

## LATEST TECHNOLOGY PARADIGM: MODERN AGRICULTURAL TECHNOLOGY FOR MILLENNIAL FARMERS

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### **Abstract**

This study explores the role of millennial farmers in driving the transformation of the agricultural sector through the adoption of modern technologies. In the context of agriculture that increasingly requires efficiency and sustainability, millennials, with better access and digital skills, show a higher tendency to integrate advanced technologies into their agricultural practices. This study examines how technologies such as precision agriculture, automation, and digital platforms are used by millennial farmers to increase productivity and manage natural resources sustainably. This study also identifies key factors influencing the adoption of agricultural technologies, including economic, social, technical, and environmental aspects. In addition, the role of government policies and support from various parties, such as the private sector, educational institutions, and non-governmental organizations, are analyzed as important catalysts in accelerating technological transformation in this sector. The results of the study indicate that although modern technologies have great potential to improve agricultural efficiency and sustainability, their successful adoption is highly dependent on adequate policy support.

**Keywords:** Paradigm, modern agricultural technology, millennial farmers

### **INTRODUCTION**

Agriculture as the backbone of human life has undergone significant changes along with technological advances. In the midst of this transformation, the millennial generation of farmers has emerged as an agent of change that

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brings a spirit of innovation to the world of agriculture. The use of technology by millennial farmers not only reflects adaptation to global trends but also creates a new paradigm in managing resources and meeting increasingly complex market demands. According to Hasan et al., (2022) the millennial generation of farmers, born between 1981 and 1996, grew up in an era where information and communication technology experienced a rapid surge. The digital skills possessed by millennial farmers play an important role in responding to the challenges of modern agriculture. Therefore, an understanding of the use of technology by millennial farmers is essential in designing policies, developing strategies, and increasing the capacity of farmers to face ever-evolving challenges. In this introduction, the background of technological change in the agricultural sector, the role of millennial farmers as the main drivers of technology utilization, and the relevance of this research in the context of sustainability and food security will be outlined. With a deeper understanding of how technology is used by millennial farmers, it is hoped that agriculture can become more efficient, productive, and sustainable, creating a solid foundation for an innovative and adaptive agricultural future.

According to Brenny, K., & Yelich Biniiecki, S. M. (2024) modern technology used in agriculture makes it easier for farmers to cultivate so that farming activities run more efficiently. In addition, this technology is one of the attractions for millennial farmers to want to enter the world of agriculture. Agricultural technology is a tool, method or method used in processing or processing agricultural inputs so as to produce output or agricultural products that are useful and effective, either in the form of raw materials, semi-finished or ready-to-use. As an agricultural country, Indonesian farmers are certainly familiar with agricultural tools like other agricultural countries, both traditional and modern.

In general, Surgawati et al., (2024) stated that modern agricultural tools are divided into four categories. First, agricultural tools used in producing seeds or seedlings. Second, agricultural tools used to plant seeds or seedlings and the cultivation process. Third, agricultural tools used when harvesting and processing results. Fourth, information technology that can be utilized to market agricultural products in groups or together with other farmers, to be more cost-effective and obtain market certainty. In recent decades, technology has experienced rapid development in various sectors, including agriculture. Agriculture, which was previously known as a traditional sector, is now undergoing a major transformation with the presence of modern technology. This technology includes the use of sensors, drones, smart irrigation systems,

to internet-based applications that allow farmers to monitor and manage their land more efficiently. This transformation is often referred to as agriculture 4.0 or smart agriculture (Kurniawati, 2024).

In the midst of this development, according to Kremen et al., (2012) the millennial generation, known as a generation that is very familiar with digital technology, is starting to show significant interest in the agricultural sector. This generation brings a new approach to agriculture, by utilizing technology to increase productivity, efficiency, and sustainability. However, the adoption of modern agricultural technology by millennial farmers is not without challenges. Some of these include limited access to advanced technology, lack of proper training, and challenges in integrating new technology with traditional agricultural practices. On the other hand, there is great potential for millennial farmers to become agents of change in facing global challenges, such as climate change and the need for food security (Canwat, V., & Onakuse, 2022).

According to Mathur, S., & Tandon, N. (2016) the latest technological paradigm in modern agriculture for millennial farmers is a very relevant topic in the context of the development of the agricultural sector in Indonesia. In recent years, the agricultural sector has faced major challenges, especially in terms of farmer regeneration. Many farmers are over 54 years old, while the younger generation tends to be reluctant to enter the world of agriculture because of the perception that this job is not promising. Therefore, it is important to attract the attention of millennial farmers by utilizing modern technology. Modern agricultural technology offers attractive solutions for millennial farmers. With the application of advanced technology, such as Smart Farming 4.0, farmers can increase the efficiency and productivity of their farming businesses. This technology not only simplifies the cultivation process but also provides opportunities for farmers to develop more profitable agricultural businesses. For example, the use of modern agricultural tools such as jarwo transplanters and harvesters can significantly increase crop yields (Dayıoğlu, M. A., & Turker, 2021).

The importance of involving the younger generation in the agricultural sector cannot be ignored. Millennial farmers have the potential to contribute to improving the welfare of society and the economy through innovation and creativity. With a better educational background and understanding of technology, they can bring positive changes in the way they farm and market agricultural products. This study aims to explore how modern agricultural technology is adopted by millennial farmers, what factors influence the adoption of this technology, and its impact on agricultural productivity and

sustainability. In addition, this study will also review how government policies and support from various parties can accelerate technological transformation in the agricultural sector, so that it can empower millennial farmers to become key players in future agriculture.

## **RESEARCH METHOD**

This study uses a descriptive method by collecting data from various reliable sources, including literature studies and recent publications. A descriptive approach is used to describe the paradigm of modern agricultural technology for millennial farmers. The first stage in this research method is collecting literature relevant to the research topic. A literature search is conducted through academic databases, scientific journals, and related publications that discuss the paradigm of modern agricultural technology for millennial farmers. The selected literature must be of good quality and relevant to the research objectives. After collecting the literature, an analysis and synthesis of the information found is carried out. Relevant data and information on modern agricultural technology adopted by millennial farmers, factors influencing the adoption of modern agricultural technology, the impact of modern technology on agricultural productivity and sustainability, government policies and support from various parties can accelerate technological transformation in the agricultural sector related to the research topic.

## **RESULT AND DISCUSSION**

### **Modern Agricultural Technology Adopted By Millennial Farmers**

The millennial generation, born in the digital era and highly skilled in using technology, has begun to enter the agricultural sector by bringing a new approach that integrates modern technology. Millennial farmers in Indonesia are increasingly adopting modern agricultural technology in response to the challenges faced by the agricultural sector. With a better educational background and a deeper understanding of technology, this generation is able to utilize innovation to increase the efficiency and productivity of their farming businesses. Technologies such as Smart Farming 4.0, which includes the use of sophisticated tools and systems, are a special attraction for young farmers to enter the world of agriculture (Candranegara et al., 2022).

According to Junaidi, J. (2024) millennial farmers tend to use the internet and social media to access the latest information on agricultural technology. They use online platforms, such as YouTube, agricultural forums, and agricultural applications, to learn best practices, technological innovations, and

market trends. Training and workshops are also important means for them to develop the technical skills needed to operate modern agricultural technology. Millennial farmers tend to be more open to the use of technological tools and devices such as drones for land mapping, soil and weather sensors, and automatic irrigation systems. They are also adopting technologies such as IoT (Internet of Things) to collect real-time data that helps in making more informed decisions regarding land management, fertilization, and irrigation. Modern technologies, such as the Internet of Things (IoT) and drones, allow farmers to monitor land and crop conditions in real-time (Sharma, R., & Singh, 2015). With better access to data, farmers can make more informed decisions regarding irrigation, fertilization, and pest control. For example, the use of drones for land mapping and crop health monitoring has become a common practice among millennial farmers, helping them manage their land more effectively. The Indonesian government has also played a significant role in encouraging the adoption of these technologies through various training and extension programs. The Ministry of Agriculture has launched various initiatives to improve technology literacy among farmers, including training on the use of modern tools and agricultural applications. In addition, agricultural cooperatives serve as a bridge between farmers and markets, providing millennial farmers with access to the necessary seeds and fertilizers and helping them market their crops. Despite the many opportunities, technology adoption also faces challenges, such as high initial costs and lack of access to adequate infrastructure. However, with support from the private sector and government, millennial farmers can overcome these obstacles and leverage technology to improve their agricultural yields (Kusnandar et al., 2023).

According to Eko, B. (2022) modern agricultural technology enables the implementation of precision farming, where farmers can manage land more effectively by utilizing data obtained from technologies such as GPS and sensors. Millennial farmers use this data to optimize the use of inputs such as water, fertilizers, and pesticides, thereby increasing efficiency and reducing environmental impact. Millennial farmers often use digital applications and platforms to monitor and manage their farming activities. These applications can include farm management systems, data analysis, and digital trading platforms that allow them to sell their crops directly to consumers or markets more easily and efficiently. Millennial farmers are also active in building networks and collaborations with research institutions, governments, and technology companies to access the latest technology and the support needed.

They are also often involved in farmer communities that focus on technological innovation to share knowledge and experiences. Millennial farmers tend to be more concerned about sustainability issues and innovation in agriculture. They are looking for ways to minimize environmental impacts through the adoption of technologies that support sustainable agriculture, such as renewable energy, waste processing technology, and organic farming methods (Griffin et al., 2020). Overall, the adoption of modern agricultural technology by millennial farmers not only increases productivity but also makes agriculture a more attractive and promising profession. By utilizing technology, the younger generation can contribute to food security and the national economy, while creating innovation in the agricultural sector.

### **Factors Influencing the Adoption of Modern Agricultural Technology**

The adoption of modern agricultural technology by farmers, especially millennial farmers, is influenced by various interrelated factors. The following are some of the main factors that influence this adoption process according to Akudugu et al., (2012):

#### **1. Economic Factors**

One of the main barriers to technology adoption is the high initial cost of purchasing and implementing new technology. Many modern agricultural technologies, such as drones, sensors, or automated irrigation systems, require significant initial investment. Farmers are more likely to adopt technology if they see the potential for long-term economic benefits, such as increased yields, reduced operational costs, and better market access. The availability of credit or loans specifically for agricultural technology can greatly influence adoption. Banks and financial institutions that provide low-interest loans or subsidies for the purchase of technology can facilitate adoption by farmers.

#### **2. Social and Demographic Factors**

Younger and more educated farmers tend to be more open to new technologies. They are more likely to explore and implement technological innovations compared to older farmers. Technology adoption is often influenced by the success achieved by other farmers in their community. If other farmers successfully implement new technology and increase productivity, this can encourage other farmers to follow suit.

#### **3. Technical Factors**

Technologies that are easy to understand and use are more likely to be adopted. If the technology is too complicated or requires special skills,

farmers may be reluctant to use it. Technologies that are easy to integrate with existing farming practices are more likely to be accepted. If new technologies require major changes in the way farming is done, adoption may be more difficult.

4. Environmental and Policy Factors

Policy support, such as subsidies, training, and fiscal incentives, can greatly influence technology adoption. Governments that actively promote modern agriculture by providing direct assistance to farmers will encourage faster adoption. Adoption of modern agricultural technologies often depends on basic infrastructure such as electricity, internet, and transportation. In less developed rural areas, limited infrastructure can be a significant barrier.

5. Cultural Factors

In many farming communities, traditional practices have been in place for many years, and there is a tendency to maintain old ways. These cultural and cultural factors can hold back the adoption of new technologies. Farmers may view adopting new technologies as risky, especially if the technology has not been proven in their environment. Uncertainty about the results and potential for failure can make farmers hesitant to adopt the technology.

6. Information and Education Factors

Farmers who have access to information about new technologies, including benefits, how to use them, and case studies of success, are more likely to adopt them. Training programs provided by governments, NGOs, or technology companies can help farmers understand and master new technologies. Effective training gives farmers the confidence to adopt and maximize the technology.

7. Market Factors

Changing market needs, such as demand for organic products or higher quality agricultural produce, can encourage farmers to adopt technologies that enable them to meet these standards. Technologies that make it easier for farmers to access markets, such as digital trading platforms, can encourage adoption. If farmers can sell their products more easily and get better prices, they are more likely to invest in the technology.

By understanding and addressing these factors, the adoption of modern agricultural technologies can be accelerated, which in turn can improve the productivity, efficiency, and sustainability of the agricultural sector.

## **The Impact of Modern Technology on Agricultural Productivity and Sustainability**

According to Abiri et al., (2023) the application of modern technology in the agricultural sector has brought significant changes that affect productivity and sustainability. The following is a description of the impact of this technology:

### **1. Increased Productivity**

**Optimization of Input Use:** Modern technologies, such as precision agriculture, allow farmers to optimize the use of inputs such as water, fertilizers, and pesticides. Sensors and real-time data help farmers provide the right amount of inputs at the right place and time, thereby increasing efficiency and yields.

**Automation of Agricultural Processes:** The use of automated machines, such as smart tractors, drones for seed or pesticide distribution, and automatic irrigation systems, has reduced manual workload and increased speed and accuracy in agricultural activities. This allows farmers to manage larger areas of land more efficiently.

**More Effective Land Management:** Technologies such as GIS (Geographic Information System) and remote sensing enable detailed mapping and analysis of land. Farmers can identify areas that need special attention and make more precise interventions, ultimately increasing production yields.

**Increased Access to Market Information:** Digital platforms and mobile applications provide farmers with direct access to market information, commodity prices, and demand trends. This helps farmers make better decisions about production and marketing, leading to increased incomes.

### **2. Sustainable Agriculture**

**Reduced Use of Chemicals:** Precision farming technologies enable more efficient application of pesticides and fertilizers, reducing the use of excess chemicals that can damage soil and water resources. This helps maintain long-term soil fertility and protect the surrounding ecosystem.

**Better Water Resource Management:** Smart irrigation technologies, such as automated drip irrigation controlled by soil moisture sensors, enable more efficient water management. This is especially important in areas prone to drought, ensuring sustainable water use and reducing the risk of over-irrigation.

**Reduced Carbon Footprint:** The use of renewable energy, such as solar panels to power irrigation pumps or greenhouses, as well as technologies that reduce the need for physical travel to manage land (such as drone

surveillance), contribute to reducing carbon emissions from agricultural activities.

**Biodiversity Conservation:** With technologies that enable more detailed and effective land management, farmers can implement more environmentally friendly farming practices, such as diverse crop rotations and protection of natural habitats around farms, which support biodiversity conservation.

### 3. Risk Management and Adaptation to Climate Change

**Early Warning and Weather Prediction:** Modern technologies, including advanced weather models and early warning systems, enable farmers to prepare for extreme weather conditions. This helps reduce the risk of losses due to natural disasters and enables farmers to adapt their farming practices to be more adaptive to climate change.

**Income Diversification:** Digital technologies and e-commerce platforms enable farmers to sell their products in wider and more diverse markets, reducing dependence on a single product or market. This helps in reducing economic risk and increasing the economic resilience of farmers.

### 4. Challenges in Sustainability

**Technological Waste Management:** While modern technology increases efficiency, the use of certain technologies, such as machinery and electronic equipment, can generate waste that requires special management to avoid damaging the environment.

**Digital Divide:** Not all farmers have equal access to modern technology, especially in remote rural areas. This can create a gap between farmers who have access and knowledge of technology and those who do not, potentially disrupting equity of yields and overall sustainability.

### 5. Improving Social Sustainability

**Farmers Empowerment:** Modern technology empowers farmers by giving them tools to increase productivity and access to markets. This not only increases their income but also strengthens their position in the agricultural supply chain.

**Continuous Education and Knowledge:** Access to technology also opens up opportunities for farmers to continue learning and growing. Continuous education through digital platforms and farmer networks can help create more resilient and innovative farming communities.

With modern technology, agriculture becomes more productive, efficient, and sustainable. However, the success of technology adoption in supporting long-term sustainability also depends on how the technology is

integrated with wise agricultural practices, supported by appropriate policies, and accessed equitably by all farmers.

### **Government Policy and Support from Various Parties Can Accelerate Technological Transformation in the Agricultural Sector**

Technological transformation in the agricultural sector requires strong support from the government and various other parties, including the private sector, educational institutions, and non-governmental organizations. These policies and support play an important role in overcoming barriers to technology adoption and ensuring that the benefits of technology can be widely felt by farmers. Technological transformation in the agricultural sector is essential to increasing productivity and sustainability. Government policies and support from various parties, including the private sector and the community, play a key role in accelerating this process. The Indonesian government has issued various policies to encourage technological transformation in the agricultural sector (Qin et al., 2022).

One important step is the implementation of the Job Creation Law, which aims to simplify licensing and accelerate the investment process in the agricultural sector. This policy is expected to attract more investment, both domestically and abroad, for the development of modern agricultural technology. In addition, programs such as the People's Business Credit provide better access to funding for small farmers to adopt new technologies. This financial support is essential to help farmers purchase the tools and technology needed to increase production efficiency. Support from the private sector is also very important in agricultural technological transformation. Collaboration between the government and private companies can create faster and more efficient innovation (Suwanan et al., 2021). For example, the development of a technology-based food logistics system involving state-owned enterprises and private companies can improve the distribution of agricultural products from production centers to consumers.

According to Koerner et al., (2020), the availability of adequate infrastructure, such as internet access and extension facilities, is also an important factor in accelerating technology adoption. Programs that focus on improving internet access in rural areas will help farmers get information and training on modern agricultural technology. In addition, effective extension from the government and related institutions can improve farmers' understanding of the benefits of new technology.4. Academics and research institutions also have an important role in the development of agricultural

technology. Through research and innovation, they can create solutions that suit the needs of farmers. Collaboration between universities and the government in agricultural research can produce more relevant and applicable technology. The community, especially millennial farmers, also needs to be involved in this transformation process. Increasing digital literacy among young farmers will help them adapt to new technologies more quickly. Training programs involving young people can create a better understanding of agricultural technologies and how to use them (Paunov, C., & Planes-Satorra, 2019).

Overall, supportive government policies, synergy between the public and private sectors, improved infrastructure, the role of academics, and community involvement are key factors that can accelerate technological transformation in the agricultural sector. With the right support, the agricultural sector can transform to become more modern, efficient, and sustainable, which will ultimately improve farmer welfare and national food security.

## **CONCLUSION**

Millennial farmers are quicker to adopt technology due to their access to information, digital skills, and openness to innovation. They use various tools and technologies, such as soil sensors, drones, and digital platforms, to improve the efficiency and productivity of their farms. Their ability to leverage these technologies has transformed the way farming is done, from a manual and experience-based approach to a more precise and data-driven approach.

Modern agricultural technologies have been shown to increase productivity by optimizing input use and automating farming processes. In addition, these technologies also support sustainability by reducing chemical use, better managing water resources, and reducing the carbon footprint of farming activities. This shows that technology not only increases economic efficiency but also supports more environmentally friendly and sustainable agriculture.

Various factors influence the level of adoption of modern agricultural technologies by farmers, including economic, social, technical, and environmental factors. Millennial farmers are more likely to adopt new technologies if they have access to education, adequate infrastructure, and financial support. However, barriers such as high initial costs and resistance to change must also be overcome.

The success of technological transformation in the agricultural sector depends heavily on government support and collaboration with various parties, including the private sector, educational institutions, and non-governmental organizations. Supportive policies, strong infrastructure, and training and education programs are key to accelerating technology adoption among farmers. This support ensures that modern technologies are accessible to all farmers and widely adopted to create more efficient, productive and sustainable farming systems.

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