



BREAKING BARRIERS TO DIGITAL ADOPTION: A CASE STUDY OF PADDY FARMERS IN WEST KALIMANTAN

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ABSTRACT

The adoption of digital agricultural technologies is regarded as a pivotal measure for enhancing productivity and efficiency in Indonesia's paddy farming sector. This research is concerned with the factors that influence the adoption of digital technologies among paddy farmers in Kubu Raya Regency, West Kalimantan. A quantitative approach was employed in the study, which involved 150 farmers. The role of government support, farmer characteristics, mentoring, and perceptions in promoting agricultural digitalisation was analysed. The findings indicate that the role of the government, particularly in the development of infrastructure and the provision of financial assistance, is the most significant factor influencing the adoption of digital technologies. Mentoring programs, in particular those that concentrate on the spheres of education and motivation, also assume a pivotal role. However, contrary to expectations, farmers' perceptions alone do not significantly impact their decision to adopt digital technologies. This suggests that, while attitudes towards technology are favourable, structural and educational support are vital for effective implementation. The study concludes that the key factors in fostering digital transformation in the region's agricultural sector are the enhancement of infrastructure, the provision of targeted training, and the offering of financial incentives.

INTRODUCTION

Indonesia, an agricultural nation with 31.5% of its area dedicated to agriculture, faces challenges in its agricultural sector, including low productivity, minimal technology use, and high climatic reliance, compounded by a digital divide in rural areas where inadequate infrastructure and socio-economic disparities hinder internet access and digital participation. However, digital technology has the potential to significantly boost agricultural productivity and efficiency by enabling



farmers to optimize resource use and improve yields, ultimately transforming the industry into a more sustainable sector that enhances the quality of agricultural products (Bocean, 2024; Fatimah et al., 2023).

Digitization in agriculture enhances management practices and real-time feedback mechanisms, which are crucial for improving crop production and addressing challenges such as inefficiencies and environmental concerns (Hrustek, 2020; Shen et al., 2023; Sparrow & Howard, 2020; Vardanyan et al., 2022), making the adoption of digital technology essential for modern agriculture to meet the demands of a growing population while promoting sustainable practices (Beksultanova et al., 2023; Martens & Zscheischler, 2022). Rice, a staple for most Indonesians, must be available in good quality and sufficient quantities, as the Indonesian government aims to become a top global food supplier by 2045 through improved agricultural sustainability and productivity, supported by strategies that include smart farming technologies such as IoT, artificial lighting, and automated irrigation to enhance yields and resource management (Khairudin et al., 2023; Ananda et al., 2023; Rahmadhani et al., 2022).

Digitization can boost paddy rice production in West Kalimantan. The digitalization of Indonesian agriculture via IoT will transform its food supply system. The Internet of Things (IoT) optimizes the utilization of resources and increases crop yields in agriculture. Farmers can now maximize production yields, reduce distribution costs, and plan their operations digitally. They can plan the pre-planting, planting, harvesting and post-harvesting periods, as well as listing expenses, insurance, fertilizer, seed and rice processing (Irawan et al., 2023; Prihadyanti & Aziz, 2022).

Despite digitalization influencing agriculture, few paddy farmers in West Kalimantan are adopting it. Low uptake of tech and digitalization by farmers hinders productivity and sustainability. The challenge is made worse by a lack of technical knowledge and skills needed to operate advanced tech like IoT (Jabbari et al., 2023; Strong et al., 2022). Many farmers lack training and support to utilize innovations, which hinders their willingness to adopt new practices. (Jabbari et al., 2023; Strong et al., 2022). To increase digitization among paddy farmers, we must identify factors that will encourage them to embrace digitalization and the Internet of Things.

This research project focuses on the experiences of paddy farmers in West Kalimantan. The research area has been selected as Kubu Raya Regency, which is a prominent centre for paddy production in West Kalimantan. Kubu Raya, located within West Kalimantan Province, possesses considerable potential for rice and paddy production. However, the region confronts several challenges, including production volatility, constrained resources, and a paucity of market intelligence. Rice production witnessed a decline from 70,329.58 tons in 2022 to 55,707.44 tons in 2023. The adoption of digital technologies holds promise as a means to enhance productivity. Digital technologies, such as access to the latest information, agricultural technology, and e-commerce platforms, hold the potential to optimize crop yields and enhance farmers' income. Online training has also been identified as a means to improve the quality of farming. Consequently, the promotion of digitalization initiatives is imperative for ensuring the welfare of farmers and maintaining food security in Kubu Raya

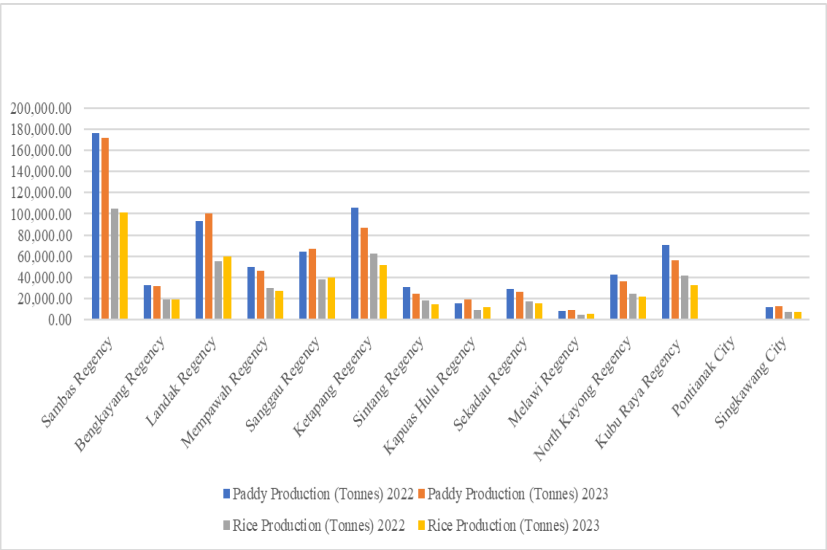


Figure 1.
Paddy and Rice Production in West Kalimantan Province
Source: Central Bureau of Statistics of West Kalimantan Province (2024)

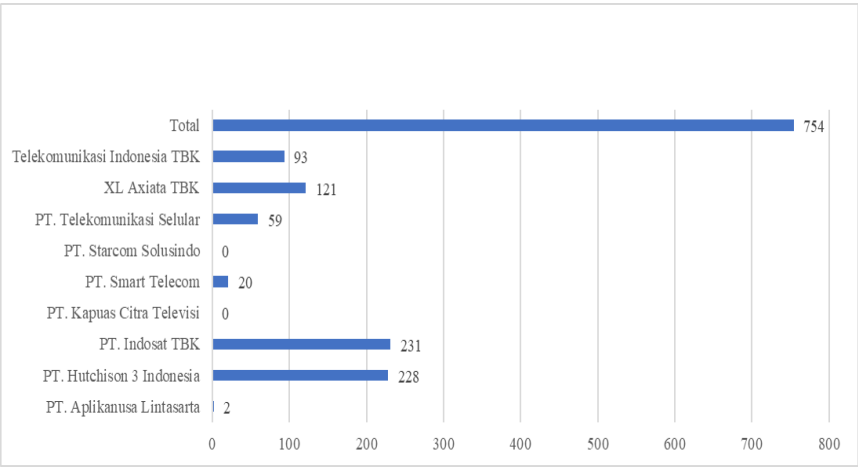


Figure 2.
Number of Base Transceiver Station (BTS) Towers in Kubu Raya Regency
Source: Communication and Informatics Office of West Kalimantan Province (2021)

Research into paddy cultivation in Kubu Raya could greatly enhance sustainable agricultural practices and paddy productivity in West Kalimantan, further supported by the local government's push for digitalization, exemplified by the construction of base transceiver station towers (BTS).

This research identifies factors influencing the adoption of digital technology by paddy rice farmers. The study also looks at the obstacles farmers face in adopting digital technology. Digitalization can improve agricultural productivity and efficiency. Paddy farmers have been slow to adopt digital technology.

Understanding why will help us provide tailored solutions. Factors include access, infrastructure, usability, perceived benefits, education, farmer characteristics, social support and regulation (Maulida et al., 2023; Mulyani & Sofea, 2020).

This study aims to understand the extent of digitization adoption among paddy farmers in West Kalimantan and identify the factors influencing this adoption, with findings intended to assist businesses and the government in promoting digital technology in agriculture while managing legal risks. Indonesian paddy farmers adopt digital technology for reasons such as access to information, training, and perceived benefits, yet many face obstacles despite the growing popularity of digital farming (Irawan et al., 2023; Rusmayadi et al., 2023). Consequently, this research can guide the development of strategies to enhance digitization adoption among paddy farmers, including improving technology access and infrastructure, providing adequate training and education, developing affordable technology, increasing government support, and enhancing farmers' digital literacy.

RESEARCH METHOD

The research was conducted using quantitative methods to obtain empirical data that currently exist. This research was conducted for 1 year in the West Kalimantan region. Kubu Raya Regency was chosen as the research location because it is the centre of paddy production in West Kalimantan. Data collection will be carried out in 3 sub-districts in Kubu Raya Regency, namely Sungai Kakap District, Rasau Jaya District and Sungai Raya District. Each sub-district will be a sample in this study, so the total respondents in this study is 150 farmers. Data collection includes primary data and secondary data, which includes farmer perceptions, farmer characteristics, the role of mentoring and agricultural digitalization. Primary data collection techniques are obtained from observation or direct observation methods in the field through direct interviews with respondents using questionnaires. Data collection in this study was conducted using a Likert scale.

The pattern of relationships between latent constructs and their indicators, latent constructs with each other, and direct error measurements can all be examined using Structural Equations Modelling (SEM). SEM is a statistical analysis technique used to test complex theoretical models using empirical data. The model usually consists of several unmeasured variables (such as perception, motivation, and satisfaction) that are linked to measured variables (such as survey responses or observational data) through parameters that can be estimated (Habibi, 2022; Lubis et al., 2020; Muhtarom et al., 2022). The analysis in this study utilized the SEM approach, processed through the LISREL program.

Within this study on the determinants of digitalization adoption among paddy rice farmers in West Kalimantan, SEM was employed to examine the relationships between the independent variables farmer perceptions (X_1), farmer characteristics (X_2), the role of assistance (X_3), and government support (X_4) and the dependent variable, agricultural digitalization (Y_1).

By using SEM, researchers can test hypotheses and estimate model parameters that cannot be tested directly using ordinary statistical methods. In addition, SEM can measure and estimate the direct and indirect effect between variables, thus enabling researchers to see the extent to which independent variables affect the dependent variable. Thus, the use of SEM in this study can provide more detailed

results and can provide deeper insights into the factors that influence agricultural digitalization by paddy farmers in West Kalimantan.

RESULT AND DISCUSSION

Respondent Characteristics

The study considers respondents' age, education, experience in agricultural production and land holdings. Most respondents had completed junior or senior high school, with few having a bachelor's or master's degree. 10.67% had no formal education, while 0.67% had only reached kindergarten. Most respondents (58.67%) managed less than one hectare, while 37.33% had between two and three, and only 4% had more than three. The respondents had 20-37 (46%) or 38-53 (42%) years of farming experience. 12% of respondents had accumulated experience spanning 61-78 years. Most respondents were between 44 and 60 years old. They were experienced farmers of productive age with a range of educational backgrounds and relatively limited land area.

A total of 150 respondents from three sub-districts in Kubu Raya Regency were selected for this study. Sungai Raya, Sungai Kakap and Rasau Jaya. Most farmers in Kubu Raya Regency are of working age. The study showed that farmers' age affects their ability to embrace digitalisation in agriculture. Farmers in Indonesia are usually between 15 and 64 years old. Farmers in this age group have more positive attitudes and higher motivation, which improves productivity (Feriadi et al., 2022; Susiana et al., 2023). Farmers in the productive age group are more inclined to adopt new technologies that can enhance their agricultural performance (Mustaming et al., 2023). They can work longer than the elderly and children. In agriculture, yields could increase if they are willing to do so. Age affects the digitalisation of agriculture, as postulated by Mulyani & Sofea (2020).

The path diagram represents the final SEM model with standardised solutions. The model has four latent variables (X_1 , X_2 , X_3 , X_4) assessed through indicators ($X_{1.1}$ to $X_{4.5}$). Factor loading values on connecting paths between indicators and latent variables vary from 0.30 to 0.87, indicating each indicator's contribution to the latent variable it represents. $X_{1.1}$ has a loading of 0.66 on X_1 , while $X_{4.1}$ has a loading of 0.62 on X_4 . These two indicators contribute significantly to their respective latent variables.

Results of Structural Equation Modeling (SEM) Analysis

The results of the SEM estimation are presented in Figure 3. From Figure 3, X_1 , X_2 , X_3 , and X_4 are directly related to Y_1 . This coefficient shows the strength of the relationship between the latent variables. X_1 and Y_1 have a weak, negative relationship (coefficient: -0.04). The coefficient for X_3 and X_4 is higher than for X_1 and X_2 , indicating that they exert a more pronounced influence on Y_1 . Furthermore, latent variable Y_1 influences five outcome variables ($Y_{1.1}$ to $Y_{1.5}$). Coefficients on the paths indicate the strength of the relationship between Y_1 and its variables. Y_1 has a coefficient of 0.87 on $Y_{1.1}$, indicating a strong relationship. The remaining coefficients range from 0.36 to 0.74, indicating Y_1 influences all variables significantly.

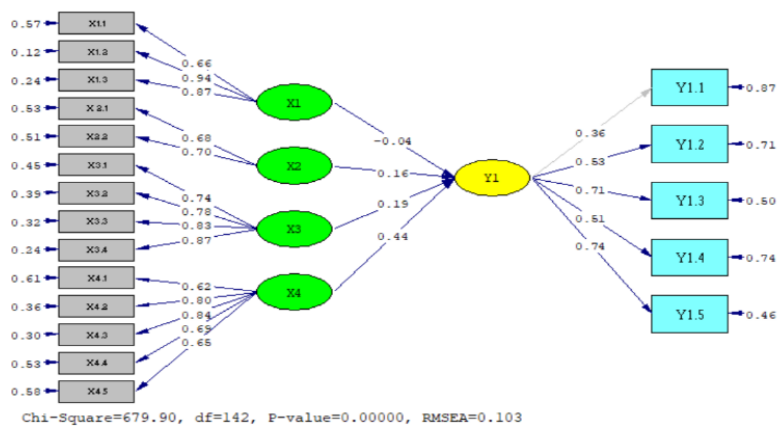


Figure 3
Estimation of SEM Model

The RMSEA value of 0.103 indicates the model may not fit the data adequately. An RMSEA value exceeding 0.08 indicates the model may require refinement to achieve a superior fit. The model demonstrates a notable impact between the latent and outcome variables, but there is still room for improvement. The result is presented in Figure 4.

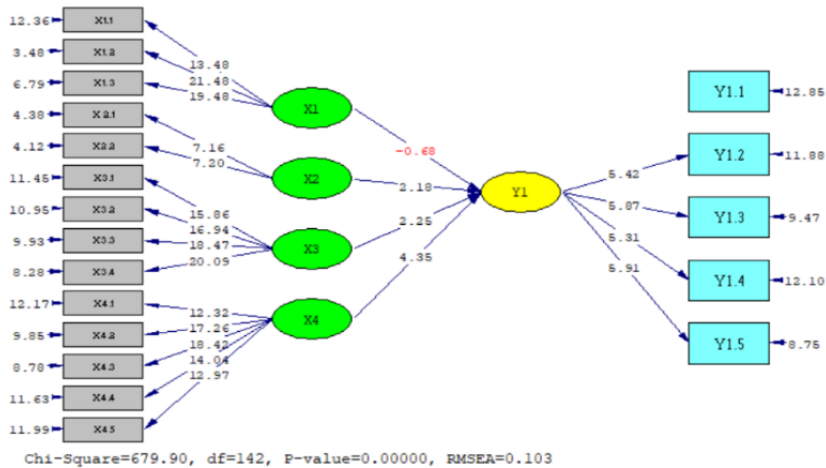


Figure 4.
Flowchart of the Final Model t-Value

The path diagram shows a structural equation model (SEM) with a t-value used to assess the significance of the relationship between variables. The model comprises four latent variables, each with several indicators. The T-values on the paths between the latent variables and their indicators indicate the significance level of the relationship.

The majority of the relationships are found to be significant. In the structural model, X1, X2, X3 and X4 are directly related to Y1. The T-value indicates the significance of relationships. X1 and Y1 have a correlation of -0.68, which is not statistically significant. The associations between X3 and Y1, as well as X4 and Y1, are significant. Moreover, latent variable Y1 exerts influence over five outcome variables.

Most relationships are statistically significant, indicating notable influence. The fit of this model is statistically significant but raises concerns. The model may not align with the data. Some relationships may require further refinement.

After retesting, we finally obtained the overall measurement results of the model with all observed variable/indicator values valid. The table shows the results of the evaluation of the validity and reliability of each latent variable or indicator.

Table 3. Significant Indicator Test Result

Variable	Construct/Indicator	Loading Factor	t-cal (>1.96)	Remarks
Farmer Perceptions, X ₁	Cognitive, X _{1,1}	0.66	13.48	Significant
	Affective, X _{1,2}	0.94	21.48	Significant
	Conative, X _{1,3}	0.87	19.40	Significant
Farmer Characteristics, X ₂	Age, X _{2,1}	0.68	7.16	Significant
	Formal Education, X _{2,2}	0.70	7.20	Significant
	Educator, X _{3,1}	0.74	15.86	Significant
Role of Assistance, X ₃	Mediator, X _{3,2}	0.78	16.94	Significant
	Motivator, X _{3,3}	0.83	18.47	Significant
	Evaluator, X _{3,4}	0.87	20.09	Significant
	Infrastructure Development, X _{4,1}	0.62	12.32	Significant
Role of Government, X ₄	Agricultural Area Improvement to Support	0.80	17.26	Significant
	Digitalisation, X _{4,2}	0.84	18.42	Significant
	Government Coordination, X _{4,3}			
	Funding for Farmers, X _{4,4}			
Digitisation of Agriculture, Y ₁	Relative Advantages, Y _{1,1}	0.36	-	Insignificant
	Compability, Y _{1,2}	0.53	5.42	Significant
	Complexity, Y _{1,3}	0.71	5.87	Significant
	Triability, Y _{1,4}	0.51	5.31	Significant
	Observability, Y _{1,5}	0.74	5.91	Significant

Farmer Perceptions (X₁)

Farmers’ perceptions of agricultural digitalization were assessed through three key components, with the affective aspect emerging as the most influential. This highlights that farmers’ attitudes and emotions toward digitalization play a central role in shaping adoption behavior.

Understanding these perceptions is essential, as they directly influence farmers’ willingness to adopt digital tools and services. For many smallholders, extension services serve as an important channel to access knowledge about digital technologies, which in turn guides their decisions (Hoang & Tran, 2023). When farmers recognize tangible benefits such as higher productivity and reduced labor

demands they are more inclined to embrace innovation (Bontsa et al., 2023; Xie et al., 2021).

However, barriers remain. Limited digital literacy and inadequate training can slow adoption (Abdulai et al., 2023; Bindurajashekar, Rani, Karthikeyan, Malarkodi, & Selvi, 2023). In addition, some farmers may be hesitant to shift from familiar, traditional practices to new digital approaches. Overcoming these challenges requires targeted training and consistent support (Abdulai et al., 2023; Bindurajashekar et al., 2023). Ultimately, farmers' attitudes, combined with access to appropriate resources, can significantly accelerate the uptake of digital technologies in agriculture.

Farmer Characteristics (X_2)

Farmers' characteristics were assessed using two indicators: age and formal education. Both indicators showed strong correlations, with loading factor values of 0.68 and 0.70 and significant t-values. These findings suggest that age and educational background play an important role in shaping farmers' readiness for digitalization in agriculture, with education serving as a key driver in the adaptation process.

The adoption of digital technologies among farmers is influenced by personal and socio-economic factors. Younger farmers, equipped with higher levels of digital literacy and familiarity with technology, tend to adopt digital tools more readily (Abdulai et al., 2022; Nnodim & Raji, 2020). In contrast, older farmers often face barriers such as limited technical expertise or hesitation toward new methods (Gao et al., 2024). Education is strongly linked to digital literacy: those with higher formal education, particularly in agriculture, are more likely to recognize the potential benefits of digitalization, including productivity gains and increased income (Zhang & Fan, 2023). To overcome disparities, tailored training and financial incentives are essential, ensuring that farmers across different age groups can effectively adopt and benefit from digital agriculture (Malinina & Gurieva, 2024; Parwada & Marufu, 2023).

Role of Assistance (X_3)

The mentoring role is reflected in four key indicators: educator, mediator, motivator, and evaluator. All four demonstrate strong loading factor values (0.74–0.87) with significant t-values, underscoring their importance. Among them, evaluation carries the greatest weight, highlighting its critical role in ensuring the effectiveness of mentoring within agricultural digitalization.

Extension workers play a central role in this process, serving not only as knowledge providers but also as mentors who guide farmers through the transition to digital practices. Through extension services, farmers gain access to information, training, and practical demonstrations that build their confidence in using digital tools. By offering consistent support and evaluation, extension workers strengthen farmers' capacity to adopt and integrate digital technologies into their agricultural practices (Rajkhowa & Qaim, 2021; Singh, 2023).

The role of extension workers in bridging communication between technology providers and farmers is crucial. By tailoring digital extension services to local needs, they ensure that farmers receive information that is both relevant and practical

(Singh, 2023). This personalized approach not only empowers farmers but also creates a collaborative space where they can exchange experiences and learn from one another, further strengthening the adoption of digital practices (Sinuhaji et al., 2024).

Effective mentoring enables farmers to make better use of digital tools such as mobile applications and data analytics that are increasingly essential in modern agriculture (Singh, 2023; Zhang & Fan, 2023). Through guidance and support, extension workers play a vital role in driving digital transformation in farming, helping to enhance both productivity and sustainability (Abdulai & Huffman, 2014; Hoang & Tran, 2023).

Role of Government (X_4)

The government's role was assessed through four key indicators: infrastructure, agricultural digitalization, coordination, and financial support. All indicators showed strong loading factor values, with agricultural improvement ($X_{4.2}$) having the most significant impact. This highlights the government's critical role in expanding digital access and strengthening infrastructure for agricultural transformation.

Government involvement in agricultural digitalization is multifaceted and central to creating an environment that supports technology adoption. Financial assistance and targeted incentives can accelerate the development and deployment of digital technologies, supported by diverse financing mechanisms that combine public, private, and social capital (Tang & Chen, 2022; Beksultanova et al., 2023). Equally important are training programs that equip farmers with the skills needed to reduce the digital divide (Zheng et al., 2024). Governments can also act as facilitators, fostering collaboration between technology providers and agricultural stakeholders to ensure that solutions align with farmers' practical needs (Eremina et al., 2022).

A supportive policy framework and proactive government engagement can significantly accelerate digital adoption in agriculture, ultimately driving higher productivity and greater sustainability (Leng & Tong, 2022; Lian, 2024).

Digitisation of Agriculture (Y_1)

The agricultural digitalization construct was assessed through five indicators. Of these, relative advantage was not statistically significant, while compatibility, complexity, testability, and observability proved significant. These results emphasize that ease of implementation, alignment with farmers' existing practices, and the ability to test and observe outcomes are critical drivers of successful adoption.

Although the benefits of digitalization such as increased efficiency and productivity are widely acknowledged, they do not exert a strong direct influence on adoption. This is largely due to persistent barriers, including high upfront costs, limited technical capacity, and inadequate infrastructure (Pillai & Sivathanu, 2020). For instance, while IoT technologies offer clear advantages, the financial burden of their implementation often deters farmers from integrating them into their practices (Pillai & Sivathanu, 2020).

The importance of testability and observability cannot be overstated, as prior studies show that farmers are more inclined to adopt technologies they can first trial

on a small scale and from which they can observe clear, tangible benefits before committing to full implementation (Oo & Usami, 2020; Putri, Syahni, Hasnah, & Miko, 2023). Likewise, when digital tools are seen as compatible with traditional farming practices, adoption becomes more likely. In contrast, high levels of complexity can discourage adoption, as farmers may feel uncertain, overwhelmed, or unable to use the technologies effectively (Abegunde et al, 2020; Putri et al., 2023).

Testability and observability are critical factors in driving farmers’ adoption of digital technologies. Evidence from previous studies shows that farmers are more willing to adopt innovations they can first trial on a small scale and from which they can observe tangible benefits before committing to full implementation (Oo & Usami, 2020; Putri et al., 2023). This step-by-step approach not only builds farmers’ confidence but also reduces perceived risks. While the broader advantages of digitalization are acknowledged, these indicators play a pivotal role in ensuring a smoother transition to digital practices, as they directly shape farmers’ perceptions and decisions regarding adoption (Oo & Usami, 2020; Putri et al., 2023).

The analysis reveals that farmers’ perceptions, personal characteristics, mentoring, and government support are pivotal in driving agricultural digitalization. Among these, perceptions, education, mentoring, and policy support emerge as the most influential factors. In the adoption process, ease of use, compatibility with existing practices, and testability prove more critical than relative advantages. This underscores that the success of agricultural digitalization depends less on the technology’s inherent benefits and more on how effectively it is adapted and made accessible to farmers.

Table 4. Hypothesis of Farmer Perceptions, Farmer Characteristics, Role of Assistance, and Role of Government on Digitisation of Agriculture

Correlation Between Variables	Path Coefficient	t-cal	Conclusion
$X_1 \rightarrow Y_1$	-0.04	-0.68	Insignificant
$X_2 \rightarrow Y_1$	0.16	2.18	Significant
$X_3 \rightarrow Y_1$	0.19	2.25	Significant
$X_4 \rightarrow Y_1$	0.44	4.35	Significant

Note: t table: 1.96

Effect of Farmers' Perception (X_1) on Agricultural Digitalisation (Y_1)

The path coefficient of -0.04 with a t-value of -0.68 indicates that farmers’ perceptions have no significant effect on agricultural digitalization. Since the t-value is below the threshold of 1.96, it suggests that perceptions do not directly influence the adoption of digital technologies in agriculture.

While farmers’ perceptions are generally recognized as shaping agricultural practices, their impact on digitalization appears less substantial than expected, likely due to contextual constraints. For example, positive perceptions of technology may encourage farmers to join extension programs or express interest in innovation, but these do not always translate into actual adoption when barriers such as poor infrastructure or high costs of digital tools persist (Korie et al., 2022).

The complexity of digital technologies can often create confusion and hesitation among farmers, overshadowing the positive perceptions they may have about the potential benefits of digitalization (Vasan & Yoganandan, 2023). In

addition, socio-cultural beliefs and traditional practices may discourage farmers from embracing new technologies, further complicating the link between perception and actual adoption (Li et al., 2017).

A lack of tailored support and training also limits farmers' ability to effectively use digital tools, even when they recognize their advantages (Thanh et al., 2015). This highlights that while farmers' perceptions are important, they represent only one part of a wider set of economic, social, and infrastructural factors that collectively shape the success of agricultural digitalization.

Effect of Farmer Characteristics (X_2) on Agricultural Digitalisation (Y_1)

The path coefficient of 0.16 with a t-value of 2.18 indicates that farmer characteristics significantly influence agricultural digitalization. Since the t-value exceeds the threshold of 1.96, it confirms that characteristics such as age, education, gender, and socio-economic status play a critical role in shaping adoption and effective use of digital technologies.

Younger farmers tend to be more open to adopting digital tools due to greater digital literacy and familiarity with technology (Hoang & Tran, 2023; Miine et al., 2023), whereas older farmers may be more hesitant, which can slow adoption (Hoang & Tran, 2023). Education also emerges as a key determinant, with better-educated farmers more capable of understanding and applying digital solutions (Amelia, 2023; Mendes et al., 2023). Gender differences further complicate adoption, as unequal access to resources and information shapes participation in digital agriculture (Abdulai et al., 2022; Abdul-Rahaman & Abdulai, 2021).

Additionally, socio-economic factors such as farm size and income levels influence farmers' capacity to invest in digital technologies (Liu & Zhang, 2023; Singh, 2023). Recognizing these characteristics is essential for designing targeted interventions and support systems that can accelerate agricultural digital transformation, ultimately enhancing productivity and sustainability.

Effect of Mentoring Role (X_3) on Agriculture Digitalisation (Y_1)

The analysis shows that mentoring plays a significant role in promoting agricultural digitalization. With a t-count exceeding 1.96, mentoring demonstrates a positive effect on the adoption of digital practices, underscoring its importance in supporting farmers.

Agricultural extension workers serve as key mentors by facilitating knowledge transfer, building technical skills, and offering encouragement to farmers. Well-structured mentoring programs help farmers navigate the complexities of digital technologies, boosting both their confidence and willingness to adopt these innovations (Lamm, Sapp, & Lamm, 2017; Tummons, Kitchel, & Garton, 2016). Practical, hands-on mentoring that emphasizes real-world applications of digital tools has been shown to improve farmers' understanding and effective use of these technologies, which is essential for driving successful digital transformation in agriculture (Malinina & Gurieva, 2024; Tortorella et al., 2023).

Mentoring also fosters a supportive environment where farmers can share experiences and learn from one another, helping to build a community of practice around digital agriculture (Ruth et al., 2020; Seli et al., 2024). This collaborative setting not only strengthens individual farmers' capabilities but also drives collective

improvements in agricultural practices within the wider community (Law et al., 2014).

In addition, the psychosocial support provided through mentoring helps to ease farmers' concerns and reduce resistance to change, making them more open to adopting digital solutions (Lamm et al., 2017; Tummons et al., 2016). By combining skill-building, knowledge transfer, and positive reinforcement, mentoring plays a pivotal role in agricultural digitalization. It equips farmers with the necessary competencies while cultivating favorable attitudes toward technology adoption, ultimately contributing to higher productivity and greater sustainability in the agricultural sector (Jones et al., 2014; Nesbitt & Barry, 2022).

Effect of Government Role (X_4) on Agriculture Digitalisation (Y_1)

The government's role emerges as the most influential factor in agricultural digitalization, with a path coefficient of 0.44 and a t-value of 4.35. This significance, supported by a t-value well above 1.96, highlights the critical contribution of government support through infrastructure development, agricultural improvement, coordination, and funding.

Government involvement shapes the regulatory environment, provides financial assistance, and promotes the infrastructure required for digital adoption. Policies such as subsidies and incentives can reduce financial barriers, particularly for smallholders who often struggle with the high initial costs of digital investments (Zeverte-Rivza et al., 2023). Evidence from both national and EU initiatives shows that targeted support measures enable farmers to adopt precision farming and other digital innovations more effectively (Zeverte-Rivza et al., 2023).

Strategic governance and long-term planning are also essential for creating an enabling environment for digital transformation. Governments can strengthen digital literacy and provide training through agricultural extension services, helping farmers understand and apply new technologies (Martens & Zscheischler, 2022). This is particularly important in contexts where digital tools significantly enhance productivity and sustainability (Fróna, 2024).

Equally critical is the development of robust digital infrastructure, including reliable internet access in rural areas, which ensures farmers can connect to digital platforms and services (Zhong, 2023). Addressing these infrastructural challenges, while fostering supportive policies, allows governments to accelerate agricultural digitalization, ultimately improving efficiency, productivity, and resilience in the sector (Poletaev, Narozhnyaya, & Kitov, 2020; Zhong, 2023).

Overall, the findings show that government support (X_4), mentoring (X_3), and farmer characteristics (X_2) exert the greatest influence on agricultural digitalization, while farmers' perceptions play a minimal role. Thus, advancing digital transformation in agriculture should prioritize policy support, mentoring, and the effective utilization of farmer characteristics.

CONCLUSION

The findings indicate that the adoption of digital agricultural technologies among paddy farmers in West Kalimantan remains limited, primarily due to inadequate infrastructure, insufficient training, and low levels of digital literacy. Positive impacts were observed when government programs expanded

infrastructure and provided financial assistance, while mentoring initiatives played a vital role in strengthening farmers' knowledge and motivation. Educational background also contributed positively to adoption. Although farmers generally held favorable perceptions of digitalization, these attitudes did not directly translate into adoption decisions, underscoring the need for targeted interventions that address structural and capacity-related barriers.

Based on these results, several strategies are essential to accelerate digital adoption. The government should continue expanding rural internet access and provide financial incentives such as subsidies or low-interest loans to encourage investment in digital tools. Policies must prioritize digital literacy programmes, especially for older and less-educated farmers, while technology providers should collaborate with local institutions to design affordable and user-friendly solutions aligned with smallholder practices. Farmers' associations and community leaders can play a pivotal role through peer-to-peer learning and mentoring networks, helping early adopters share experiences that reduce resistance to change. In parallel, universities and research institutions should engage in participatory research to test and refine technologies so they remain practical, scalable, and locally relevant. If these recommendations are effectively implemented, they will narrow the digital divide, enhance productivity, and contribute to Indonesia's broader ambition of becoming a global food producer by 2045.

AUTHOR CONTRIBUTION STATEMENT

[Author 1]: research conceptualization, methodology design, data collection, data analysis, initial manuscript draft; [Author 2]: legal analysis, research supervision, writing (review & editing); [Author 3]: data analysis, writing (review & editing), addressed reviewer's comments. All authors reviewed and approved the final version of the article.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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ETHIC STATEMENT

Ethical review and approval were waived for this study as it did not involve any intervention and posed minimal risk to participants. Nevertheless, informed consent was obtained from all respondents prior to participation, and all data were anonymized and kept confidential.

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