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EVALUATING THE IMPACT OF DIGITALIZATION ON AGRICULTURAL PRACTICES : A REVIEW

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ABSTRACT

Digital agriculture is a strategic approach aimed at enhancing agricultural production and revenue on a worldwide scale. Determining the effects, aims, and obstacles of digitalization in the agricultural sector is a complex task, primarily attributable to the abundance of literature available in this domain. A systematic review is a valuable tool utilized to assess the impact of digitalization in the agricultural sector. In this study, we conducted an analysis of articles pertaining to the digitization of agriculture during the past decade. Our aim was to provide a comprehensive assessment that encompasses both quantitative and qualitative findings. In this study, we present an analysis of global article publishing patterns, focusing on the research contributions from a specific geographical zone. Additionally, we examine the most influential and often used keywords by the writers. A total of 42 papers were selected from the Scopus database for the purpose of conducting a systematic review in these studies. The objective of this study is to investigate the scientific output of publications, prolific researchers, most cited papers, nations' contributions, and the prevalence of author keywords. One of the primary constraints is the restricted time frame. The evaluation procedure relies on the utilization of information technology. Furthermore, this finding serves as a valuable reference for researchers doing future studies on the digitalization of agriculture in a specific area. It highlights the significance of digitalization in shaping farmers' perspectives and underscores the need to examine its influence in greater detail.

Key words : Agriculture, Systematic research, Food Production, Farmers, Digitalization.

Introduction

Agricultural technology, sometimes referred to as "smart farming," encompasses the rapidly evolving domain of digitalization within the agricultural sector, which uses cutting-edge technologies to transform traditional techniques for farming. The present review of literature examines the existing information and studies on the digitalization of agriculture, with a focus on identifying the key issues, innovations and the ways in which it contributes to agricultural sustainability, productivity, and food security in a broad sense. The process of digitalization, which refers to the use of technology in several sectors including agriculture and other businesses, is anticipated to provide substantial effects. Digitalization refers to the integration and utilization of various information communication technologies, such as the Internet, mobile technologies, and devices, along with data analytics. Its purpose is to improve the processes of creating, collecting, exchanging, aggregating, combining, analyzing, accessing, searching and presenting digital content. This includes the development of services and applications. The recent surge in attention towards the deployment of digital technologies in the agricultural sector has been noteworthy (McFadden *et al*., 2022). Digital technology adoption in agriculture has attracted a lot of interest lately. Some studies conducted that investigated the elements that impact technology adoption in agriculture, stressing the significance of infrastructure, community connections, and ready access to technology. The degree to which farmers are willing to adopt these technologies is a critical factor when determining the

outcome of automation initiatives (Qrunfleh and Tarafdar, 2014).

Precision agriculture is a fundamental idea in the digitalization of farming, wherein sensors, GPS technology, and data analytics are employed to optimize various agricultural activities. Researchers have conducted studies to investigate the benefits of precision agriculture in enhancing resource efficiency, reducing environmental impact and increasing agricultural yields (Fig. 1) (Zhang and Kovacs, 2012). The utilization of Internet of Things

Fig. 1 : Digital transformation of the agriculture.

(IoT) technology enables the remote monitoring of farm activities and facilitates the real-time collection of data. Some study exploring the potential applications of the Internet of Things (IoT) in various automated activities, such as pest management, veterinary care, and irrigation. The decision-making and efficiency of farmers experience significant enhancement as a consequence. The utilization of big data and data analytics in the agricultural sector has become increasingly prevalent due to the substantial volume of data being processed inside established farming operations (Lagerkvist and Olson, 2017). Scholars have demonstrated the ways in which these technologies assist risk assessment, modeling of predictions, and well-informed decision-making across a range of agricultural instances (O'Brien *et al.*, 2018). The promotion of sustainable practices for agriculture has been greatly aided by digitalization. Recent a study shows that explores the potential of technological advances to mitigate waste, minimize the application of pesticides and fertilizer, and encourage ecological environmentally friendly agricultural practices (Mishra *et al.*, 2017). High agricultural growth in India is necessary for the country's overall economic expansion as well as for the majority of the population to have access to employment and food security. Although, growth has been faster during the last 20 years, inclusive growth with an emphasis on agriculture has been lacking (Upadhayay, 2019).

According to the Niti Aayog (2019) India's National Artificial Intelligence (AI) Strategy also seeks to actualize the potential social and economic advantages that the technology may present. In addition, the National Strategy on AI identifies agriculture as one of the sectors where AI-driven solutions should be implemented first. Madasamy (2020) stated that in the contemporary industrial culture, AI and E-Leadership are rapidly being used as the language of innovation and intelligent technologies. India has been making progress towards its digitalization goals because of well-designed federal and provincial-level Programmes. Precision agriculture, climate-smart agriculture, supply chain management, and financial inclusion are the four main areas of Indian agriculture where digitization of agriculture can spur innovation and transformation (Indian Council of Agricultural Research, 2023).

For the study purpose, a systematic study was conducted based on the PRISMA Model. The study is taken the last 8 years 2015 to 2022 from the Scopus database. Article inclusion and exclusion criteria were carried out in the research. Exclusion of the documents is done on the basis of relevancy of the subject, field and the country.

Table 1 : Search String or Filtering criteria and selection of the relevant articles.

Filtering Criteria	Reject	Accept
Search criteria		
Search Engine / Database: Scopus Search date: 29 September 2023 Search term: "Digitalization of Agriculture"		111
Year: 2015 - 2022	2	49
Subject Area: Environmental Science, Earth and Planetary Sciences, Computer Science, Agriculture and Biological science, Economics, Econometrics and Finance, Business Management and Accounting	2	47
Document type: Conference Paper, Review Paper, Article	1	45
Country : India, Russian Federation, Germany, Italy, China	2	44
Language : English	0	42

Research questions

In order to answer the research questions (RQs), this research uses a systematic literature and review approach to determine the effect of the digitalization of agriculture on the global level.

Few questions are given below:

RQ (1). What are the current publication trends in the field of "Digitalization of agriculture"?

RQ (2). Which countries and authors given contributors to the extant literature are the most important and impactful?

RQ (3). Which Articles have the most citation in this field of research?

RQ (4). What is the frequently keyword used in this

field of study?

RQ (5). What is the scope for further research?

Co-occurrence of the Author Keyword based on review articles

The following figure represents the no. of frequency or co-occurrence of the author keyword used in their articles. This figure is generated from the Word cloud site. The total no. of the keywords is app. 148 in 42 documents. Out of this, highest frequency word is agriculture which is used 22 times in the review articles.

Article Publication trends in Digitization of agriculture

The year-wise distribution of the 49 articles from 2015 to 2022 is represented in table. Around 24% of the publications in the last eight years were published in 2022. The highest publication is in the year of 2021 that are approx. 44% of the total publication. There is no publication in the year for 2015 to 2018(Fig. 2). It indicates that agriculture industry is implementing digital technology at a rapid rate, it is still moving more slowly than other industries like healthcare, manufacturing, mining, automotive, energy, etc.

The most Influencing Articles and Country wise publication in Digitalization of Agriculture (2015 to 2022)

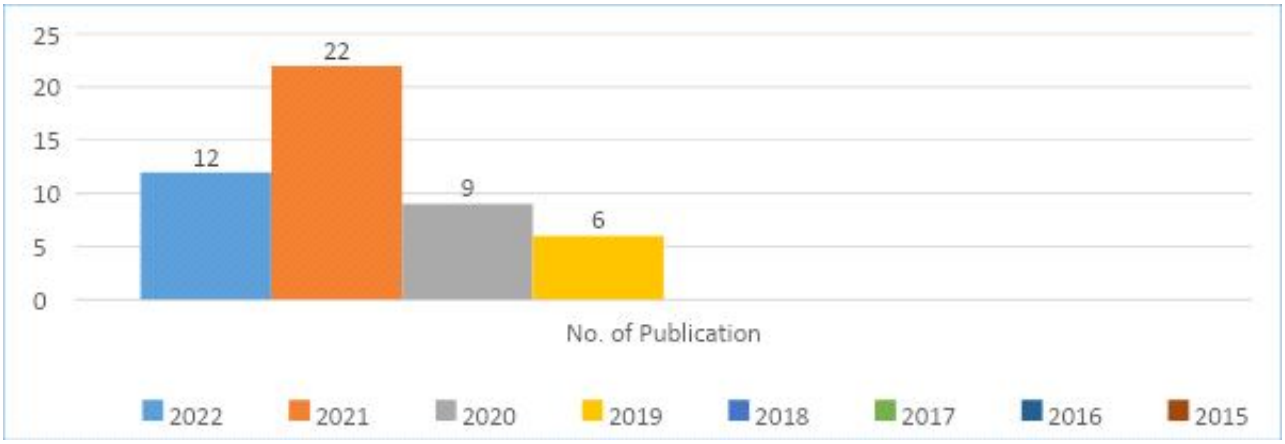

Fig. 2 : Article Publication Trends in the selected five countries.

In this section, it represents the most cited article in the field of digitalization of agriculture from 2015 to 2022. The author "Rolandi et.al (2019)" have published paper "The digitalization of agriculture and rural areas: Towards a taxonomy of the impacts", this paper has the highest citation "36" and it is belonging to "Italy" country. By the following, "Hackfort (2021) have got citation "25" of his paper title" Patterns of inequalities in digital agriculture: A systematic literature review". By the overview of the following table, it can be observed the highest no. of the publication if from the Russian Federation and the lowest publications are from India, China and Italy.

The Global Status of Digitalization in Agriculture

India ranks second in terms of agricultural performance. Farmers are primarily preoccupied with three key issues, namely crop rotation, fertilizer use, and irrigation. The primary emphasis lies in the utilization of contemporary technologies within the agricultural sector, with the objective of enhancing crop productivity. The implementation of Internet of Things (IoT) technology in the field of agriculture has significantly enhanced our capacity to accurately assess crop production and other variables that impact yield. The agricultural production system has experienced significant changes due to the use of precision agriculture technology in recent decades (V.B. *et al*., 2022). The agricultural industry in Germany exhibits a significant degree of mechanization, characterized by an upward trend in land consolidation and a persistent decrease in the total count of agricultural establishments. In 2016, the Federal Ministry for Food and Agriculture reported that around 275,400 farms were responsible for the management of 16.7 million hectares of agricultural land (Federal Ministry for Food and Agriculture). The German government provides subsidies for the digitization of agriculture through a range of financial schemes aimed at supporting research and development efforts, as well as the enhancement of digital infrastructures in rural regions (Prause, 2021).

The digital technologies most often employed in the agricultural industry in Germany include smartphone applications, which are utilized by 40% of the respondents, and GPS-enabled farm machinery, which is used by 45% of the respondents. According to the survey data, a total of 32% of the participants indicated their utilization of sensors, whilst 28% reported employing smart equipment in order to facilitate the implementation of location-

Table 2 : The Most Influencing Articles and Country wise publication in digitalization of Agriculture (2015 to 2022).

Authors	Paper Title	Year	Citation	Country
Sarker *et al.*	Big Data Driven Smart Agriculture: Pathway for Sustainable Development	2019	34	China
Hackfort *et al.*	Patterns of inequalities in digital agriculture: A systematic literature review	2021	25	Germany
Prause *et al.*	Digital agriculture and labor: A few challenges for social sustainability	2021	22	Germany
Kuntke *et al.*	Resilience in Agriculture: Communication and Energy Infrastructure Dependencies of German Farmers	2022	8	Germany
Martens and Zscheischler	The Digital Transformation of the Agricultural Value Chain: Discourses on Opportunities, Challenges and Controversial Perspectives on Governance Approaches	2022	10	Germany
Saritha *et al.*	Nanotechnology - Big impact: How nanotechnology is changing the future of agriculture?	2022	11	India
Sadu *et al.*	Digitalization of agriculture by using the application of IoT and robotics	2022	0	India
Rolandi *et al.*	The digitalization of agriculture and rural areas: Towards a taxonomy of the impacts	2021	36	Italy
Kuzmich *et al.*	The impact of digitalization of agriculture on sustainable development of rural territories	2021	7	Russian Federation
Guzueva *et al.*	The impact of automation of agriculture on the digital economy	2020	5	Russian Federation
Tokhiriyon and Poznyakovsky	New biocomplex for nutrient-metabolic support of bone tissue	2019	5	Russian Federation
Aleksandrov *et al.*	Agriculture sphere in the era of Industry 4.0: The world experience and Russian practice of the digital business model building in the agroindustry	2021	5	Russian Federation
Akmarov *et al.*	Assessing the Potential of the Digital Economy in Agriculture	2021	5	Russian Federation
Alt *et al.*	Digitalization: Problems of its development in modern agricultural production	2020	4	Russian Federation
Solodovnik *et al.*	The role of the Internet of Things as direction for the development of agriculture 4.0 for rural areas	2021	3	Russian Federation
Skvortsov	The Development of Labour Relations in the Digital Transformation of Agriculture	2020	2	Russian Federation
Sulimin *et al.*	The introduction of the digital farming concept in the agricultural sector of Russia	2020	2	Russian Federation
Kulyasov *et al.*	Precision agriculture in the Russian Federation: Problems and directions in development	2020	2	Russian Federation
Semin *et al.*	Digitalization of agriculture as priority direction of increase of management efficiency of the agricultural organizations	2020	2	Russian Federation
Sergeevna *et al.*	Digital platforms in the new world of digital agricultural business	2021	2	Russian Federation
Utrendeeva *et al.*	Legal Support of Digitalization of the Agro-Industrial Complex of Russia: Problems and Development Prospects	2021	2	Russian Federation

Table 2 continued...

Table 2 continued...

Authors	Paper Title	Year	Citation	Country
Asalkhanov *et al.*	Some Aspects of Digital Transformation of Agriculture in the Irkutsk Region	2022	1	Russian Federation
Vorobeva *et al.*	Digitalization of agriculture in Russia: A regional aspect	2021	1	Russian Federation
Karataeva *et al.*	Direction of digital transformation of agriculture in Russia	2021	1	Russian Federation
Gavrilova	Impediments to the digitalization of agriculture in Africa	2022	1	Russian Federation
Korchevskaya and Makhmudov	Effictive technologies for automation and robotization of the agro-industrial complex	2021	1	Russian Federation
Starykh *et al.*	Regional aspect of digitalization of the agricultural sector in modern conditions	2022	1	Russian Federation
Orishev *et al.*	Promising intelligent technologies for agricultural development	2021	0	Russian Federation
Vorobyov *et al.*	Digitalization of the system of state and corporate strategic planning in the development of agro-food markets in Russia	2021	0	Russian Federation
Sazonov and Sazonova	Development of a model of a universal technological platform for digitalization in the agro-food complex	2022	0	Russian Federation
Andreev and Makarova	Implementation of digital technologies in agriculture on the example of the Republic of Sakha (Yakutia)	2021	0	Russian Federation
Kopteva and Romanova	Digitalization as a condition for developing agriculture and ensuring food security of the country	2019	0	Russian Federation
Al-Gunaid *et al.*	The System of Intelligent Identification of Harmful Objects in the Field of Agriculture	2021	0	Russian Federation
Alt *et al.*	Problems and tasks of using digital technologies in agriculture	2021	0	Russian Federation
Akmarov *et al.*	About the Role of Digitalization of Agriculture in Reducing the Impact of Climate on the Technological Development of Crop Production	2022	0	Russian Federation
Vorobyova *et al.*	Demand for digital technologies by agricultural producers of the Altai Territory	2021	0	Russian Federation
Daroshka *et al.*	Technological landscape of the Russian agroindustry: How to make right digital infrastructure?	2021	0	Russian Federation
Lyubanova *et al.*	Existentialism of Engineering Marketing and Technological Entrepreneurship in Large Agricultural Enterprises	2021	0	Russian Federation
Trukhachev *et al.*	Personnel training for the agricultural sector in terms of digital transformation of the economy: Trends, prospects and limitations	2019	19	Russian Federation
Stepanova	Innovative development of the export oriented regional agro-industrial cluster	2020	11	Russian Federation
Kulyasov *et al.*	Management of digital technologies development in agriculture of the Russian Federation	2020	8	Russian Federation
Erunova *et al.*	Geospatial database for digitalization of agriculture of the Krasnoyarsk territory	2019	8	Russian Federation

specific treatments for pesticides and fertilizers. Drones and robots were utilized by 12% and 11% of the surveyed population, respectively. According to Rohleder *et al*. (2020), there was a prevalent use of digital solutions for farm management. Approximately half of the participants reported utilizing digital field management systems and digital communication tools. In the context of Italy, a variety of digital technologies, such as sensors, blockchain, and artificial intelligence (AI) were given careful study, including a diverse array of applications. The primary domains and regions of digitalization were identified and elucidated, along with their corresponding outcomes. The utilization of the grid and the suggested taxonomy may facilitate the process of reflecting upon potential results and contribute to the formulation of appropriate remedies, including behaviors or policies aimed at addressing the associated ramifications (Rolandi *et al*., 2021).

The process of digitalization has the potential to improve crop yields, increase farmers' revenues and boost the production of superior and safer food, all while reducing farming expenditures and minimizing the environmental effect of agricultural practices. There exists a possibility, however, that specific farmers will exclusively reap the advantages of these breakthroughs (in high-income nations as opposed to low-income nations, for instance). There is a likelihood that agricultural operations will increasingly rely on technologically advanced enterprises that provide digital tools and services. Additionally, there is a possibility for food production to progressively prioritize algorithms that reduce human intervention. The provided taxonomy seeks to mitigate the unforeseen implications of digitalization by facilitating the anticipation of adverse outcomes (Rolandi *et al*., 2021). The implementation of big data in China has led to a growing necessity for the use of smart agriculture practices. Individuals are unable to make development if they want to disregard this reality. The subject matter under consideration involves the challenges pertaining to both food safety and security, compounded by the substantial pressures exerted by population growth. The agricultural sector, in its nascent stage, encounters several obstacles including concerns around data privacy, data quality, data availability, initial investment requirements, infrastructural limitations, and specialized knowledge requirements. The utilization of big data has the potential to bring about a significant transformation in agricultural methods within a limited timeframe, despite the agriculture sector's current lack of capacity to adequately address its requirements (Sarker *et al*., 2019).

Irrespective of a country's level of development, the implementation of big data technologies requires meticulous planning and the integration of all available smart devices in the market. The achievement of success necessitates a degree of ambition at the governmental level. The study conducted by Sarker *et al*. (2019) presents a comprehensive seven-stage model that elucidates the data source, the nature of the data, the resulting outcomes, and the utilization of knowledge in effectively leveraging big data technology for the purpose of promoting environmentally sustainable practices in agriculture.

The majority of the literature research conducted in this study has been carried out within the Russian Federation. According to several scholarly sources, precision farming is a comprehensive manufacturing process that leverages advancements in information technology (IT) to automate and computerize various aspects of farming management. This includes the automated control and regulation of agricultural machinery and equipment, with the aim of optimizing agricultural techniques and enhancing the productivity of plants and animals (Chen and Kim, 2002; Kise *et al*., 2005; Redmond *et al*., 2018; Vorobeva, 2021).

Conclusion

Agrarian policies, however, need to actively support social sustainability. It can be difficult to ensure fair and equitable working conditions because labour is expensive and farmers are under intense pressure from supermarkets and wholesalers to reduce costs and improve quality. Therefore, we require fresh policy ideas that permit "decent work" in agriculture as an alternative to merely automating and replacing physical labour.

Agriculture's digitalization has become an influential trend that is changing the world economic growth, especially when it comes to countries like Germany, Italy, China, Russia, and India. The different implications of digitalization on agriculture—such as higher productivity, a more effective use of resources, and acceptance of sustainable practices—have been highlighted in this research study. Digital technology has several advantages, but it also has drawbacks, notably unequal access to technology and worries about data security.

By giving farmers the opportunity to utilize markets, real-time information and precision agricultural practices, digitization has the possibility to entirely reshape the agricultural industry in India. Smart farming technologies are essential for China for tackling issues related to food security and increase the yield and quality of crop products. Russia may use electronic records to improve resource management, data-driven decision-making and

monitoring in its large and regularly isolated agricultural hinterlands. Digital technologies can be applied to enhance productivity and mitigate the negative impacts by Germany and Italy, which are both recognized for their precision agriculture methods.

The advent of the digital revolution carries substantial implications on a global scale. These nations are positioning themselves as leaders in the global agricultural sector by making further advancements in their digitization efforts. However, the management of the digital divide poses issues, particularly in rural areas, as well as the preservation of data security and privacy, and the guarantee of equitable access to digital resources. This study also proposes potential areas for further research, including the assessment of the influence of digitalization, rural connectivity, data privacy and security in the agriculture industry, the state of sustainable agriculture in relation to resilience and climate change, and other relevant topics.

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