia.

Faizal Ardiansyah is a student who has graduated from the Brawijaya University campus, Indonesia. He obtained a bachelor's degree from the Department of Informatics Engineering, Brawijaya University, Indonesia in 2019.