chemistry proceedings

MDPI

Proceeding Paper

A Bibliometric Overview over Smart Farming †

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† Presented at the 1st International Online Conference on Agriculture—Advances in Agricultural Science and Technology, 10–25 February 2022; Available online: https://iocag2022.sciforum.net/.

Abstract: Agriculture technology has been used to increase farm productivity, allowing the management of spatial and temporal variability of soil factors, crops, and animals. Due to the advances in technologies such as the Internet of Things—where the devices monitor, analyze, and make decisions—farms are connected, forming the concept of smart agriculture. Thus, it is possible to increase efficiency, quality, and speed and at the same time reduce cost and wastes. In this study, we conducted a bibliometric review of smart farming concepts to identify the state of the art of technologies in agriculture. Data collected from Scopus are analyzed using VOSviwer software. The software is a tool for building and visualizing bibliometric networks, allowing the construction of networks based on citation relationships, bibliographic coupling, or occurrence of important terms. The results of the article present an overview of smart farming development.

Keywords: smart farming; agriculture; livestock; commodities

Citation: de Souza, J.S.; dos Reis, J.G.M.; da Cruz Correia, P.F.; Rodrigues, G.S. A Bibliometric Overview over Smart Farming. *Chem. Proc.* **2022**, *10*, 28. https://doi.org/10.3390/IOCAG2022-12327

Academic Editor: Massimo Cecchini

Published: 28 February 2022

1. Introduction

Agriculture has been adopting several technological resources to an increase productivity over the years. Nowadays, this phenomenon is called Precision Agriculture [1]. However, there are other terms associated in the literature such as Digital Agriculture [2,3], Agriculture 4.0 [4], and Smart Farming [5]. All of them emerged from the need to follow the technological advances in agricultural production [3,5].

Overall, the proposal is the use of information technologies to increase productivity and planting quality using sensors to obtain process optimization and cost reduction [2–4]. However, before agriculture reached its current state, it passed through several milestones [4,5].

The first milestone was when nomads learned the art of cultivating the land to obtain food, so there was no need for a change when hunting animals to eat [4]. The second milestone took place in the development and refinements of agricultural techniques introducing crop rotation techniques to preserve the soil and reduce area depletion [6]. Another highlight was the use of fences, changing from collective planting to individual. These and other events became known as the English Agricultural Revolution at the beginning of the Industrial Revolution [6]. The third milestone was the use of machinery to increase production, replacing animal-drawn equipment for steam equipment or motorized machinery [4]. The Green Revolution is characterized by the increase in agricultural production in the intensive use of genetically modified seeds, the use of industrial inputs, and mechanization and reduction in manpower.

The fourth milestone is associated with concepts involving Industry 4.0 or the Fourth Industrial Revolution [1,4], which makes use of emerging technologies such as Cloud Computing [7], Artificial Intelligence (AI) [7], Robotics [8,9], and the Internet of Things (IoT) [10] to increase efficiency, quality, and speed of production and reduce costs and waste of input [1,2].

This immersion of new technologies in the agricultural sector has great potential to change agriculture as we know it, making it possible to use Unmanned Aerial Vehicles (UAVs) [11] such as drones for aerial analysis of planting or to assist in the identification of plants, and in the use of Unmanned Ground Vehicles (UGVs) [12], remotely controlled tractors to harvest crops or plow the land.

Digital agriculture can impact other sectors, such as agribusiness [13,14], the environment, and social issues [15], giving the opportunity to develop different solutions.

The aim of this paper is to investigate the publication surrounding the topic in this century to identify the number, the evolution in this period, the authors involved, and main concepts. We consider in this study that all the names about the subject are part of smart farming approach.

The research is conducted using the Scopus database and Vosviewer software and is part of an ongoing Ph.D. that intends to investigate the development and use of technologies in agriculture. The article is divided in four sections; after this introduction, we summarize the methodology, present the results, and make some final remarks in the conclusion section.

2. Methodology

This paper presents a bibliometric review [16,17] regarding articles published related to the concepts of smart farming to identify the state of the art of technologies in agriculture.

Using the Scopus database, we adopted the term smart farming and collected data from 2002 to 2021—19 years—considering review papers and in the English language. The data of the papers obtained were extracted in CSV format and analyzed with VOSviwer software (Visualizing Scientific Landscapes) [18].

The VOSviewer is a software to build and visualize bibliometric networks based on citation, authors name, journals, etc. [16,19]. It allows us to extract reports for the type of analysis, questions, and quantity among other functions of data mining. This tool permits us to create and visualize bibliometric networks [16,19].

The software version adopted was 1.6.17 from 22 July 2021 [18].

3. Results

We obtained 194 papers regarding the topic of smart farming. Our results identified a rise in the number of publications after 2016 (Figure 1).

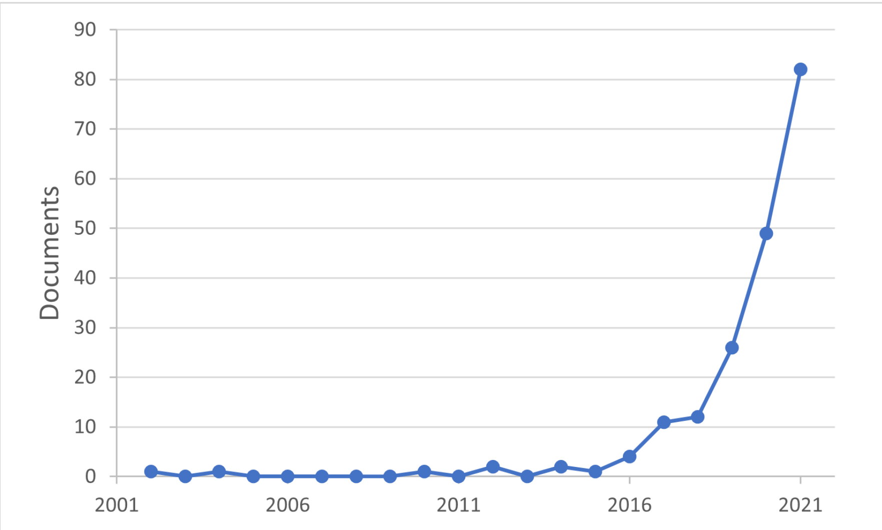

Figure 1. Evolution of scientific publications by year.

Among all the publications, some studies can be highlighted. Pongnumkul et al. [20] analyzed the use of smartphone-based sensors in agriculture to obtain crop data. The authors identified 12 agricultural applications, 6 farm management applications, 3 information system applications, and 4 extension service applications, and made advances in the agricultural sector. Using the sensors of a smartphone, it was possible to develop applications that allow the management of the resources of a medium-sized farm or vegetable garden.

The authors Shi et al. [10] highlight the security and privacy of technologies in smart farming, where they warn about proxy attacks, DoS (Denial-of-Service) attacks, and malicious code injection and how to avoid them. They report on applications that collect private data from users and present some alternatives that help prevent data leakage.

In 2019, authors Farooq et al. [21] highlight some countries that have been successful in creating and implementing regulations and policies to standardize smart farming.

After 2016, publications commence to introduce other areas of study in the agriculture sector (Figure 2), such as Engineering, Social Sciences, Business, Management, and Accounting. This change allowed the development of several studies involving smart agriculture, food safety and quality, and efficient energy consumption in agriculture.

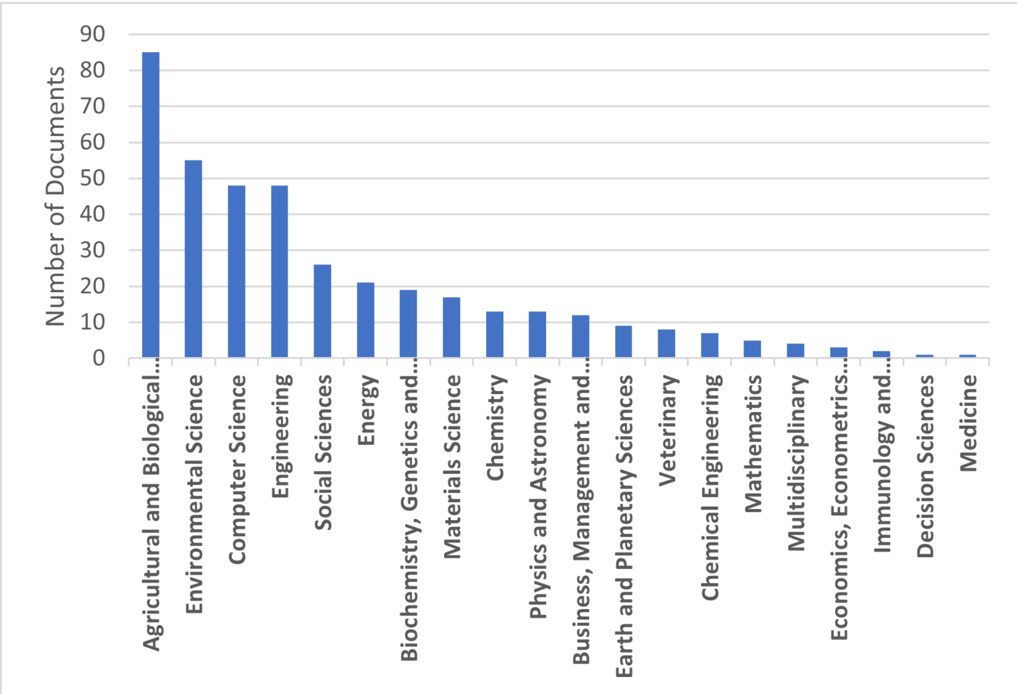

Figure 2. Documents by subject area.

In the bibliometric analysis through the VOSviwer software, the parameters created a map based on bibliographic data extracted from Scopus, with the option of bibliographic coupling of documents to identify the main publications and understand the state of the art of the concept of application of smart agriculture (Figure 3).

Observing Figure 3, it is possible to identify the main authors of scientific publications related to the topic of smart agriculture.

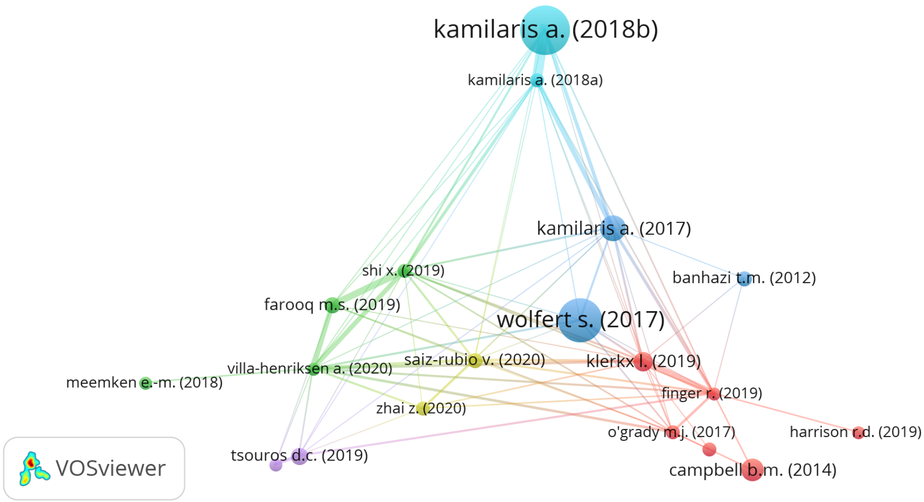

Figure 3. Network Visualization.

The relationship between authors is defined by the thickness of the connecting line between them, and each node represents the number of citations that each publication received. It is possible to infer that smart agriculture is part of an IoT ecosystem that uses A.I. for decision making, which will bring benefits to the farmers. These benefits were obtained from the literature reviewed. Some of these benefits are:

- Increase in production: the optimization of all processes related to agriculture and livestock;
- Water saving: weather forecasts and sensors that measure soil moisture allow watering only when necessary and for the right amount of time;
- Quality improvement: an analysis of the production quality obtained in relation to the strategies used makes it possible to adapt the latter to increase the quality of the next production;
- Cost reduction: the automation of sowing, treatment, and harvesting processes in the case of agriculture reduces resource consumption;
- Pest detection and health care: the early detection of pests in crops or diseases in animals makes it possible to minimize this impact on production and improve animal welfare;
- Increases sustainability: saving resources such as irrigation water and maximizing land use reduces environmental impact.

Through the literature review, it was identified that a farm with smart agriculture takes four steps to be efficient and sustainable:

1. Note: the sensors will read and record the data in a bank for analysis;
2. Diagnosis: artificial intelligence will analyze the data based on predefined business models and rules for identification and decision making;
3. Decision: artificial intelligence will make the decision guided by machine learning;
4. Execution: artificial intelligence will direct some technological device to perform the task.

The bibliometric review allow us to establish some questions: With all these advanced technologies, the farms are being automated and reducing the workforce; how will the employees be reallocated? Will they be released from their occupations? What will the impacts on society be? Will prices be affordable for the small farmer?

To answer these and other questions, it is necessary to carry out further studies on future perspectives in the use of Smart Agriculture, Management of Technological Resources and Traceability of the Agrifood Supply Chain. These are the objectives of authors in the future. This paper is part of a Ph.D. study that started in the second semester of 2021.

4. Conclusions

In this research, a review was presented to understand the state of the art of the concepts of application of Intelligent Agriculture. It is concluded that the application of smart farming will bring great benefits to the farmer. It will make production more efficient by way of increasing production, increase quality in cultivation and optimization, and help to reduce resource waste.

There are several limitations of this study, challenges and problems that were not addressed in this study and that may be addressed in future studies. However, this study attended the objective to explore smart farming concepts in the literature.

Author Contributions: Conceptualization, J.S.d.S.; methodology, J.S.d.S.; software, J.G.M.d.R., P.F.d.C.C. and G.S.R.; validation, J.G.M.d.R.; formal analysis, J.G.M.d.R.; investigation, J.S.d.S.; writing—original draft preparation, J.S.d.S.; writing—review and editing, J.G.M.d.R. All authors have read and agreed to the published version of the manuscript.

Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior—Brasil (CAPES)—Finance Code 001.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors would like to thank Capes for the financial support of this research.

Conflicts of Interest: The authors declare no conflict of interest.

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