
THE ROLE OF DIGITAL TECHNOLOGY IN THE TRANSFORMATION OF AGRICULTURE TOWARD SMART FARMING

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ABSTRACT

Agriculture is one of the important sectors in the Indonesian economy. However, the agricultural sector also faces various challenges, such as climate change, limited land, and high production costs. One solution to overcome these challenges is to utilize digital technology. The transformation of agriculture towards smart farming is one effort to utilize digital technology in agriculture. The aim of this research is to analyze the role of digital technology in the transformation of agriculture towards smart farming. This study used qualitative research methods. The data collection technique in this research is a literature study with publication period criteria in the last 10 years, namely 2014-2024. The data obtained was then analyzed in three stages, namely data reduction, data presentation and drawing conclusions. Research results from 15 pieces of literature show that digital technology plays an important role in the transformation of agriculture towards smart farming. Digital technology can increase agricultural productivity, agricultural operational efficiency and the competitiveness of agricultural products. Digital technology can increase agricultural productivity by increasing the efficiency of agricultural inputs and increasing agricultural productivity. Meanwhile, the company's operational efficiency is through increasing the effectiveness of communication and supply chain management. Meanwhile, product competitiveness is carried out by improving product quality and increasing product added value.

Keywords: Digital Technology, Agricultural Transformation, Smart Farming.

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INTRODUCTION

The agricultural sector is vital to the national economy because it contributes a large part to the country's Gross Domestic Product (GDP), is the primary source of export income, and provides employment opportunities for millions of people (Rótolo et al., 2022). Named the backbone of the economy, the agricultural sector is the main focus for the country in developing and prioritizing agriculture and the food security of the population, especially in a social context, as a crucial element in human development (Bukhtiarova et al., 2019). Even though the agricultural sector has a crucial role in providing food and creating jobs, it is not free from various challenges that need to be faced (Kazekami, 2024). Factors such as climate change, limited land, and high production costs are the main obstacles that need to be overcome (Sitti Arwati, 2018); one solution to overcome these challenges is to utilize digital technology as a potential solution to overcome these challenges.

Agricultural digital technology refers to implementing information and communication technology through devices, networks, services, and applications to assist actors in the agricultural sector in decision-making and resource management (Abiri et al., 2023). According to reports from MercyCorps and Rabobank, 55 agricultural digital technologies are currently present in Indonesia,

and most of them are still in the early stages of development (seed or early ventures). McKinsey data projects that adopting modern technology in the agricultural sector could contribute an additional US\$ 6.6 billion per year to economic output. For example, agricultural digital technology such as TaniHub, which facilitates direct connections between farmers and consumers, can reduce supply chain complexity and help farmers reduce their dependence on intermediaries. Traditionally, farmers often sell their agricultural products in large quantities to intermediaries, so they have limited bargaining power to determine producer prices (Setiawan, 2021).

Utilizing digital technology in agriculture is one of the efforts toward intelligent farming. Smart Farming is an agricultural system that aims to increase efficiency and productivity in agricultural activities (Alwis et al., 2022). This concept mainly arises from applying digital technology, agricultural mechanization, and digital-based marketing systems. Smart Farming is not just about utilizing advanced technology but also integrating this approach with various aspects of agriculture (Osrof et al., 2023). The main focus of this concept is to achieve high effectiveness in agricultural production results. So, by utilizing technology such as automatic rice planting equipment, modern land processing equipment, and integrated rice harvesting equipment, agricultural production can be optimized optimally in a shorter time (Azma, 2023).

Previous research (Rachmawati, 2020) shows that the main agenda for smart Farming 4.0 is digital transformation in the agricultural sector and the development and use of digital technology in the agricultural sector. To this end, the government must design a strategy for developing national digital infrastructure, attracting foreign investment, increasing human resources, and building an innovation ecosystem. Designing incentives for technology investment and harmonization of regulations is needed.

Other research (Simarmata, 2019) shows that the adoption of smart farming and the involvement of young people in becoming millennial farmers are the keys to the success of Indonesian agriculture in the future. By utilizing information technology, the millennial/digital farmer generation can easily access various technologies and innovations to (1) increase productivity, add value, and increase the competitiveness of Indonesian agricultural products and (2) utilize national, regional, and international markets.

The novelty of this research is that it examines the impact of adopting digital technology in agriculture on society's social and economic life. Apart from that, identifying the benefits and challenges in implementing smart farming from a social and economic perspective. This research can help develop new theories related to intelligent farming concepts and applications, enriching scientific literature. This research aims to analyze the role of digital technology in transforming agriculture towards intelligent farming.

METHOD

This study used qualitative research methods. Qualitative research methods are research approaches that aim to understand phenomena or events in depth, complex and contextual. Qualitative research focuses on the interpretation of meaning, social construction, and the context in which the phenomenon occurs (Kusumastuti & Khoiron, 2019). The data collection technique in this research is literature study. Data collection techniques were carried out through searching and utilizing literature sources related to the role of digital technology in agricultural transformation.

Literature sources include books, journal articles, technical documents, and other relevant sources of information. The data criteria used in this research are data sourced from trusted sources with a publication period of the last 10 years, namely 2014-2024. The data obtained was then analyzed in three stages, namely data reduction, data presentation and drawing conclusions. This research procedure begins with creating a problem formulation, then exploring journals and other information relevant to the research, the data that has been collected is then analyzed using predetermined criteria to obtain 15 journals used in this research, after that the manuscript is prepared and conclusions are drawn.

RESULTS AND DISCUSSION

Along with advances in internet-based digital technology, the agricultural sector faces significant challenges. The world has entered the era of Industrial Revolution 4.0, which is supported by five leading technologies, including the Internet of Things (IoT), artificial intelligence, human-machine interface in driverless vehicles, robotics technology (intelligent robotics), and 3D printing technology. As a sector with a crucial role in ensuring food availability, the agricultural sector must adapt and optimize internet-based digital technology. The future of agriculture is no longer conventional. On the contrary, internet-based technology will play an essential role in monitoring crop conditions, soil, weather, and even using tractors that can be operated via smartphone (Lesmana, 2023).

Agricultural technology aims to increase labor efficiency, increase land productivity, and reduce production costs. The application of tools and machines in the production process aims to increase efficiency, effectiveness, productivity, and quality of results and reduce farmers' workload. Agricultural technology can be defined as the introduction and utilization of various mechanical aids used in carrying out agricultural operations (Rusydi & Rusli, 2022).

Digital technology opens up opportunities to increase agricultural productivity through various strategies; one significant way is by increasing the efficiency of using agricultural inputs. By utilizing digital technology, farmers can be more focused on managing fertilizers, pesticides, and water so they can optimize resource use and reduce waste. Apart from that, digital technology also plays a vital role in increasing overall plant productivity. Farmers can use appropriate cultivation technology, such as precision irrigation systems, fertilization, and more accurate pest and disease control. This technology allows farmers to provide optimal environmental conditions for plants, optimize growth, and significantly increase crop yields (Siregar, 2023). Thus, digital technology helps in efficient resource management and contributes to increasing crop productivity in the agricultural sector.

Digital technology also has a crucial role in increasing the efficiency of agricultural operations in several ways, one significant aspect of which is increasing communication effectiveness. The use of digital technology by farmers can enable them to communicate more efficiently with various parties, including suppliers, buyers, and government agencies. This smoother and faster communication allows for the exchange of more accurate and timely information, helping farmers make better decisions and respond to changing conditions more quickly (Putri et al., 2023). Apart from that, digital technology also plays a role in increasing the efficiency of supply chain management. Farmers can utilize this technology to manage supply chains more efficiently, reduce

risks, and reduce production costs (Tutuhatunewa et al., 2015). Therefore, by monitoring and optimizing all processes in the supply chain, from production to distribution, farmers can increase their profits and achieve more efficient results. Thus, digital technology improves communication and optimizes supply chain management in the agricultural context.

Digital technology can also significantly contribute to increasing the competitiveness of agricultural products by improving product quality. Farmers can improve the quality of agricultural products by using appropriate cultivation technology, such as harvesting systems carried out at optimal times and effective post-harvest technology (Molenaar, 2020). In this way, agricultural products can meet higher quality standards, increase market attractiveness, and compete effectively locally and internationally. Digital technology also plays a role in increasing the added value of agricultural products. Farmers can use this technology to develop processed products with high added value. Using technology in the processing process and adding value to agricultural products can create various products with unique characteristics, expand markets, and increase product competitiveness in an increasingly competitive market (Nurjati, 2021).

Adopting digital technology in the agricultural sector broadly impacts society's social and economic lives. From a social perspective, the use of digital technology changes how society interacts with the agricultural sector. Easier access to agricultural information through digital platforms expands people's knowledge of modern agriculture practices. This increases public awareness about agricultural innovation and supports their involvement in agricultural activities, both as consumers and in supporting local farmers.

In the economic aspect, adopting digital technology has had a positive impact, especially in increasing agricultural productivity (Cesco et al., 2023). Applying intelligent sensors, data analysis, and automation devices allows farmers to increase operational efficiency and optimize crop yields. Farmers' income and the local economy can increase with this increase in productivity. In addition, new business opportunities in the digital agricultural ecosystem, such as developing agricultural applications, providing technology-based consulting services, and agricultural e-commerce, can provide additional economic benefits for society (Siringo-Ringo, 2023).

The application of digital technology in intelligent farming brings several significant benefits but also faces several challenges that need to be overcome to ensure that these benefits can be felt evenly and sustainably in society and the agricultural economy, including the following:

Benefits of Implementing Digital Technology in Smart Farming:

Social Perspective

1) Education and Awareness

Applying digital technology in intelligent farming can increase public education and awareness of modern agricultural practices. More accessible information can provide a better understanding of agricultural innovation.

2) Society Participation

Digital technology enables active community participation in agricultural activities. Through online platforms, people can be involved in various aspects, including supporting local farmers or making decisions related to agriculture.

Economic Perspective

1) Increased Productivity

Digital technology can increase agricultural productivity through process automation, crop monitoring, and data analysis. This can result in higher agricultural yields and increase farmer income.

2) New Business Opportunities

The application of digital technology creates new business opportunities in the agricultural sector, such as agricultural application development, technology-based consulting services, and agricultural e-commerce. This can open new jobs and increase the sustainability of the local economy.

Challenges of Implementing Digital Technology in Smart Farming:

Social Perspective

1) Technology Gap

The main challenge is the community's gap in access and understanding of technology. Some groups in society may experience difficulties in adopting digital technologies, which can increase inequality.

2) Changes in Workforce Structure

Increased automation and mechanization can impact traditional workforce structures. Some traditional agricultural jobs may be displaced, so efforts are needed to support workforce transition.

However, it needs to be acknowledged that adopting digital technology can also have impacts that need to be considered. Increased mechanization and automation may impact the structure of the workforce, with some traditional jobs being replaced by technology. Therefore, it is essential to design policies that support workforce transition, empower communities to access digital technologies, and ensure that this adoption contributes to social inclusiveness and economic empowerment of communities.

CONCLUSION

The role of digital technology is very significant in changing the face of agriculture towards the concept of smart farming. This transformation brings positive changes by increasing productivity and operational efficiency in the agricultural sector, as well as strengthening the competitiveness of agricultural products. Increasing agricultural productivity is achieved using digital technology to increase the efficiency of agricultural input use and overall production results. The operational efficiency of agricultural companies is also improved through improved communication and supply chain management by utilizing digital technology. Apart from that, increasing the competitiveness of agricultural products occurs by focusing on improving product quality and adding added value to these products using technology. Thus, the implementation of digital technology not only has an impact as innovation at the agricultural level, but also supports crucial aspects such as productivity, efficiency, and competitiveness in the agricultural industry as a whole. This reflects a shift towards smarter, modern, and sustainable agriculture.

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