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DIGITAL BUSINESS MODELS IN THE DEVELOPMENT OF MODERN AGRICULTURE: AN EMPIRICAL STUDY IN FARMER COMMUNITIES

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Digital business model, modern agriculture, farmer communities, digital transformation, market access.

ABSTRACT

This research aims to analyze the application of digital business models in the development of modern agriculture, with a focus on the farming community in Cirebon Regency. The agricultural sector in Indonesia still faces various challenges such as low productivity, limited market access, and dependence on traditional distribution chains. Digital transformation is believed to be a strategic solution to increase efficiency, expand market access, and strengthen the competitiveness of smallholders. This study uses a qualitative approach with a case study design. Data was collected through in-depth interviews with farmer group leaders and digital assistants, distribution of questionnaires to farmers who have participated in digitalization training, and field observations during one planting cycle. The results show that 80% of respondents experienced increased online market access, 70% improved production recording efficiency, and 60% demonstrated technical competency in agritech applications. However, 75% still faced internet infrastructure constraints. The digital business model provides real benefits in the form of increased online market access, production recording efficiency, and local innovation opportunities. However, significant barriers remain, especially the limitations of digital literacy, internet infrastructure, and social resistance. Community-based adaptation strategies, such as the role of millennial farmers as digital agents and peer learning systems, have proven effective in supporting the transformation process. This study concludes that digital business models have great potential in strengthening the sustainability of modern agriculture, noting that there is more comprehensive ecosystem support.

INTRODUCTION

Agriculture is a sector that has a vital role in supporting food security and national economic development, especially in developing countries such as Indonesia. This sector not only contributes to the supply of foodstuffs, but also absorbs a large number of workers and supports the regional economy. However, serious challenges are still faced, such as low land productivity, limited access for farmers to capital and technology, and uneven distribution of crops. This has an impact on the instability of farmers' income and the weak competitiveness of local agricultural products in the global market (Kumar et al., 2021; Nugroho & Hartati, 2022; Pratama, 2023).

In Indonesia, more than 29% of the population still depends on the agricultural sector for their livelihood. However, the sector's contribution to Gross Domestic Product (GDP) has been on a downward trend, from 14.3% in 2010 to around 12.4% in 2022. This decline shows a stagnation in

productivity and lagging behind innovation when compared to the industrial and service sectors. More than 90% of Indonesian farmers are still small-scale and traditional, so the adoption of innovation is slow. Reliance on conventional distribution patterns makes them vulnerable to price fluctuations and exploitation by middlemen (FAO, 2021; BPS, 2022; Sari & Wibowo, 2022).

Limited market access is the main problem that hinders the improvement of farmers' welfare. The distribution chain of agricultural products in Indonesia tends to be long, causing added value to be enjoyed more by intermediaries than producers. Meanwhile, limited information on prices, quality standards, and consumer preferences weakens farmers' bargaining power. This condition demands a business model that is able to cut distribution chains, increase efficiency, and provide wider access to information for farmers (Zhang & Liu, 2022; Susanto & Arifin, 2021; Rahmawati & Putra, 2021).

Digital transformation through the application of information technology-based business models is one of the promising strategies to improve conventional agricultural systems towards more efficient and sustainable modern agriculture. The adoption of digital technology not only supports increased productivity, but also strengthens farmers' connectivity with markets, financial institutions, and end consumers. Global trends show that the integration of technologies such as the Internet of Things (IoT), big data, blockchain, and e-commerce is a key factor in building a *smart agriculture* ecosystem with significant policy implications for developing countries like Indonesia (Teece, 2020; Jamil et al., 2022; Widodo & Astuti, 2023). The trend of digital technology adoption in Indonesia's agricultural sector shows an increase, although it is still relatively low compared to other countries.

Table 1. Penetration of Agricultural Digitalization in Indonesia (2019–2023)

Year	Percentage of Farmers Using Digital Technology (%)	Dominant Technology
2019	12.5	Social Media & E-commerce
2020	19.8	Agritech & Marketplaces Applications
2021	27.4	Agriculture IoT (soil/weather sensor)
2022	35.2	Agricultural e-commerce platform
2023	41.6	Blockchain & Big Data Analytics

(Source: BPS, 2023; FAO, 2022; World Bank, 2023)

This data reveals significant opportunities for encouraging digital business model adoption in accelerating modern agricultural transformation in Indonesia. Studies on agricultural digitalization have been conducted across various countries. Susanto & Arifin (2021) highlight digital platforms' role in expanding market access for smallholder farmers in Indonesia. Zhang & Liu (2022) found that blockchain application improves agricultural supply chain transparency in China. Meanwhile, Navas-Bonilla et al. (2025) through systematic study emphasized digital technology's important role in strengthening inclusive agricultural sustainability. However, research still predominantly focuses on technological aspects rather than community-based business model strategies (Susanto & Arifin, 2021; Zhang & Liu, 2022; Navas-Bonilla et al., 2025).

Although previous literature discusses digital technology's role in agriculture, a research gap exists regarding how digital business models can be empirically implemented in farming communities, particularly considering social, economic, and cultural dimensions influencing local-level digital adoption. Most research emphasizes technological aspects without examining these

contextual factors. Additionally, empirical studies on Indonesian farmers' adaptation patterns to digital business models remain limited, leaving no tested framework to support digital agriculture transformation policies (Rahmawati & Putra, 2021; Nugroho & Hartati, 2022; Wahyudi, 2023).

This research's novelty lies in developing a community-based digital business model integrating technology with farmers' socio-economic collaboration aspects. Unlike previous studies focusing solely on technology application, this research emphasizes how farming communities can build inclusive, efficient, and sustainable business systems through field-based empirical investigation. This provides new contributions to agricultural digitalization strategy literature in developing countries (Pratama, 2023; Zhang et al., 2023; Navas-Bonilla et al., 2025).

Based on the above description, this study aims to: (1) identify digital technology utilization patterns by farming communities; (2) analyze supporting and inhibiting factors for digital business model adoption in agriculture; and (3) formulate context-appropriate digital business models to strengthen modern agricultural sustainability in Indonesia. Thus, this study contributes theoretically to agricultural digitalization studies development and practically to government policies and farmer community strategies (Jamil et al., 2022; Widodo & Astuti, 2023; BPS, 2023).

RESEARCH METHOD

Research Design

This research uses a qualitative approach with a case study design. This approach was chosen because the focus of the research is to explore in depth how to apply digital business models in the development of modern agriculture in farming communities. The case study allows researchers to understand the phenomenon holistically, from the socio-economic context to the patterns of farmers' interaction with digital technology. Thus, this study not only illustrates empirical facts, but also analyzes the dynamics and meanings behind the adoption of digital business models by farmers (Creswell & Poth, 2018; Yin, 2019; Moleong, 2021).

Location and Research Subject

The location of the research was determined in one of the farming communities in Cirebon Regency, West Java, which has begun to integrate digital technology in its agricultural activities, such as the use of agritech applications, agricultural e-commerce, and digital recording systems. The selection of the location was carried out purposively with the consideration that this community is in the transition stage from traditional agriculture to modern agriculture. The research subjects consisted of 15 community member farmers, 2 farmer group leaders, and 3 field assistants involved in the agricultural digitalization program. Subject selection was carried out using purposive sampling techniques to obtain informants relevant to the research objectives. All participants provided informed consent, and ethical clearance was obtained from the institutional review board prior to data collection (Sugiyono, 2020; Miles et al., 2018; Patton, 2019).

Research Instruments

The main instrument of research is the researcher himself as a human instrument who plays an active role in collecting, analyzing, and interpreting data. To support the data collection process, the researcher also used semi-structured interview guidelines, participatory observation sheets, and supporting documents in the form of community reports, production records, and digital transaction

data. The validity of the data is maintained through triangulation of sources and techniques, so that a comprehensive picture of the phenomenon being studied is obtained (Moleong, 2021; Creswell & Poth, 2018; Sugiyono, 2020).

Data Collection Techniques

Data were collected using three complementary techniques—(1) in-depth interviews with farmers, group leaders, and field assistants to probe experiences with digital business models, adoption challenges, and perceived impacts on productivity and market access, guided by questions on technologies adopted and reasons, barriers faced, effects on income and market reach, and required supports; (2) participatory observation, in which researchers embedded in farmer community activities to observe adoption processes, member interactions, and managerial practices across digital agricultural supply chains, focusing on usage frequency, social learning patterns, infrastructure constraints, and local innovations; and (3) a documentation study assembling digital transaction records, mentoring reports, and internal community data. These methods enabled triangulation to bolster validity. Data were analyzed thematically through transcription, open coding, axial coding, and theme development, with iterative analysis conducted throughout the fieldwork to refine and saturate emerging insights (Yin, 2019; Miles et al., 2018; Sugiyono, 2020).

Data Analysis Technique

Data analysis followed Miles et al.'s (2018) interactive model consisting of three stages: (1) Data condensation organizing and reducing field notes, interview transcripts, and observation records; (2) Data display creating matrices, charts, and thematic networks to identify patterns; and (3) Conclusion drawing and verificationinterpreting findings and validating through member checking and peer debriefing. Thematic analysis was employed to identify recurring themes related to digital adoption, barriers, and community adaptation strategies. NVivo 12 software was used to facilitate coding and categorization processes.

Table 2. Research Methodology Summary

Aspect	Description
Approach	Qualitative case study
Location	Cirebon Regency, West Java
Participants	15 farmers, 2 leaders, 3 assistants
Sampling	Purposive sampling
Data Collection	Interviews, observation, documentation
Duration	One planting cycle (3 months)
Analysis	Thematic analysis using NVivo 12
Validation	Triangulation, member checking

RESULTS AND DISCUSSION

This study involved 20 respondents consisting of 15 community farmers, two farmer group chairmen, and three field assistants. Most of the farmers are in the age range of 30–55 years, with

an average formal education background of junior and senior high school, as well as more than 15 years of farming experience. The majority of respondents are smallholders with less than 1 hectare of land, so access to capital and technology is still limited. However, around 60% of them have participated in agricultural digitalization training organized by the government and private institutions, especially related to the use of agritech applications and online marketing platforms. These findings are in line with Febrianda's (2021) research which states that the level of digital technology adoption among smallholders is influenced by factors such as education, age, and participation in training (*Febrianda, 2021*).

In-depth interviews with two farmer community leaders and three digital companions yielded some important findings. First, the community's main motivation for adopting a digital business model is to expand market access and cut long distribution chains. By utilizing digital platforms, the community hopes to obtain a more stable and profitable selling price. This finding is in line with Sinaga (2025) research which shows that agricultural digitalization is able to significantly increase the connection between farmers and end consumers (*Sinaga, 2025*).

Second, the main challenges they face are low digital literacy, limited internet infrastructure, and the resistance of some senior farmers who are still more comfortable with traditional distribution methods. This is consistent with the *Policy and Investment Roadmap of Digital Agriculture in Indonesia report* which identifies literacy and infrastructure as the biggest obstacles to the digitalization of the agricultural sector in Indonesia (*Rikolto, 2023*).

Third, the adaptation strategy carried out by the community is to hold regular training, collaborate with local agritech startups, and appoint millennial farmers as digital agents to assist other members in using the application. The Agrovital study (2024) also found that millennial farmers play an important role as a catalyst in accelerating technology adoption among communities (*Agrovital, 2024*).

To reinforce the findings of the interviews, questionnaires were distributed to 10 farmers who had completed digitalization training. The results of the questionnaire showed that 80% of respondents felt that there was an increase in online market access through agricultural e-commerce platforms, 70% of respondents admitted that they were more efficient in managing production through digital recording, and 60% of respondents understood the technical use of agritech applications. However, 75% of respondents still complained about unstable internet infrastructure, while 85% of respondents emphasized the need for follow-up assistance from external parties.

Table 3. Summary of Results of the Questionnaire of Trained Farmers

Aspects	**% Agree / Strongly Agree**
Increased access to online marketplaces	80%
Production management efficiency	70%
Technical understanding of agritech applications	60%
Internet infrastructure constraints	75%
In need of further assistance	85%

These findings reinforce Susanto and Arifin (2021) research showing that although farmers are interested in digital technology, infrastructure and literacy limitations remain primary obstacles.

This aligns with Zhang and Liu (2022) study affirming successful digital business model implementation requires infrastructure support and ongoing training.

Through three-month participatory observation, researchers documented several farmers using agritech applications for planting recording, fertilization, and crop management. Community members utilized WhatsApp groups to share market price information and coordinate crop distribution, demonstrating organic technology diffusion pioneered by digitally-literate millennial farmers.

Additionally, local innovations emerged, including simple weather sensors installed in rice fields to monitor soil moisture. Community interaction occurred dynamically through peer learning systems during training sessions. This supports Febrianda (2021) findings that social interaction significantly influences successful digital technology adoption in agriculture.

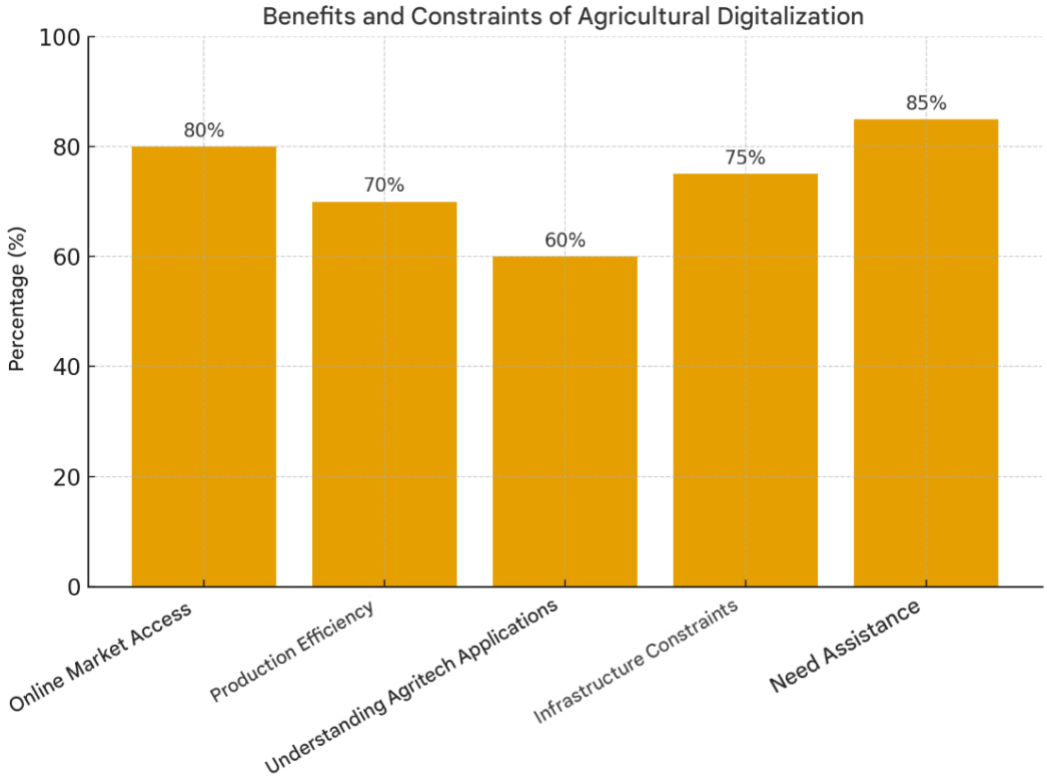

Figure 1. Comparative Graph of Benefits and Constraints of Agricultural Digitalization
(This graph illustrates that the benefits of digitalization are considerable, but structural constraints are still very dominant.)

Table 4. Synthesis of Interview and Observation Findings

Theme	Interview Findings	Field Observation
Access to digital markets	Used as the main motivation	Actively share prices via WhatsApp groups
Training & digital agents	Intensive training, millennial agents	Peer learning between farmers
Infrastructure	Significant internet barriers	Frequent network disruptions
Agritech technology	Positively welcomed	Simple weather sensor starts using

Overall, results demonstrate farming communities possess substantial potential for digital business model adoption but require stronger ecosystem support in infrastructure, literacy, and sustainable mentoring. Digitalization has provided tangible benefits through increased market access and production efficiency, yet full success remains hampered by structural barriers. This corresponds with global studies emphasizing multi-stakeholder collaboration (government, private, and community) importance in developing sustainable digital agriculture (Navas-Bonilla et al., 2025; Rikolto, 2023; Susanto & Arifin, 2021).

Interviews with farmer group leaders and digital companions reveal that digital business model adoption is viewed as crucial strategy for expanding market access while breaking lengthy traditional distribution chains. Through digital platforms, farmers can sell crops directly to consumers or retailers without intermediaries, increasing profit margins and price stability. This interpretation aligns with Sinaga (2025) findings explaining agricultural digitalization contributes to price transparency and strengthens farmers' bargaining position in national markets. However, interviews also revealed obstacles including low digital literacy, limited internet infrastructure, and resistance from senior farmers preferring conventional methods. These barriers align with the Policy and Investment Roadmap of Digital Agriculture in Indonesia report emphasizing literacy, infrastructure, and social resistance as main factors hindering digital agriculture technology adoption (Rikolto, 2023). Notably, communities address these problems through adaptation strategies such as appointing millennial farmers as digital agents, conducting regular training, and collaborating with agritech startups. These findings reinforce Agrovital (2024) view emphasizing young farmers' important role in accelerating agricultural digitalization processes.

Questionnaire results from ten trained farmers provide concrete understanding of digitalization benefits and challenges. Eighty percent of respondents reported increased online market access after using digital platforms, while seventy percent assessed digital recording helped improve production efficiency, indicating digitalization's real benefits in crop distribution and production management. This result aligns with Zhang and Liu (2022) research finding e-commerce application in agriculture shortens supply chains and improves distribution efficiency. Despite this, approximately seventy-five percent of respondents still face internet infrastructure constraints, and eighty-five percent emphasize the need for follow-up assistance, showing digital transformation requires not only technological interventions but also sustainable ecosystem support, including intensive training programs and field mentoring. This condition corresponds with Susanto and Arifin (2021) findings

explaining agricultural digitalization success is highly determined by mentoring program quality.

Three-month field observations strengthened interview and questionnaire results, showing community digital technology use remains selective, limited to planting recording, fertilization, and price information access through WhatsApp groups. Agritech apps are primarily used by younger farmers familiar with digital technology, while senior farmers tend to lag behind, reflecting generational digital divide affecting overall adoption success. Additionally, local innovations emerged including simple weather sensor usage to monitor soil moisture, showing that despite incomplete modern technology integration, farming communities can adapt according to local needs. These findings support Febrianda (2021) study confirming agricultural technology adoption success is influenced by community social interaction and ability to contextualize technology according to local realities. Furthermore, community interaction patterns show training occurs through peer learning mechanisms, where tech-savvy farmers assist colleagues, proving technology adoption in traditional communities is more effective through organically-developed social solidarity-based approaches rather than top-down interventions.

Compared to previous research, this study provides new perspectives. While Susanto and Arifin (2021) emphasized infrastructure and literacy limitations as main obstacles to agricultural digitalization in Indonesia, this study confirms these findings but also demonstrates that community-based adaptation strategies such as digital agents and peer learning systems can be relatively effective solutions. Meanwhile, Zhang and Liu's (2022) study in China emphasized blockchain application in increasing consumer trust in agricultural products. This research differs by highlighting online market access and production efficiency aspects directly experienced by smallholders, thus enriching literature by providing empirical overview of digitalization's contribution to farmer welfare. An unexpected finding emerged regarding the speed of peer-to-peer learning adoption compared to formal training programs, suggesting that informal knowledge transfer mechanisms may be more culturally appropriate than structured interventions in Indonesian farming communities. Additionally, Navas-Bonilla et al. (2025) systematic study confirms inclusivity is key factor in agricultural digitalization sustainability. This study adds that inclusivity can be realized through community mechanisms positioning farmers as main actors, not merely technology recipients.

Regarding practical implications, this study emphasizes the need to design community-based digital business models more adaptive to local conditions, integrating not only technology but also social collaboration, literacy, and sustainability aspects. Government and private institutions should develop long-term mentoring programs ensuring farmers can truly leverage digital technology. Short training should be followed by mentoring mechanisms, digital agent provision, and adequate infrastructure support. Specifically, recommendations include: (1) establishing dedicated digital agent networks in each sub-district; (2) developing mobile-based training modules accessible offline; (3) creating public-private partnerships for rural internet infrastructure improvement; (4) designing incentive programs for early adopters; and (5) integrating digital literacy into existing agricultural extension services. Additionally, agricultural digitalization needs integration with supply chain systems, not only improving production efficiency but also connecting farmers with markets, financial institutions, and logistics networks. If this integration is achieved, digitalization can make real contributions to national food security and farmer welfare improvement.

Although producing relevant findings, this study has limitations. First, respondent numbers remain limited to one farming community in Cirebon Regency, preventing result generalization throughout Indonesia. Second, the qualitative approach used provides analytical depth but does not allow broad-scale quantitative measurement, for example related to income increase or statistical productivity. Third, limited research time caused observations covering only one planting cycle, not describing long-term impacts of digital business model implementation. This limitation aligns with similar research reflection by Susanto and Arifin (2021) emphasizing the need for qualitative and quantitative method combinations to produce more comprehensive understanding. Therefore, follow-up research is strongly recommended to expand respondent numbers, use mixed methods approaches, and assess long-term social and economic impacts. Future studies should also examine digital business model sustainability across different crop types and regional contexts, as well as investigate gender dimensions in agricultural digitalization adoption.

Overall, discussion results show digital business models have great potential for improving smallholder welfare in Indonesia. Real benefits including increased market access and production efficiency have been experienced, but structural challenges such as literacy, infrastructure, and social resistance remain major barriers. These empirical findings strengthen existing literature while offering novelty in community-based strategies that can be adaptive solutions for agricultural digitalization sustainability in Indonesia.

CONCLUSION

This study shows that applying digital business models in Indonesia's farming communities has strong potential to improve welfare by expanding market access and increasing production-management efficiency. Interview, survey, and observation data confirm benefits such as shortening distribution chains and creating direct-to-consumer sales opportunities; 80% of trained farmers reported increased market access, 70% experienced production efficiency gains, and 60% acquired technical competencies in agritech. However, adoption is still constrained by low digital literacy, limited internet infrastructure, and resistance to change among some senior farmers.

Successful implementation is determined not only by technology but also by supporting social mechanisms: involving millennial farmers as digital agents, providing continuous local training, and fostering community-based peer learning. Academically, the study confirms that adopting digital business models improves economic efficiency while strengthening collaborative social dynamics within farmer groups. Practically, it calls for long-term mentoring, infrastructure upgrades, and integration of digital technologies with agricultural supply chains. Future research should employ mixed-methods across regions, conduct longitudinal assessments over multiple planting cycles, and perform cost–benefit analyses of different digitization models. Thus, digital business models are a promising sustainability strategy, but they require comprehensive ecosystem support to ensure benefits are widely and sustainably optimized.

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