Proceedings of the International Conference on Agricultural Strategy for Sustainability (ICASS)
October 22–23, 2025 – Pekanbaru, Indonesia
Volume 2, Number 1 (2025): 117-130

Digitalization of Agriculture and Government Policy Implementation in Enhancing Farmers' Competitiveness in the Era of Digital Transformation in Riau Province

Indrian Syafitri[1], Nurman[1], Annisa Mardatillah[1], Resti Hefriyenni[2]
[1]Business Administration, Universitas Islam Riau
[2]Universitas Rokania

*E-mail: indriansyafitri21@soc.uir.ac.id (Corresponding author)

Abstract. The rapid development of digital technology has brought significant transformations in the agricultural sector, particularly in improving efficiency, productivity, and farmers' competitiveness. This study aims to analyze the implementation of government policies in supporting the digitalization of agriculture to enhance farmers' competitiveness in the digital transformation era, with a specific focus on Riau Province. The research employs a qualitative descriptive method through in-depth interviews, field observations, and document analysis involving agricultural agencies and farmer groups. The findings reveal that various digitalization initiatives such as the application of e-agriculture systems, digital marketing platforms, and precision farming technologies have positively influenced farmers' access to information, markets, and technology. However, the effectiveness of these policies remains constrained by farmers' low digital literacy, inadequate technological infrastructure in rural areas, and weak inter-agency coordination. Therefore, strengthening digital governance, improving human resource capacity, and expanding rural internet access are essential to realizing an inclusive and sustainable agricultural transformation. This study contributes to a deeper understanding of the relationship between public policy and digital innovation in enhancing the competitiveness of farmers in Indonesia.

Keywords: Agricultural digitalization, Digital transformation, Farmers' competitiveness, Riau Province, Policy implementation

1. Introduction

The agricultural sector continues to serve as one of the backbones of Indonesia's national economy. Beyond its role as a provider of employment and a primary source of livelihood for rural communities, this sector significantly contributes to national food security and the export of strategic commodities. However, in an increasingly competitive global landscape, Indonesian agriculture faces a range of structural challenges, including low productivity, climate change, natural resource degradation, price volatility, and uneven access to technology across regions. To address these challenges, the Indonesian government has directed agricultural development toward modernization and digitalization as part of a broader strategy to enhance efficiency, sustainability, and national competitiveness [1].

Agricultural digitalization refers to the utilization of digital technologies such as the Internet of Things (IoT), precision sensors, drones, mobile applications, big data analytics, and artificial intelligence (AI) across the agricultural value chain, from cultivation and harvesting to post-harvest management, distribution, and marketing [2] [3]. These technologies enable farmers to access real-time information, optimize input usage, increase productivity, minimize risks, and

expand market access. Moreover, digitalization facilitates the implementation of traceability systems demanded by global markets to ensure sustainability and food safety [4].

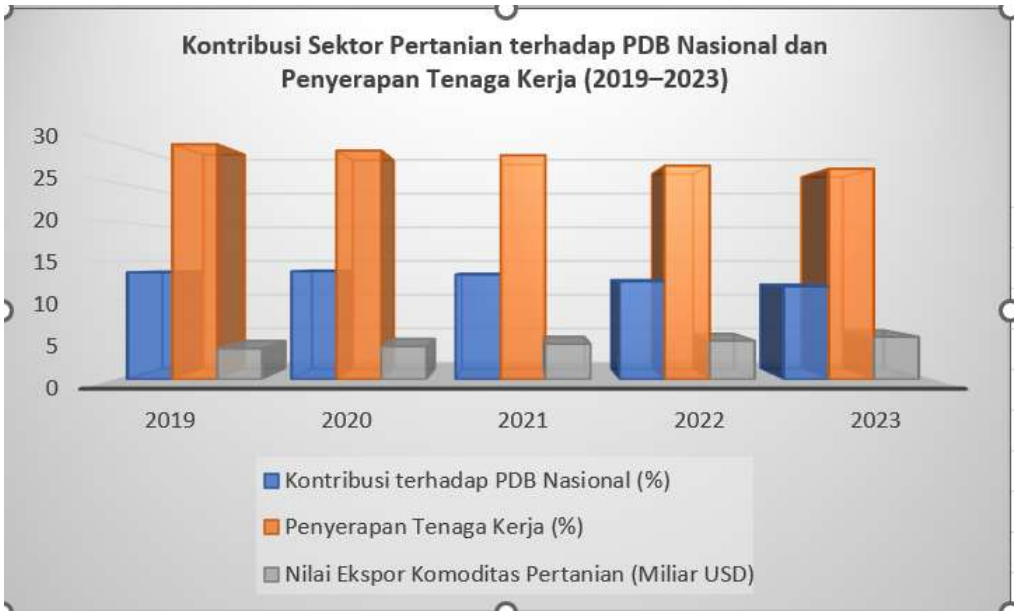

Figure 1. Contribution of the Agricultural Sector to National GDP and Employment (2019–2023)
Source: [5] [6]

Riau Province is recognized as one of Indonesia's key producers of strategic commodities, particularly palm oil, rubber, rice, maize, and horticultural products. The agricultural sector plays an essential role not only in supporting regional economic growth but also in absorbing rural labor. However, farmers in Riau continue to face multiple challenges, including limited market access, low digital literacy, financial constraints, weak farmer institutional structures, and inadequate information technology infrastructure in remote areas. On the other hand, Riau holds significant potential for agricultural digitalization. Several agritech startups have begun to penetrate the region by offering digital marketing services, application-based agricultural inputs, and digital micro-loan services. Yet, without coherent, consistent, and sustainable government policies, the adoption of digital technologies among smallholder farmers will struggle to reach a broader scale.

The Indonesian government, through the Ministry of Agriculture, has introduced several policies to promote modernization and digitalization in the agricultural sector. One of the flagship initiatives is the Agriculture 4.0 program, which emphasizes the use of big data, e-commerce, and digital platforms to strengthen farmers' competitiveness. Additionally, the One Agricultural Data Policy aims to consolidate data on production, distribution, prices, and food stocks to support evidence-based policymaking [7] [8].

At the provincial level, including Riau, regional policies are expected to be more adaptive in supporting digital transformation. Local governments need to facilitate the development of rural internet infrastructure, provide digital literacy training for farmers, strengthen the role of agricultural extension officers as digital extension agents, and build partnerships with the private sector and agritech startups. According to FAO [9], synergy among government, private sector, and local communities is an essential prerequisite for ensuring that agricultural digitalization operates effectively, inclusively, and sustainably.

Figure 2. Key Challenges of Agricultural Digitalization in Riau Province
Source: [6] [7] [8]

Farmers' competitiveness in the global era is no longer determined solely by production capacity but also by access to information, markets, and technology. Through digitalization, farmers can access real-time price information, directly connect with consumers via digital platforms, and use weather and pest prediction applications to reduce crop failure risks. Furthermore, digitalization supports sustainable agricultural practices by minimizing the overuse of fertilizers and pesticides through precision technology. This aligns with the global trend toward environmentally friendly food systems. According to [10], countries that have successfully integrated digitalization into their agricultural systems tend to be more competitive in international trade, achieve higher production efficiency, and are more resilient to economic and climate shocks.

Despite the growing body of research on agricultural digitalization at the national and international levels, studies that specifically analyze government policy implementation in supporting digital transformation at the provincial level particularly in Riau remain limited. Most prior studies emphasize the technical aspects of technology use, while the policy, institutional, and socio-economic capacity dimensions of farmers are often underexplored. Yet, the effectiveness of agricultural digitalization is strongly influenced by a conducive policy framework, available infrastructure, and local human resource readiness.

Previous research has shown that the success of agricultural digitalization depends not only on the availability of technology but also on institutional readiness, human resource capacity, and the effectiveness of multi-level government policies [4] [11]. Local governments play a vital role in translating national policies into contextualized local programs, such as digital training, technology subsidies, partnerships with agritech startups, and infrastructure development. However, empirical studies that examine how the implementation of agricultural digitalization policies in Riau Province contributes to enhancing farmers' competitiveness are still scarce. Most existing research remains descriptive and lacks a systematic analysis linking policy frameworks, technology adoption, and competitiveness outcomes.

Nationally, the central government has introduced several policy packages and initiatives to accelerate digital transformation in the food sector such as the development of an Electronic-Based Government System (SPBE) architecture, the One Food Data Initiative, the National AI and Data Roadmap, and Ministry of Agriculture programs for smart farming and youth digital literacy. At the provincial and district/city levels, policies must translate national directions into contextualized programs (e.g., the establishment of digital agricultural service centers, partnerships with agritech startups, and cooperative support for digital transformation). The

success of these initiatives depends on cross-sectoral coordination (agriculture, communications and informatics, regional planning), sustainable financing, and data-driven monitoring and evaluation mechanisms. Top-down policies must also be complemented by bottom-up approaches that consider farmers' adaptability and local institutional capacity.

Although various policy initiatives and pilot projects have been implemented across regions, empirical studies documenting how provincial-level government policies concretely enhance smallholder farmers' competitiveness particularly in Riau remain limited. Much of the existing research is descriptive or based on small-scale case studies without integrated policy analysis linking technological, institutional, economic, and regulatory aspects. Therefore, a study examining the implementation of agricultural digitalization policies in Riau Province covering infrastructure readiness, farmers' digital literacy, intermediary institutions (cooperatives and extension officers), digital financing access, and impacts on productivity and marketing would provide essential contributions for both policymakers and academia.

Agricultural digitalization offers real opportunities to enhance farmers' competitiveness in the digital transformation era, both by increasing productivity and expanding market access. However, the success of its implementation depends on the quality of coordinated policies between national and local governments, infrastructure and institutional readiness, and investments in human resource capacity development. Focusing research on policy implementation in Riau Province will fill an important knowledge gap and provide practical policy recommendations to accelerate an inclusive and sustainable agricultural transformation.

2. Research Methods

This study employed a qualitative descriptive approach using in-depth interviews, field observations, and documentary studies as its main data collection techniques. The research was conducted in Riau Province, particularly in major agricultural centers such as Kampar Regency, Indragiri Hulu Regency, and Rokan Hulu Regency, which represent both food crop and plantation agriculture. The informants consisted of farmers, agricultural extension officers, officials from the Riau Provincial Department of Agriculture, local agribusiness actors, and academics focusing on agricultural digitalization issues.

The data collection methods included interviews, observations, and document analysis. Observations were conducted to obtain clearer and more detailed information regarding the research objects, while secondary data were gathered from literature reviews, legal and policy documents, research proposals, mass media reports, and other relevant sources. Data analysis was carried out after the data collection process was completed, employing the interactive analysis model developed by [12], which involves four concurrent flows of activity: data reduction, data display, and conclusion drawing/verification.

Figure 3. Interactive Analysis Model [12]

3. Results and Discussion

1. Conceptualization of Agricultural Digitalization in the Era of Digital Transformation

Agricultural digitalization represents a new paradigm in the management of the agricultural sector, integrating information and communication technology (ICT) to enhance the efficiency, productivity, and sustainability of agricultural systems. The Food and Agriculture Organization [9] defines agricultural digitalization as the application of digital technologies such as the Internet of Things (IoT), big data analytics, artificial intelligence (AI), drones, blockchain, and mobile-based applications across the entire agricultural value chain, from production and distribution to marketing. Through these technologies, farmers can obtain real-time data regarding land conditions, soil moisture, weather, and crop status, which facilitates evidence-based decision-making.

The transformation toward smart farming or precision agriculture has become a crucial component of the global agricultural development agenda. The World Bank emphasizes that digitalization serves as a key catalyst in transforming food systems into more resilient and sustainable ones, particularly amid challenges such as climate change, urbanization, and population growth. Supported by IoT sensors, monitoring drones, and satellite-based information systems, farmers are now capable of precisely monitoring and intervening in land and crop conditions, thereby reducing production costs and improving yields [13].

According to [14] , agricultural digitalization not only improves production efficiency but also adds value to the supply chain through enhanced price transparency, better logistics management, and reduced post-harvest losses. For example, blockchain technology enables end-to-end product traceability, thereby increasing consumer trust in the safety and authenticity of agricultural products. Additionally, digital platforms facilitate smallholder farmers' access to markets and financial institutions through the integration of digital marketplaces and agricultural fintech services.

Within the context of the global digital economy, farmers' competitiveness is no longer solely determined by their ability to produce in large quantities, but also by their technological adaptability and integration into modern supply chains (Organisation for Economic Co-operation and Development [10]. Farmers who master digital technologies, understand market data, and leverage digital innovations gain a stronger competitive advantage in global markets. The digital transformation process, therefore, necessitates improvements in farmers' digital literacy and managerial capacity to maximize the benefits of these technologies.

In Indonesia, agricultural digitalization has become a strategic government priority in the face of Industry 4.0 and the knowledge-based economic transformation. The Ministry of Agriculture of the Republic of Indonesia [15] asserts that the Agriculture 4.0 program focuses on developing digital agricultural platforms, digitizing agricultural extension services, and integrating farmer data through an e-agriculture system. The main objectives include enhancing production efficiency, strengthening national food security, increasing export competitiveness of key commodities, and reducing income disparities among farmers across regions, including in Riau Province.

Furthermore, the implementation of agricultural digitalization in regions such as Riau holds particular significance, as the province's economy is heavily reliant on plantation and agricultural sectors, including palm oil, rice, and horticulture. Digitalization can strengthen local farmers' competitiveness by improving productivity, reducing input costs, and expanding market access through digital platforms. In addition, local government policies that support digital transformation such as the development of rural internet infrastructure and digital literacy training for farmers are key elements in ensuring the successful implementation of agricultural digitalization.

Conceptually, agricultural digitalization is closely linked to the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) and SDG 9 (Industry, Innovation, and Infrastructure). Thus, digitalization is not merely an instrument of economic efficiency, but also

a social and environmental strategy aimed at creating an inclusive, adaptive, and equitable food system [9] [10] [14].

2. Implementation of Government Policies in Agricultural Digitalization

The implementation of government policies in agricultural digitalization in Indonesia reflects the state's commitment to addressing the challenges of digital transformation and enhancing the competitiveness of the agricultural sector at the global level. The government has developed various strategic programs focused on the integration of digital technologies into agricultural systems through both national and regional policy initiatives. According to the Ministry of Agriculture of the Republic of Indonesia [15], major programs such as Agriculture 4.0, the National Agricultural Information System (SIPN), One Agricultural Data Program, and the e-Extension System represent concrete steps toward establishing a data-driven agricultural ecosystem that promotes efficiency, transparency, and connectivity among actors in the agricultural value chain.

The Agriculture 4.0 concept adopted in Indonesia draws inspiration from the Industry 4.0 model, which combines automation technologies, the Internet of Things (IoT), big data analytics, and artificial intelligence (AI) in agricultural production systems [9]. The implementation of this concept aims to create smart agricultural systems capable of monitoring and controlling environmental conditions, crop nutrient needs, and resource optimization with precision. Additionally, the One Agricultural Data Program seeks to integrate data across various institutions, including the Ministry of Agriculture, the Central Bureau of Statistics (BPS), and the Geospatial Information Agency (BIG), to enable more accurate and evidence-based policymaking [15].

The Food and Agriculture Organization [9] emphasizes that the effectiveness of agricultural digitalization depends on three fundamental pillars: 1) public policies that support innovation and digital inclusion, 2) adequate digital infrastructure, and 3) human resource capacity building in the agricultural sector. Without sufficient support in these areas, the adoption of digital technologies risks widening the digital divide between farmers with access to technology and those without. Therefore, the government's role extends beyond providing digital tools it must also ensure that farmers are capable of utilizing these technologies effectively through digital literacy training, rural internet development, and the establishment of digital agricultural cooperatives as institutional support systems.

The World Bank also underscores the importance of a collaborative approach in implementing agricultural digitalization policies. The government should act as a facilitator and regulator, ensuring that the digital ecosystem operates inclusively, while the private sector, research institutions, and universities serve as innovators and technology accelerators. This collaborative model can strengthen the digital agricultural value chain, encompassing the provision of sensor technologies, digital market information systems, and access to agri-fintech financing solutions [13].

In the context of Riau Province, the implementation of agricultural digitalization policies forms part of the region's development strategy, which aims to enhance competitiveness and sustainable economic growth based on natural resources. According to the Riau [16], the local government focuses on strengthening agricultural human resources through training in digital farming, promoting the use of smart farming applications, and expanding internet access in agricultural zones. Additionally, partnerships with universities, such as the University of Riau, and private agritech companies have been established to accelerate the adoption of digital technologies.

However, the implementation of these policies still faces several challenges. First, limited digital infrastructure in rural areas, particularly in remote regions such as Indragiri Hulu and Rokan Hulu, remains a major obstacle to adopting internet-based agricultural technologies. Second, there exists a significant human resource capacity gap, as many traditional farmers still lack sufficient digital literacy to operate modern agricultural applications. Third, policy

synchronization between national and regional levels has not been fully achieved, resulting in overlapping programs and the absence of effective monitoring systems to evaluate policy outcomes [10] [16].

Therefore, the successful implementation of agricultural digitalization policies in Riau Province requires a holistic and empowerment-oriented approach. The central and regional governments must strengthen cross-sector collaboration and ensure that the digital transformation genuinely benefits farmers not only institutions or large corporations. Strategic measures to achieve this include: 1) expanding rural digital infrastructure, 2) improving farmers' digital literacy through community-based training, 3) developing technology mentoring systems within farmer groups, and 4) reinforcing the local innovation ecosystem by engaging universities and local agritech startups.

In conclusion, the implementation of agricultural digitalization policies should not be viewed merely as a technological initiative, but as part of a structural reform of the agricultural sector toward a more resilient, inclusive, and competitive system in the era of digital transformation [9] [11] [16].

3. Agricultural Digitalization in Riau Province: Conditions, Challenges, and Opportunities

Riau Province is one of Indonesia's regions with vast agrarian potential. Its economic structure remains largely supported by primary sectors, particularly palm oil, rubber, and coconut plantations, as well as food crops such as rice, corn, and horticulture. This potential gives Riau a comparative advantage in supplying agricultural raw materials and agro-industrial products within the Sumatra region [5]. However, to enhance the competitiveness of agricultural products in both national and international markets, a transformation toward digital agriculture has become imperative. Agricultural digitalization assists farmers in data-driven decision-making, improving production efficiency, expanding market access, and creating a sustainable and climate-resilient agricultural system [9].

In recent years, the implementation of smart plantation management in Riau has begun to show measurable progress, particularly within large-scale plantation sectors. Several palm oil companies have adopted IoT-based sensors, drone mapping, and data analytics to optimize fertilizer use, monitor soil moisture, and control pest and disease outbreaks in real time. A study by [17] found that the application of digital technology in major plantation companies in Riau increased production efficiency by 15–20% and significantly reduced operational costs. However, digital adoption among small and medium-scale farmers (smallholders) remains limited due to constraints in access to technology, infrastructure, and financing.

The main challenges in implementing agricultural digitalization in Riau Province can be categorized into three key dimensions: infrastructure, human resources, and institutional capacity. First, in terms of digital infrastructure, internet coverage in rural areas remains limited, especially in remote regions such as Indragiri Hilir, Kuantan Singingi, and Rokan Hulu. This limitation restricts the use of digital farming applications and cloud-based systems that require stable connectivity. Second, from the perspective of human resource capacity, farmers' digital literacy levels remain low. Many farmers are not accustomed to using digital devices such as smartphones for farm management and continue to rely on conventional methods in agricultural decision-making. NThird, from an institutional standpoint, coordination among government agencies and the involvement of the private sector in supporting the digital agriculture ecosystem are still suboptimal [16].

These findings align with the United Nations Development Programme [18] report, which highlights that major barriers to digital technology adoption in agriculture across developing countries include limited infrastructure, low digital literacy, and a lack of inclusive policy support. Therefore, agricultural digitalization requires not only technological innovation but also institutional reform and human capital investment. The government needs to strengthen the innovation ecosystem by providing digital literacy training for farmers, expanding rural internet

connectivity, and building collaborative partnerships among government bodies, academia, and the private sector to develop local agritech platforms.

Despite these challenges, the opportunities for agricultural digitalization in Riau Province are immense. The rapid growth of agritech startups in Indonesia presents a crucial momentum for agricultural digital transformation. Platforms such as TaniHub, eFishery, and 8Villages have demonstrated that digital technologies can shorten supply chains, enhance transaction efficiency, and increase farmers' profit margins [19]. Similar business models could be adapted by farmers in Riau with strong policy support from local governments that promote digital innovation. For instance, integrating regional agricultural information systems with digital agricultural marketplaces could enable farmers to sell their produce directly to consumers without intermediaries, thereby increasing their net income.

Moreover, agricultural digitalization in Riau opens opportunities for the development of data-driven precision agriculture and digital farming finance platforms, allowing farmers to access credit based on their land productivity data. These programs can be implemented through partnerships with microfinance institutions and agri-fintech startups operating in the agricultural sector. Consequently, digitalization not only improves productivity but also fosters financial inclusion and digital economic participation in rural areas.

From a sustainability perspective, digitalization can also serve as a solution to environmental challenges. The use of sensor technologies and data analytics enables the optimization of water, fertilizer, and pesticide usage, reducing the negative environmental impact. This aligns with the framework of sustainable agriculture promoted by the [9] and [10], where resource efficiency and environmental sustainability are integral components of the modern digital agricultural system.

With consistent policy support, multi-stakeholder collaboration, and technological capacity building at the grassroots level, Riau Province has the potential to become a national model for digital agricultural transformation in Indonesia. The implementation of inclusive and adaptive digitalization strategies will not only strengthen the position of local farmers in global value chains but also improve their economic well-being and resilience in the digital economy era.

4. The Role of Inclusive Policies in Enhancing Farmers' Competitiveness

Inclusive policies serve as the foundational pillar for strengthening farmers' competitiveness in the era of digital transformation. In the context of modern agricultural development, top-down policy approaches are no longer sufficient to address the growing complexity of challenges faced by farmers. A collaborative and participatory approach involving multiple stakeholders—including farmers, government institutions, academia, financial institutions, and the private sector—is required. According to [20], the success of agricultural digitalization depends not only on the availability of technology but also on the existence of a policy ecosystem that promotes farmers' active participation in decision-making and innovation development.

Inclusive policies position farmers as the primary subjects of development rather than mere beneficiaries. In this regard, the government acts as a facilitator and enabler, not just a regulator. This approach aligns with the inclusive innovation system model proposed by [21], which argues that agricultural innovation can only be sustainable when all stakeholders have equitable access to information, technology, and markets. Therefore, inclusive policies aim to ensure equal access to digital technology, strengthen farmers' institutional capacity, and expand cross-sectoral collaboration networks.

Within the framework of a digital agriculture ecosystem, inclusive policies must be supported by four key pillars: 1) access to information, 2) digital literacy and human resource capacity, 3) inclusive financing, and 4) equitable technological infrastructure. First, access to information is a fundamental element in enhancing farmers' competitiveness. Through digital platforms such as the National Agricultural Information System (SIPN) or locally based

agricultural applications, farmers can access real-time data on prices, weather, and cultivation recommendations. Second, digital literacy and human resource development must be strengthened through continuous training and mentoring by digital agricultural extension agents, who act as intermediaries between technology and farmers to ensure the effective application of innovation in the field [9].

Third, inclusive financing is a critical aspect of promoting the adoption of digital technologies. According to the [10], access to credit and digital financing for smallholder farmers remains one of the main barriers to agricultural transformation in developing countries. Therefore, governments need to develop performance-based digital financing schemes such as credit scoring systems derived from yield data or land productivity applications. These programs can be implemented through collaboration among local banks, cooperatives, and agrifintech startups, which are capable of providing microloans that are fast, transparent, and digitally managed.

Fourth, the equitable distribution of digital infrastructure is a prerequisite for the effective implementation of inclusive policies. In many rural areas of Riau Province, internet connectivity and access to technological devices remain limited. Local governments, in collaboration with the Ministry of Communication and Information Technology, need to expand rural broadband networks and smart village initiatives to ensure that all farmers can access digital technologies equally. Such infrastructure serves as the foundation for building a sustainable digital ecosystem [19] .

In the context of Riau Province, the implementation of inclusive policies can be realized through several concrete strategies. First, strengthening the role of digital agricultural extension officers as agents of technological transformation at the grassroots level. These extension officers should be trained not only in technical aspects of farming but also in operating digital applications, using sensors, and performing agricultural data analysis. Second, establishing Regional Agricultural Data Centers that integrate production, pricing, distribution, and weather data to support evidence-based decision-making. Third, expanding farmers' access to digital financing through partnerships among local governments, financial institutions, and local agritech companies. Fourth, developing regional e-marketplace systems that facilitate direct transactions between farmers and consumers, thereby shortening the supply chain and increasing farmers' income margins [5] .

Data-driven and innovation-based inclusive policies can also strengthen the structural competitiveness of Riau's agricultural sector. Through the integration of agricultural and digital transformation policies, governments can promote the creation of efficient and transparent value chains. For instance, the application of blockchain-based agriculture systems can enhance supply chain transparency and strengthen consumer trust in local agricultural products. Moreover, public-private partnerships (PPPs) in agritech development can accelerate innovation adoption, reduce implementation costs, and amplify socioeconomic impacts in rural communities.

From a global perspective, the Food and Agriculture Organization (FAO, 2022) emphasizes that inclusive and digital-based agricultural policies significantly contribute to sustainable rural development, market efficiency, and national food security. In the long term, such policies will strengthen the position of local farmers in global markets while accelerating the transformation of food systems toward models that are more resilient, equitable, and competitive. Therefore, the implementation of inclusive policies in Riau Province should not merely be seen as a regional development agenda but as part of a strategic effort to achieve national agricultural self-reliance and sustainability in the digital economy era.

5. The Impact of Digitalization on Farmers' Resilience and Competitiveness

Agricultural digitalization has a significant impact on farmers' resilience and competitiveness in terms of productivity, efficiency, and the sustainability of farming systems. According to the Organisation for Economic Co-operation and Development [10] the application of digital technologies such as the Internet of Things (IoT), big data analytics, artificial intelligence

(AI), and geographic information systems (GIS) can optimize the management of agricultural resources, reduce production costs, and enhance yields in a sustainable manner. These technologies enable farmers to access real-time information on weather conditions, pest outbreaks, and market prices, thereby facilitating more precise and adaptive decision-making in response to environmental changes.

Beyond economic aspects, digitalization also has profound social and institutional implications. Digital platforms such as e-marketplaces and agritech innovations (e.g., TaniHub and eFishery) have made it easier for farmers in Riau to sell their products directly to consumers, shortening the distribution chain and increasing profit margins [19]. Furthermore, digitalization promotes financial inclusion by expanding access to digital financing and mobile banking services that were previously out of reach for smallholder farmers. Consequently, digital technology contributes to the creation of a more inclusive, efficient, and competitive agricultural ecosystem.

Nevertheless, these positive impacts coexist with persistent structural challenges, particularly concerning the digital divide. As highlighted by the United Nations Development Programme [18], farmers with limited access to technology and digital training are often left behind in leveraging the opportunities brought by digitalization. This disparity risks widening the gap between large and small-scale farmers as well as between urban and rural regions. Therefore, government policies must emphasize the principle of digital inclusiveness by ensuring equitable access to digital infrastructure, expanding farmers' digital literacy, and providing subsidies or incentives for agricultural technology adoption among vulnerable groups.

Moreover, agricultural digitalization holds tremendous potential in strengthening national food security through the implementation of early warning systems for climate change and natural disasters. AI-driven and satellite-based systems can detect drought or flood risks early, allowing farmers to adjust cropping patterns in advance and minimize potential losses (FAO, 2023). In Riau Province, efforts to integrate weather information systems with local agricultural applications have shown positive results in reducing crop failure risks caused by extreme weather fluctuations [5].

Overall, agricultural digitalization in Riau Province has had a tangible impact on enhancing farmers' productivity and competitiveness. However, it still requires strong supporting policies to ensure sustainability and equitable distribution of benefits. Collaborative approaches among government bodies, the private sector, academia, and farming communities are essential for building a resilient, adaptive, and highly competitive agricultural system in the digital transformation era.

6. Strengthening Strategies for Agricultural Digitalization Policy in Riau Province

The strategy for strengthening agricultural digitalization policy in Riau Province must be designed comprehensively, integratively, and sustainably, involving all relevant stakeholders. This is crucial considering Riau's strategic role as one of Indonesia's leading producers of major agricultural commodities such as palm oil, rubber, coconut, and rice. The digital transformation of the agricultural sector should not only aim to increase productivity but also to enhance competitiveness, environmental sustainability, and the overall welfare of farmers. Therefore, policy strategies should focus on five key dimensions: digital infrastructure, human resource capacity, institutional and collaborative frameworks, inclusive financing, and data-driven monitoring and evaluation.

a. Rural Digital Infrastructure

The foundation of agricultural digital transformation lies in the availability of adequate digital infrastructure. In many rural areas of Riau, limited internet access and a lack of technological devices remain major barriers to digital adoption. According to the [10], poor digital connectivity in rural regions hampers farmers' integration into smart farming systems. Therefore, the provincial government should expand broadband internet networks to sub-district and village levels, in collaboration with telecommunication providers to ensure affordable connectivity. Additionally, establishing Rural Technology Centers in each sub-district could

provide training, technical consultation, and maintenance services for agricultural digital tools. Supporting infrastructure such as electricity and renewable energy systems should also be strengthened to ensure the sustainable use of technology in the field [9].

b. Human Resource Capacity

Human capital is a decisive factor in the success of agricultural digitalization. Digital literacy among farmers in Riau remains relatively low, particularly among smallholders and older farmers. The government needs to develop competency-based training programs to enhance the capacity of farmers and agricultural extension workers in using digital applications, IoT devices, and agritech platforms. A Digital Farmer Training program could be implemented with support from local universities and research institutions. Moreover, the role of agricultural extension officers should evolve into that of "digital facilitators," acting as intermediaries between technology providers and farmers [19]. Such an approach will make the technology adoption process easier, more contextual, and sustainable.

c. Institutional Strengthening and Collaboration

Institutional capacity building is essential to ensure that the agricultural digital ecosystem functions effectively. Local governments should empower farmer cooperatives to evolve into digital cooperatives that facilitate online transactions, procurement of agricultural inputs, and digital marketing of farm products. Furthermore, collaboration between the government, private sector, agritech startups, and academia must be expanded. According to [20], cross-sector partnerships serve as critical catalysts for agricultural innovation. In Riau, collaboration with startups such as TaniHub and eFishery can provide farmers with better market access and financing opportunities. Universities can contribute through research and development of locally relevant technologies, such as pest prediction or weather-based decision-support applications.

d. Inclusive Financing

Digital-based agricultural financing policies are essential to ensure economic inclusivity among farmers. Access to capital remains a challenge for smallholders in Riau due to limited collateral and financial records. Implementing digital credit scoring systems based on production data and transaction behavior could provide more accurate assessments of farmers' creditworthiness [18]. Additionally, local governments could promote digital agricultural insurance schemes based on weather and satellite data to protect farmers from crop losses due to climate variability. These financing schemes should involve regional financial institutions, fintech companies, and digital cooperatives to ensure that the benefits reach all layers of the farming community.

e. Data-Driven Monitoring and Evaluation

Monitoring and evaluation play a vital role in ensuring the effectiveness of agricultural digitalization policies. The Riau Provincial Government should utilize an integrated One Agricultural Data System to track productivity, income levels, and the rate of digital technology adoption among farmers. These data can serve as a foundation for evidence-based policymaking. According to [22], real-time, data-driven monitoring systems enable governments to identify implementation barriers and adjust strategies dynamically. In Riau, strengthening agricultural data systems through the integration of information from agricultural offices, cooperatives, and local agritech platforms will make policies more accurate and responsive to farmers' needs.

Overall, the strategy to strengthen agricultural digitalization policies in Riau must be holistic, inclusive, and adaptive to the dynamics of global technological change. Cross-actor collaboration and data-driven policymaking will accelerate the establishment of a resilient, efficient, and competitive digital agricultural ecosystem in the province.

Agricultural digitalization serves as a key strategy for enhancing the competitiveness of Riau's agricultural sector amid the wave of global digital transformation. Through the adoption of technologies such as the Internet of Things (IoT), big data analytics, artificial intelligence (AI), and digital information systems, Riau's agriculture has great potential to transition toward smart agriculture a system oriented toward efficiency, productivity, and sustainability. However, this

transformation cannot progress optimally without comprehensive, inclusive, and locally adaptive government policies.

Conceptually, agricultural digitalization is not merely about technological adoption but represents a broader transformation of social, economic, and institutional systems at the farmer level. Empirical findings and studies [9] [10] [19] have shown that digitalization can enhance supply chain efficiency, expand market access, and strengthen farmers' bargaining power in modern agricultural ecosystems. In Riau Province—one of Indonesia's primary producers of palm oil, rubber, coconut, and rice the potential for digital application is immense. The implementation of digital systems in land and production management has already demonstrated significant improvements in productivity and reductions in operational costs [23].

Riau's local government policies should therefore adopt an ecosystem-based and collaborative approach, where the government acts as an innovation facilitator, while academia, private sectors, and agritech startups drive technological adoption. Priority actions should include strengthening rural digital infrastructure, providing digital literacy training for farmers, developing digital cooperatives, and expanding technology-based financing. Furthermore, implementing a One Agricultural Data monitoring and evaluation system will ensure that policies remain dynamic and responsive to field realities [22].

In conclusion, agricultural digitalization in Riau Province holds tremendous potential to enhance farmers' competitiveness and regional food security. However, this potential can only be realized if the government successfully integrates digitalization policies with infrastructure development, human capital enhancement, and robust institutional frameworks. Through cross-sectoral collaboration and evidence-based policymaking, Riau can emerge as a leading model of advanced, inclusive, and sustainable digital agriculture in Indonesia.

4. Conclusion and Suggestion

1. Conclusion

Agricultural Digitalization in Riau Province has become a key factor in enhancing farmers' competitiveness and economic resilience amid the accelerating pace of digital transformation. The findings of this study reveal that the utilization of digital technologies such as data-driven agricultural applications, weather information systems, land mapping through drones and satellites, and e-commerce platforms for agricultural products has had a positive impact on improving production efficiency, reducing operational costs, and expanding market access for farmers. Through digitalization, farmers are now able to make more timely and data-driven decisions, thereby increasing both productivity and profitability in their farming operations. However, the process of agricultural digitalization in Riau still faces significant structural and social challenges. Limited internet access in rural areas, low levels of digital literacy among farmers, and unequal access to technological devices have created disparities in the distribution of digital benefits. Moreover, the lack of integration among institutional information systems and weak inter-agency coordination have hindered the effective implementation of agricultural digitalization policies. These challenges demand that the government not only focus on providing digital infrastructure but also prioritize the strengthening of human resource capacities and institutional frameworks to ensure that digital transformation is truly inclusive.

The Riau Provincial Government has demonstrated its commitment to digital transformation through various initiatives, such as smart farming programs, e-extension services, and the development of the Riau Agricultural One Data system. These initiatives serve as a vital foundation for realizing an agricultural system that is more efficient, adaptive to climate change, and competitive in the global market. With strong regulatory support, multi-actor partnerships (including government, private sector, academia, and local communities), and evidence-based policy innovation, agricultural digitalization in Riau has the potential to become a sustainable model of technology-based economic empowerment in Indonesia.

2. Suggestion

Based on the analysis and field findings, several strategic recommendations should be considered to strengthen the implementation of agricultural digitalization policies in Riau Province:

1. Strengthening Rural Digital Infrastruc-ture. The local government needs to expand high-quality internet networks to reach rural areas and remote plantation regions. Collaboration with the private sector and telecommunication service providers is a strategic step to reduce the digital divide that remains significant in many rural areas. Enhanced connectivity will enable farmers to access digital platforms, market information, and agricultural innovations more effectively.
2. Enhancing Farmers' Capacity and Digital Literacy. Continuous training programs are essential to improve farmers' abilities to operate digital devices, utilize agricultural applications, and conduct basic data analysis. The establishment of digital extension officers in each district can accelerate the process of technology adoption at the grassroots level. These officers will serve as intermediaries between technology providers and farmers, ensuring that digital tools are used appropriately and sustainably.
3. Strengthening Agricultural Institutions and Innovation Ecosystems. The government should support the establishment of digital cooperatives and agritech incubators that serve as platforms for collaboration among farmers, agribusiness actors, and technology startups. Such collaborative models can expand access to markets, promote agricultural innovation, and improve financing opportunities through digital channels. This approach encourages a more integrated and participatory agricultural ecosystem [20].
4. Developing Inclusive and Data-Driven Financing Policies. Innovative financing schemes such as digital credit scoring, digital agricultural insurance, and app-based access to financial services need to be developed to ensure that smallholder farmers are not left behind in the digital economy. These mechanisms can facilitate fairer access to capital, mitigate climate risks, and increase farmers' resilience to market fluctuations [18].
5. Integrating a Unified Agricultural Data System. The implementation of a One Agricultural Data System should be strengthened to ensure cross-sectoral use in monitoring productivity, distribution, and technology adoption among farmers. Accurate and integrated data serve as a foundation for formulating more adaptive and evidence-based policies. This integration enables policymakers to design targeted interventions that respond dynamically to on-the-ground realities [22].
6. Ensuring Continuous Supervision and Evaluation. A digital evaluation system is needed to periodically monitor the effectiveness of agricultural digitalization policies. The use of a monitoring dashboard can help the government assess the policy's impact on productivity improvement, cost efficiency, and farmers' welfare. Such continuous feedback mechanisms ensure that digital transformation in agriculture remains effective, transparent, and aligned with development goals.

References

[1] Pertanian. (2022). Indonesia's digital agriculture roadmap 2022–2030. Jakarta: Ministry of Agriculture.
[2] Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J. (2021). Big data in smart farming: A review. Agricultural Systems, 193, 1-14. https://doi.org/10.1016/j.agsy.2021.103226
[3] United Nations FAO. (2022). Digital agriculture transformation in Asia. Rome: FAO.
[4] OECD. (2023). Digital opportunities for sustainable agriculture. Paris: OECD Publishing.
[5] Pusat Statistik Provinsi Riau. (2024). Riau Province in figures 2023. Pekanbaru: BPS Riau Province.

[6] Kementerian Pertanian Republik Indonesia. (2023). Strategic plan of the Ministry of Agriculture 2020–2024. Jakarta: Ministry of Agriculture of the Republic of Indonesia.
[7] Febrinova, R. (2024). Digitalization of cooperatives and farmers' readiness in facing agriculture 4.0 in Riau. Jurnal Pembangunan Daerah, 12(2), 45–58.
[8] ASEAN-FFTC Policy Brief. (2023). Progressing Indonesia's agriculture 4.0. FFTC-AP.
[9] FAO. (2021). Digital agriculture: The future of farming. Rome: Food and Agriculture Organization of the United Nations.
[10] OECD. (2022). The digitalisation of agriculture: Policy implications and future directions. Paris: OECD Publishing.
[11] Klerkx, L., Jakku, E., & Labarthe, P. (2021). A review of smart farming technologies: Drivers, barriers, and policy implications. Global Food Security, 29, 100532. https://doi.org/10.1016/j.gfs.2021.100532.
[12] Miles, M. B., & Huberman, A. M. (1994). Qualitative data analysis: An expanded sourcebook (2nd ed.). Sage Publications.
[13] World Bank. (2020). Agriculture 4.0: The future of farming technology. Washington, DC: World Bank Group.
[14] Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2022). Big data in smart farming: A review. Computers and Electronics in Agriculture, 199, 107–115. https://doi.org/10.1016/j.compag.2022.107115.
[15] Kementerian Pertanian Republik Indonesia. (2023). Indonesia's agriculture 4.0 roadmap. Jakarta: Ministry of Agriculture of the Republic of Indonesia.
[16] Dinas Pertanian Provinsi Riau. (2023). Annual report on the development of agricultural digitalization in Riau Province. Pekanbaru: Department of Agriculture of Riau Province.
[17] Nasution, M., Rinaldi, A., & Putra, M. A. (2022). Smart plantation management in Indonesia's palm oil industry: A case of Riau Province. Journal of Sustainable
[18] UNDP. (2022). Bridging the digital divide in agriculture: Policy frameworks for inclusive growth. New York: United Nations Development Programme.
[19] World Bank. (2023). Agritech innovation and rural transformation in Southeast Asia. Washington, DC: World Bank Group.
[20] Basso, B., & Antle, J. (2020). Digital agriculture to design sustainable agricultural systems. Nature Sustainability, 3(4), 254–256. https://doi.org/10.1038/s41893-020-0500-2
[21] Gatto, M., Le, P. D., Pacillo, G., Maredia, M., Labarta, R., Hareau, G., & Spielman, D. J. (2021). Policy options for advancing seed systems for vegetatively propagated crops in Vietnam. Journal of Crop Improvement, 35(6), 763–789. https://doi.org/10.1080/15427528.2021.1881011
[22] FAO. (2023). Digital agriculture transformation for sustainable rural development. Rome: FAO.
[23] Putra, D., & Sari, W. (2023). The impact of precision agriculture on farmers' productivity in Riau Province. International Journal of Smart Agriculture, 6(1), 33–47.