Bibliometric and economic analysis in precision agriculture

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Abstract

This article aims to better understand as well as the evolution of research status through the available literature on economic analysis in Precision Agriculture (PA). PA is used to improve agriculture processes. Economic analysis of Precision Agriculture scientific papers' are reported and discussed. The Scopus and Dimensions data based were used to obtain the research records under study. Indicators of scientific productivity; collaboration between counties and research impact were evaluate through economic analysis.

The keywords included in the publications and subjects' areas under which the research was published were also evaluated through PA economic analysis. A total of 112 articles were analyzed from 1995 to 2024. The most productive journal were Precision agriculture (13); Computers and electronics agriculture (4); Fields crops research (4); and Agricultural Water research (3). The most keywords were precision agriculture (61); economic analysis (59), Agriculture (23); Irrigation (20); and crop yield (19). Citation countries were classified with United States at first place; and Australia; Malaysia; Spain and India were arrived in second to fifth place respectively. There is no collaborative study between countries.

Keywords

Precision agriculture, economic analysis, cost analysis

1. Introduction

Human subsistence increase pressure for food security and sustainability as well as a need to halt environmental degradation has focus attention on the efficient use of farm resources (Tey and Brindal; 2012). Smart Agriculture, known as Smart Farm Technology for sustainable farmland, is the farm management approach where decision making relies on information-based knowledge. It describes an advanced type of farming technology utilizing robot technology and Information and Communication Technology (ICT) to promote labor saving, precision and high-quality production Ochiai (2023); Iba and Lilavanichakul (2023). For, Ochiai (2023); smart agriculture, is expected to reduce the labor load and working time for farm production, improve farm profit through expanding farm size and enable sustainable agriculture farmland Avolio et al. (2014); Lieder and Schroter-Schlaack (2021). For example; in Japan; Smart Agriculture improves farm productivity by reducing labor costs and working time Ochiai (2023); Iba and Lilavanichakul (2023). GPS machines such as tractors or plantors, remote controlled weeding machines, drones for spraying chemicals and equipment can make more efficient for farmers Ochiai (2023).

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2. Materials and methods

The bibliometric database was compiled by searching the Scopus abstract and citation databases for key words and variants on 17 October 2023, using the following query string (TITLE-ABS-KEY("economic analysis") OR TITLE-ABS-KEY("economic study") OR TITLE-ABS-KEY("economic evaluation") OR TITLE-ABS-KEY("financial analysis") OR TITLE-ABS-KEY("costs and benefits evaluation") OR TITLE-ABS-KEY("commercial analysis")) AND (TITLE-ABS-KEY("precision agriculture") OR TITLE-ABS-KEY("site-specific crop management") OR TITLE-ABS-KEY("site specific crop management") OR TITLE-ABS-KEY("precision crop management") OR TITLE-ABS-KEY("site-specific agriculture") OR TITLE-ABS-KEY("site specific agriculture") OR TITLE-ABS-KEY("site-specific farming") OR TITLE-ABS-KEY("site specific farming") OR TITLE-ABS-KEY("as-needed farming") OR TITLE-ABS-KEY("prescription farming") OR TITLE-ABS-KEY("smart farming")).

The selection and structure of keyword used during the search was an iterative process guided by the authors' experiences in this particular research focus area and previous literature identified through preliminary searches in google scholar. The search was conducted without applying any constraints on the timespan; however, articles that were not published in accredited peer-reviewed journals and not written in English were exclude. The search in Scopus and Dimension results returned 112 articles.

We replaced 15th International Congress on Agricultural Mechanization and Energy in Agriculture, ANKAgEng 2023 by two articles such as 1- Analysis of Factors Affecting Farmers' Intention to Use Autonomous Ground Vehicles Johnny Waked, Gabriele Sara, Giuseppe Todde, Daniele Pinna, Georges Hassoun, Maria Caria; 2- Economic Analysis of Subsurface Drainage Systems in North Central Iowa Kapil Arora, Kelvin Leibold.

We removed some articles which are not relied on the area:

Antecedents of smart farming adoption to mitigate the digital divide – extended innovation diffusion model

2- Comparison of uniform and variable rate nitrogen and phosphorus fertilizer application for grain sorghum

3-Developing and testing an algorithm for site-specific N fertilization of winter oilseed rape

4- Development of an automated slope measurement and mapping system

5- Fossil energy usage for the production of baby leaves

6- Multidisciplinary studies on sustainable nitrogen fertilisation considering the potential of satellite-based precision agriculture; [Multidisziplinäre Untersuchungen zur nachhaltigen Stickstoffdüngung unter Berücksichtigung der Möglichkeiten der satellitengestützten Präzisionslandwirtschaft]

7- Smart green house for controlling & monitoring temperature, soil & humidity using IoT.

At the end of the process of screening 112 articles are retained for this bibliometrics analysis.

For data analysis, we use R bibliometrix package.

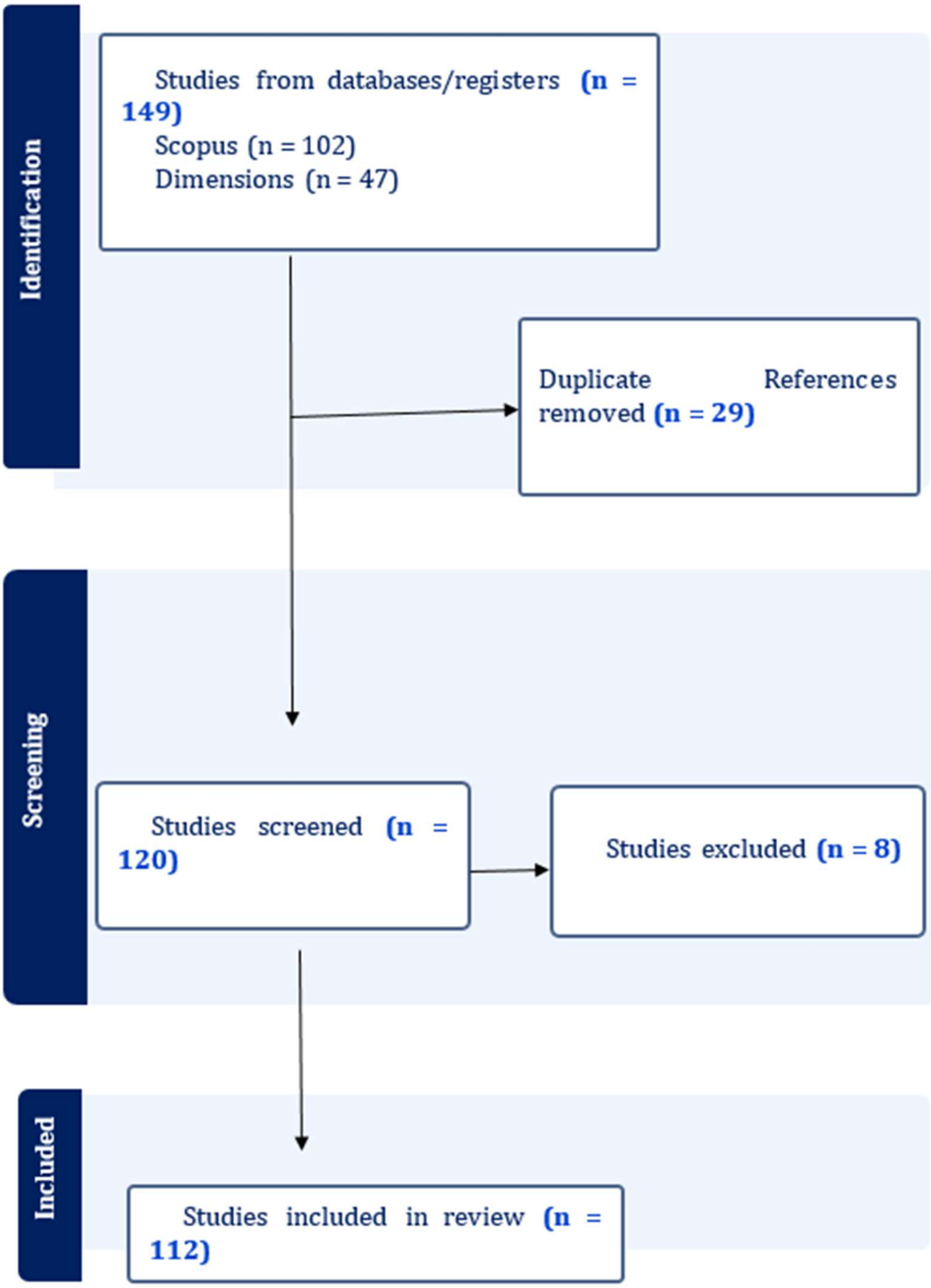

Fig. 1. Screening process

3. Results

3.1. Historical evolution

A summary of the key statistics regarding the final literature dataset is provided in table 1. Research on smart agriculture economic analysis first engaged in 1995 and has been gradually increased with a compound annual growth rate of 2,42%. The highest production was achieved in 2012, representing 46% (For confirmation) of the total publication Figure 2. The period of 2005; 2009 and 2012 had the highest average total at 123 citations per publication, peaking at 138, 33 - 80,33 - 62, 67. In comparison, the highest average TCs per year occurred in 2012 at 138,33.

3.2. Most influential journals

The final literature database consisted of 64 journals with 93 publications on economic analysis of precision agriculture. The journal Precision agriculture, Computers and electronics and Field crop research have the highest number of articles accounting for 65% of the total publications. Precision agriculture also retain their position at the top of the ranking for TCs with 138. Therefore, this is the dominant journal in this particular domain research focus area.

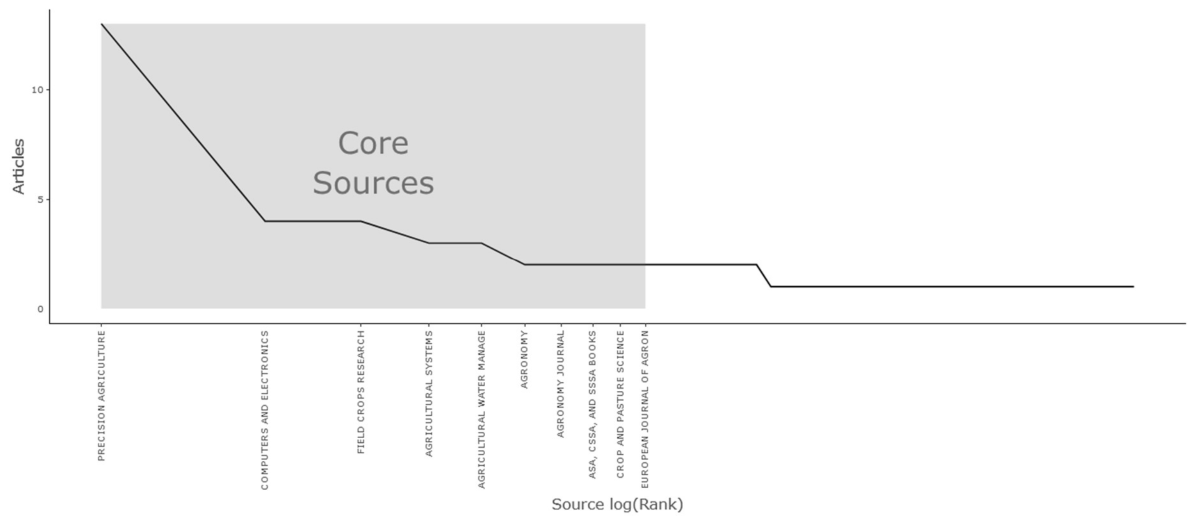

Fig. 2. Bradford’s law frequency

According to Bradford’s law, the are broadly three zones that can categorize the frequency of citations emanating from journals for particular research focus area. Zone 1 represents the most influential journals as they are cited most frequently in that subject area and likely attract the greatest interest from researchers. Zone 2 and zone 3 represent the journals with the average and least citations, respectively (Abafe, Bahta and Jordan 2022).

3.3. Analysis of publications by country

Regarding the geographic distribution of published research on the use of economic analysis of precision agriculture; 30 countries have been involved in precision agriculture economic analysis. USA (26), Australia (9), Brazil (8), Italia (7), Spain (4) and Danmark (3) are the only countries to have produced more than 2 publications on the economic analysis of precision agriculture and account for 63% of the total number of the publications. Only USA features consistently in the tops countries. Collaborations between authors have been mostly restricted to the countries in which they reside, however there are no international collaboration between authors while economic analysis is very important to be analyzed in smart agriculture domain.

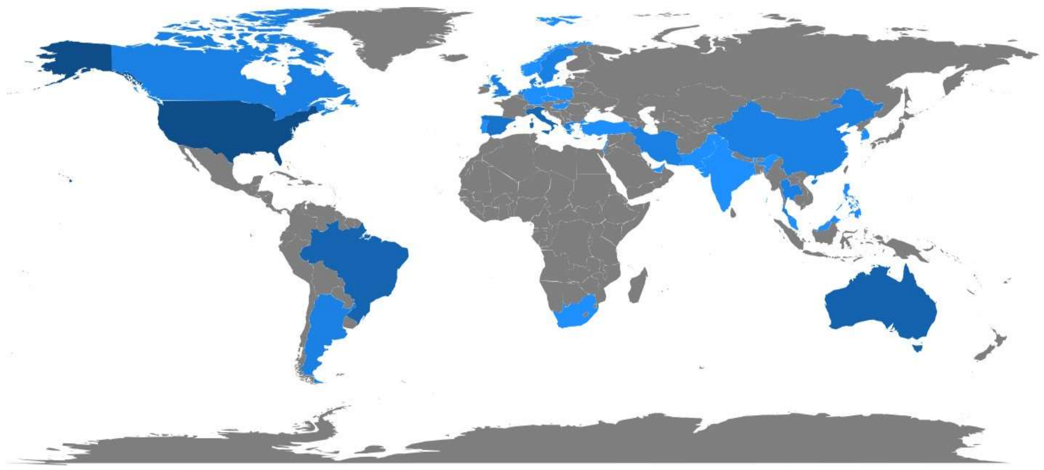

Fig. 3. Global publications and collaborations, where by the darker the shade of blue, the larger the number of publications.

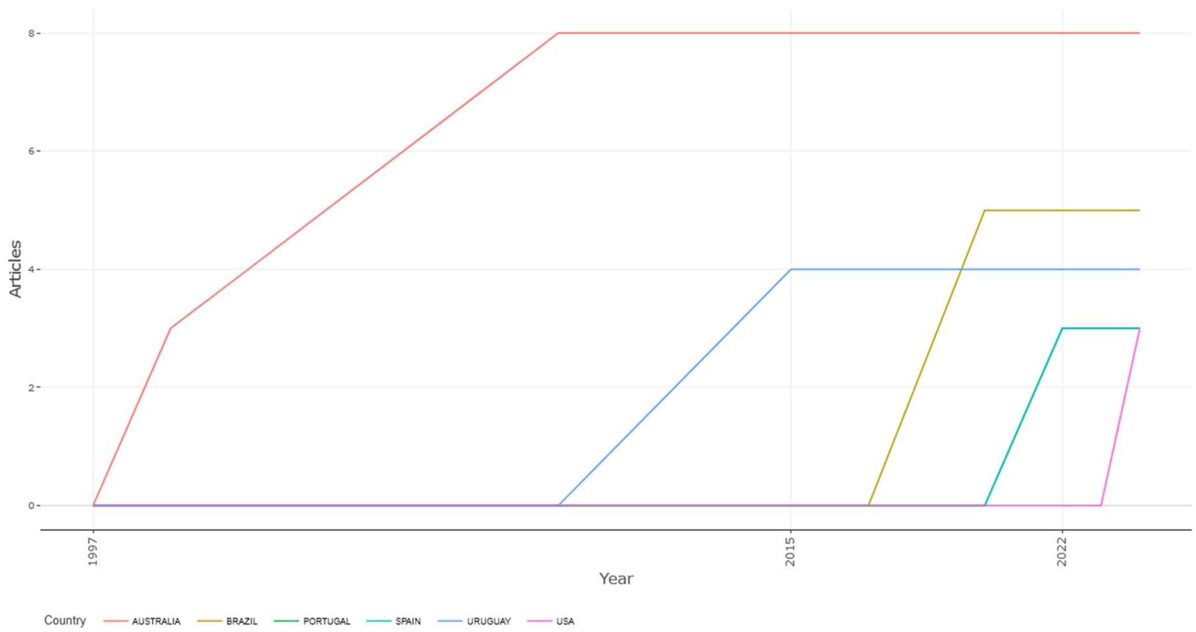

Fig. 4. Countries' productions over times

3.4. Most influential Authors and citation analysis

Some authors have been known by the citation index. The first author, Robertson has written more than four articles, second by Gandorfer, Lite and Sadler known with three articles. For two articles, some authors are known. We have Abuzar; Best; Bullock; Buschermohle; Camp and Chandra.

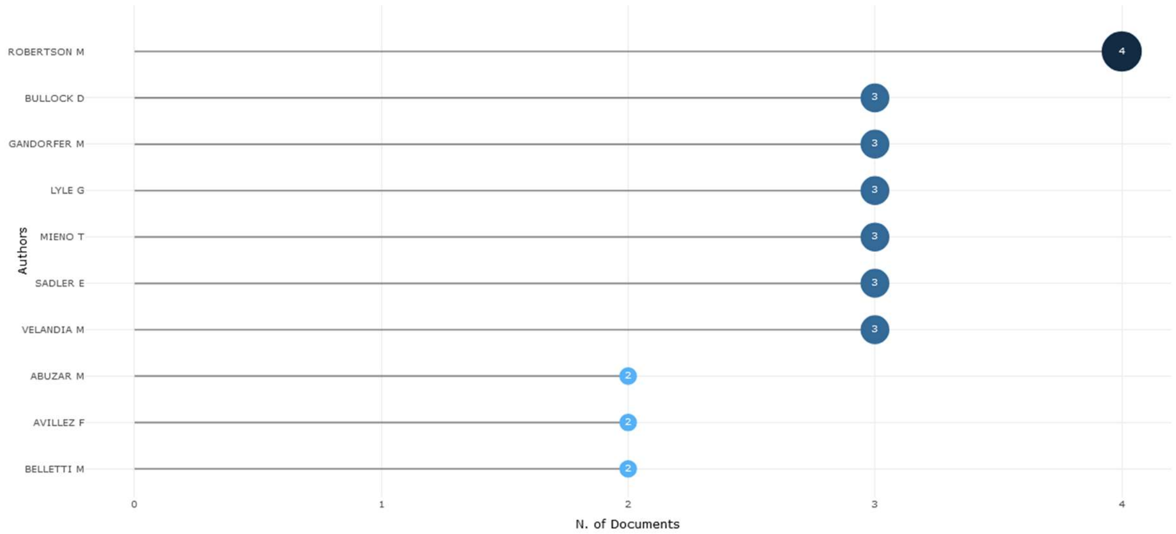

Fig. 5. Citation index

3.5. Analysis of keywords frequency, growth and co-occurrence

Perceptual cart based on two axes such as relevance degree and development degree show the following results. The first category is relative to the most important research themes which are sustainable agriculture and development; crop yields; precision agriculture; economic analysis; soils; decision support systems; land use and human procedures. The second category concerns cost benefit analysis; earnings drainage; agricultural technology; technology adoption; investment; ground vehicles and pesticides. Through these results, we are in force to thank that agricultural and development sustainability are important research theme in the literature in one hand Avolio et al. (2014); Lieder and Schroter-Schlaack (2021) and the agricultural technology' cost benefit analysis in second hand Ochiai (2023); [1].

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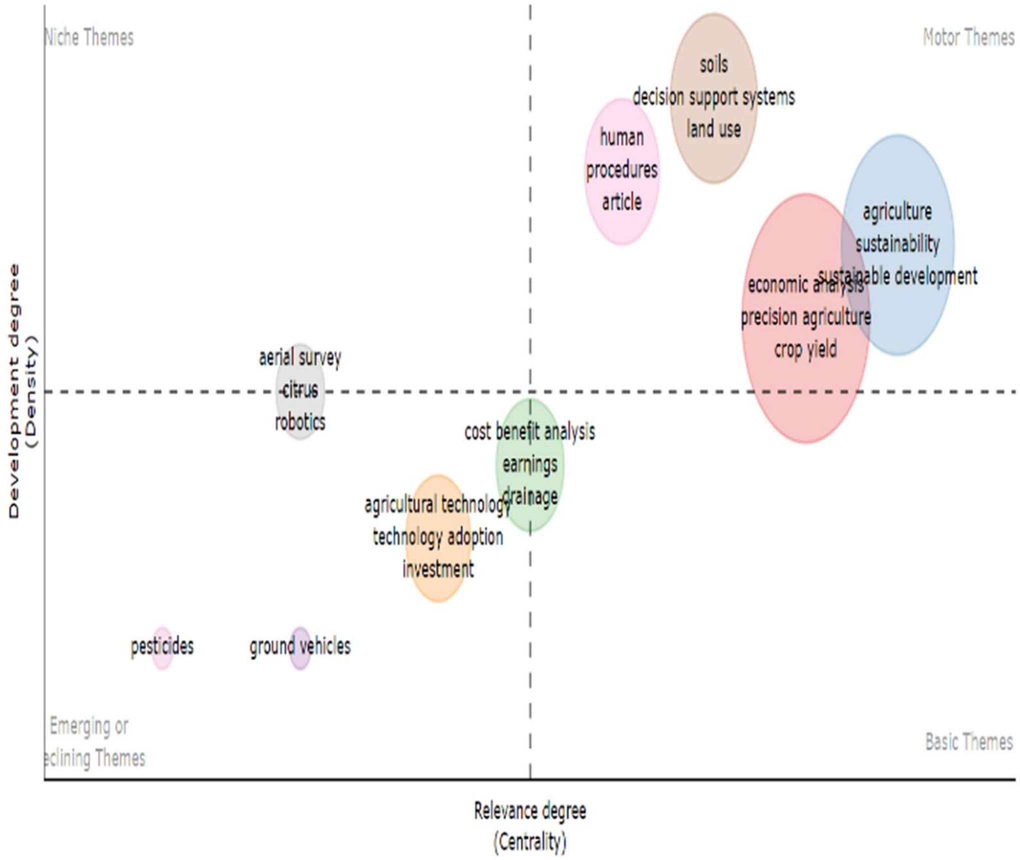

Fig. 6. Perceptual cart

Thematic map show important themes which take authors attention in this field.

Fig. 7. Thematic map

3.6. Precision agriculture economic analysis

The economic analysis of precision agriculture, supported by bibliometric research, highlights the significant potential of these technologies to increase productivity, reduce costs and efficiency gains, and improve environmental sustainability.

One of the most compelling economic reasons for adopting precision agriculture is the **reduction in input costs**. Precision Agriculture technologies enable more efficient use of resources such as water, fertilizers, pesticides, and labor, leading to cost savings. Precision agriculture can lead to **increased crop yields** by enhancing resource management and improving the ability to monitor crop health efficiency [2-4]; [8]. This is particularly important as the global demand for food is rising due to population growth. Another important economic benefit is the positive impact of precision agriculture on **environmental sustainability**, which can have indirect long-term financial benefits for farmers [5-7].

However, the adoption of PA depends on various factors, including farm size, access to capital, the region's technological infrastructure, and the ability to integrate new systems with existing practices [13].

A thorough economic analysis, based on both cost-benefit studies and ROI models, is essential for farmers to make informed decisions about investing in precision agriculture. Additionally, policy makers play a crucial role in supporting the adoption of these technologies through incentives, subsidies, and training programs.

In the coming years, the economic landscape of precision agriculture will likely continue to evolve, with more focus on affordability, scalability, and the broader economic and environmental impact of these technologies. [7-9]. As bibliometric analysis reveals, the growing body of research will further clarify how precision agriculture can be economically integrated into diverse farming systems around the world, ultimately making agriculture more efficient, sustainable, and profitable [5-7].

4. Discussions

Economic analysis of smart agriculture remained capital for sustainable agriculture [2]. Bibliometric review show that sustainability of agriculture and sustainable development are important and need smart technologies tools for agricultural efficiency [2-4] ; [5-7]. Many scientists are very preoccupied of agricultural effect on environment degradation; climate change; degradation of soil cover; destruction of natural ecosystem etc. [7-9]; [5]. For [10] increasing production of crops, livestock and aquatic products for food security must be the objective of smart agriculture which haven’t a negative impact on environment [10-12]. For productivity and yields improvement; some research focused on smart farming technology adoption [13]. Economic reasons are main reason of smart agriculture adoption [13]. For them; adoption of smart agriculture in two regions (North and south) in Germany provides economic gains for both technical (sensor’ based technology and mapping based technology) for farmers; however they don’t find the neighboring farmers adopted the technologies [13-14].

5. Conclusion

In conclusion; this bibliometric analysis illuminates the dynamic evolution of smart agriculture economics analysis. Since smart agriculture is known as important for farmland efficiency; it was become an obligation to examine his economic contribution Ochiai (2023) [1]. This bibliometric analysis sheet the light on what is known and what is to be known for scientific aspect. The economic contribution of smart agriculture is very important because smallholder struggle for their subsistence, they have little resources to face Smart Farming Technologies charges such as drone acquisition as soon as its’ utility is recognized by researchers and agrobusiness actors. As we can imagine smart agriculture need collaboration of scientists, agrobusiness men and government to overcome smart agriculture’ obstacles Ochiai [1].

Declaration on Generative AI

The author(s) have not employed any Generative AI tools.

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