Jurnal Dinamika Sosial Ekonomi Vol. 26 No. 1, Juni 2025 : 114-128
ISSN 1411-593X (print)); ISSN 2721-3137 (online)

The Impact of the Digitalization System for Subsidized Fertilizer Distribution on the Productivity of Rice Farmers in Malang Regency

Pengaruh Sistem Digitalisasi Tata Kelola Pupuk Bersubsidi Terhadap Produktivitas Petani Padi Di Kabupaten Malang

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submission date: June 2, 2025 approved date: June 29, 2025

ABSTRACT
This research analyses the impact of digitalising the subsidised fertiliser distribution system on the productivity of rice farmers in Malang Regency. The research was conducted on 484 rice farmers from 33 sub-districts during the period of August-November 2024. The research results show that digitalisation does not have a significant direct impact on rice productivity. However, digitalisation has a positive effect on farmer satisfaction and technology accessibility. Farmers' satisfaction and technology accessibility have proven to play a significant mediating role in the relationship between digitalisation and productivity. The success of digitalising subsidised fertiliser distribution depends on increasing farmer satisfaction through responsive services and improved technology accessibility. The research recommends optimising the role of agricultural extension workers and increasing the involvement of farmer groups to maximise the benefits of the digital system.

Keywords: Digitalisation, subsidised fertilisers, productivity

ABSTRAK
Penelitian ini menganalisis dampak digitalisasi sistem distribusi pupuk bersubsidi terhadap produktivitas petani padi di Kabupaten Malang. Penelitian dilakukan terhadap 484 petani padi dari 33 kecamatan selama periode Agustus-November 2024. Hasil penelitian menunjukkan bahwa digitalisasi tidak memiliki pengaruh langsung yang signifikan terhadap produktivitas padi. Namun, digitalisasi berpengaruh positif terhadap kepuasan petani dan aksesibilitas teknologi. Kepuasan petani dan aksesibilitas teknologi terbukti berperan sebagai mediator yang signifikan dalam hubungan antara digitalisasi dan produktivitas. Keberhasilan digitalisasi distribusi pupuk bersubsidi bergantung pada peningkatan kepuasan petani melalui layanan yang responsif dan peningkatan aksesibilitas teknologi. Penelitian merekomendasikan optimalisasi peran penyuluh pertanian dan peningkatan keterlibatan kelompok tani untuk memaksimalkan manfaat sistem digital.

Kata kunci : Digitalisasi, pupuk bersubsidi, produktivitas

INTRODUCTION

Agriculture is a strategic sector that is very important for the Indonesian economy. The agricultural sector contributes 12.53% to the national GDP, provides employment for around 27.7% of Indonesia's total workforce (BPS, 2024), and significantly contributes to national food security. As an agrarian country with a population of over 270 million people, Indonesia heavily relies on the agricultural sector to maintain economic and social stability.

Rice, as a staple food for the majority of the Indonesian population, is at the centre of the national agricultural system. Its availability and affordability are crucial for economic and social stability, considering Indonesia's rice consumption reaches 94.9 kg per capita per year (Ministry of Agriculture, 2023). Factors affecting rice productivity include farmer performance, access to subsidised fertilisers, agricultural technology, and agricultural extension support.

Malang Regency, as one of the main rice-producing areas in East Java, contributes 35.04% to the regional GDP (Cipta et al., 2018) but still faces challenges in increasing rice yields. The rice productivity in this regency is not yet optimal compared to its potential, especially in the context of utilising modern technology and the efficiency of agricultural input distribution. To increase productivity, the local government's initiative focusses on enhancing the role of agricultural extension officers to better assist farmers. The improvement of extension services is expected to enhance farmers' ability to engage in technical cultivation and optimally access subsidised fertilisers.

The government fertiliser subsidy program, which aims for timely and targeted supply, still faces various structural challenges. These issues include poor demand planning (Rachman & Sudaryanto, 2016), inadequate supervision (Rachman & Sudaryanto, 2016), misdistribution (Rachman & Sudaryanto, 2016; Riki et al., 2022), supply shortages at the farmer level (Prihantini & Lutfiyanto, 2019; Prabowo, 2023), and rising prices of non-subsidized fertiliser (Ratrifa, 2023). In the context of modernising the distribution system, the government has developed various digitalisation initiatives. Pupuk Indonesia has implemented digitalisation from fertiliser production to distribution through the Rekan

application or Retail Management System (RMS), which is claimed to improve service quality and facilitate farmers' access. The Distribution Planning & Control System (DPCS) operational since 2020 enables real-time monitoring of the distribution process from the producer's warehouse to the farmer level.

Novelty of this research is related to the location of Malang Regency that has never been researched, then the digitalization component is farmer productivity, farmer satisfaction and technology accessibility. Although the digitalisation of subsidised fertiliser distribution has become a focus of government policy, research examining its impact on rice productivity is still limited. Previous studies have focused more on separate aspects, such as the research by Rachman & Sudaryanto (2016) which analysed the effectiveness of the fertiliser subsidy program in general without considering the aspect of digitalisation, or Prihantini & Lutfiyanto (2019) who examined the availability of fertiliser at the farmer level using a conventional approach. Similarly, Riki et al. (2022) examined the issue of misdistribution in the manual system without exploring the potential of digital solutions. Research on existing agricultural technology is more focused on the adoption of production technologies such as agricultural tools and superior seeds rather than input distribution technology, resulting in a lack of research integrating digital technology with fertiliser distribution systems.

Rice productivity studies generally analyse technical cultivation factors without considering the efficiency of the input distribution system, and there is a lack of research linking the distribution system with productivity outcomes. This research fills the literature gap by analysing the impact of the digitalisation of subsidised fertiliser distribution on rice productivity in Malang Regency, focussing on the mediating role of farmer satisfaction and access to technology. Unlike previous studies that examined separate aspects, this research integrates the dimensions of digital technology, distribution systems, farmer satisfaction, and productivity into a comprehensive analytical framework. Understanding these factors aims to provide empirical recommendations in the development of effective and sustainable agricultural policies, particularly in the context of the digital transformation of Indonesia's agricultural sector.

METHOD

This research uses a quantitative method with a survey approach conducted in Malang Regency during the period of August-November 2024. The research population consists of rice farmers in Malang Regency, with a total of 106,668 farmers spread across 33 sub-districts. The sample determination used the Slovin formula with a confidence level of 95% and a margin of error of 5%, resulting in a sample of 484 farmers selected proportionally at random from all sub-districts.

Primary data were collected through structured interviews with farmer respondents using a 5-point Likert scale questionnaire (1=strongly disagree to 5=strongly agree). Secondary data were obtained from the farmers' profiles sourced from the Malang Regency Agriculture Office, including data on land area, production, and the demographic characteristics of the farmers. Data validation was carried out through source triangulation by conducting in-depth interviews with agricultural extension officers and fertiliser distribution kiosk managers.

This research analyses four main variables with the following measurements: first, the Digitalisation of Subsidised Fertiliser Management (X1) measured through indicators of ease of access to digital applications, speed of the ordering process, accuracy of distribution data, and transparency of information. Second, Farmer Satisfaction (X2) measured based on satisfaction with service quality, timeliness of distribution, availability of fertiliser, and responsiveness of officers. Third, Technology Accessibility (X3) measured through ease of internet access, smartphone ownership, ability to use applications, and support for technological infrastructure. Fourth, Rice Productivity (Y) is measured based on the yield per hectare, improvement in grain quality, efficiency in fertiliser use, and production stability.

Data analysis using Structural Equation Modelling (SEM) with the help of WarpPLS-7.0 software to test the structural relationships between variables. The research model examines the direct effect of digitalisation on productivity, as well as the indirect effect through the mediation of farmer satisfaction and technology accessibility. The research hypotheses are formulated as follows: H1: The

digitalisation of subsidised fertiliser management has a positive effect on rice productivity; H2: The digitalisation of subsidised fertiliser management has a positive effect on farmer satisfaction; H3: The digitalisation of subsidised fertiliser management has a positive effect on technology accessibility; H4: Farmer satisfaction has a positive effect on rice productivity; and H5: Technology accessibility has a positive effect on rice productivity.

RESULTS AND DISCUSSION

Characteristics of Respondents

Table 1. Respondent Characteristics

Characteristics	Category	Number (n)	Percentage (%)
Gender	Male	416	86
	Female	68	14
	Total	484	100
Age	< 35 years old	44	9,1
	35-45 years old	157	32,4
	46-50 years old	100	20,7
	51-55 years old	105	21,7
	> 55 years old	78	16,1
	Total	484	100
Education	Not completed elementary school	19	3,9
	Completed elementary school	85	17,6
	Completed junior high school	88	18,2
	Completed high school	234	48,3
	Diploma/Bachelor's degree	58	12
	Total	484	100

Source: Processed Primary Data (2024).

Based on the age distribution data of respondents using the midpoint method of class intervals, the average age of farmers is 46.5 years. The largest number of respondents is found in the age range of 35-45 years with 157 farmers (32.4%), indicating that most rice farmers in Malang Regency fall into the productive age category. Regarding the non-productive age (>64 years), the data shows that farmers aged >55 years only make up 16.1% of the total respondents, indicating that the rice farming sector in Malang Regency is still dominated by productive labour, although there is a tendency towards an ageing population in the agricultural sector that needs attention for long-term sustainability.

Validity Test

Validity and reliability tests confirmed all question items for digitalization, satisfaction, accessibility, and productivity variables were valid. The convergent validity test showed all factor loadings exceeded 0.7, with p-values below 0.05 and Average Variance Extracted (AVE) over 0.5, confirming the data's validity.

Table 2. Results of Outer Loading Tests

No.	Indikator	*Factor Loading*	Result	*P-value*	Result
1.	X1.1	0,896	Fulfilled	<0.001	Valid
2.	X1.2	0,918	Fulfilled	<0.001	Valid
3.	X1.3	0,869	Fulfilled	<0.001	Valid
4.	X2.1	0,915	Fulfilled	<0.001	Valid
5.	X2.2	0,915	Fulfilled	<0.001	Valid
6.	X3.1	0,913	Fulfilled	<0.001	Valid
7.	X3.2	0,913	Fulfilled	<0.001	Valid
8.	Y1.1	0,913	Fulfilled	<0.001	Valid
9.	Y1.2	0,896	Fulfilled	<0.001	Valid
10.	Y1.3	0,867	Fulfilled	<0.001	Valid

Source: Processed Primary Data (2024).

Based on the outer loading test results in Table 2, all research indicators show good validity with factor loading values ranging from 0.867 to 0.918, where all these values are above the minimum threshold of 0.7 required in SEM analysis. The p-value for all indicators shows results <0.001, significant at the 99% confidence level, confirming that all indicators are valid and reliable for measuring their respective latent constructs. The indicator with the highest factor loading is X1.2 (0.918), which measures the digitalisation of subsidised fertiliser management, while the indicator with the lowest factor loading but still meets the criteria is Y1.3 (0.867), which measures rice productivity, indicating that all research instruments are suitable for further analysis.

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Table 3. *Average Variance Extracted* (AVE)

No.	Variable	Parameter	AVE
1	Digitalization	>0,5	0,801
2	Satisfaction	>0,5	0,837
3	Accessibility	>0,5	0,834
4	Productivity	>0,5	0,796

Source: Processed Primary Data (2024).

Based on the Average Variance Extracted (AVE) test results in Table 3, all research variables demonstrate good convergent validity with AVE values ranging from 0.796 to 0.837, where all values exceed the minimum threshold of 0.5 required in SEM analysis. The farmer satisfaction variable has the highest AVE value of 0.837, followed by technology accessibility (0.834), fertiliser management digitalisation (0.801), and rice productivity (0.796). These high AVE values indicate that each latent construct can explain more than 79% of the variance of its indicators, thus it can be concluded that all variables have adequate convergent validity and are suitable for use in the research structural model.

Reliability Test

Table 4. *Reliability Test*

No.	Variabel	Composite Reliability	Cronbach's Alpha	Parameter	Keterangan
1	Digitalisasi	0,923	0,875	>0,7 (CR) >0,6 (CA)	Reliabel
2	Kepuasan	0,911	0,805	>0,7 (CR) >0,6 (CA)	Reliabel
3	Aksesibilitas Teknologi	0,909	0,803	>0,7 (CR) >0,6 (CA)	Reliabel
4	Produktivitas	0,921	0,869	>0,7 (CR) >0,6 (CA)	Reliabel

Source: Processed Primary Data (2024).

Based on the reliability test results in Table 4, all research variables show a very good level of internal consistency with Composite Reliability values ranging from 0.909 to 0.923, where all values are above the minimum threshold of 0.7 required. The Cronbach's Alpha values for all variables also indicate acceptable reliability with a range of 0.803 to 0.875, all of which are above the minimum threshold of 0.6. The digitalisation variable has the highest reliability value (CR=0.923; CA=0.875), indicating that the measurement instrument for this variable has the most stable internal consistency, while the technology accessibility variable has the lowest but still very adequate value (CR=0.909; CA=0.803). Therefore, it can be concluded that all research instruments are reliable and suitable for further analysis.

Model Fit Test (Model Fit and Quality Indices)

The analysis results concerning the impact of the digitalization system for subsidized fertilizer distribution on rice farmers' productivity in Malang Regency in 2024, utilizing SEM-WarpPLS 7.0, are presented in Figure 1.

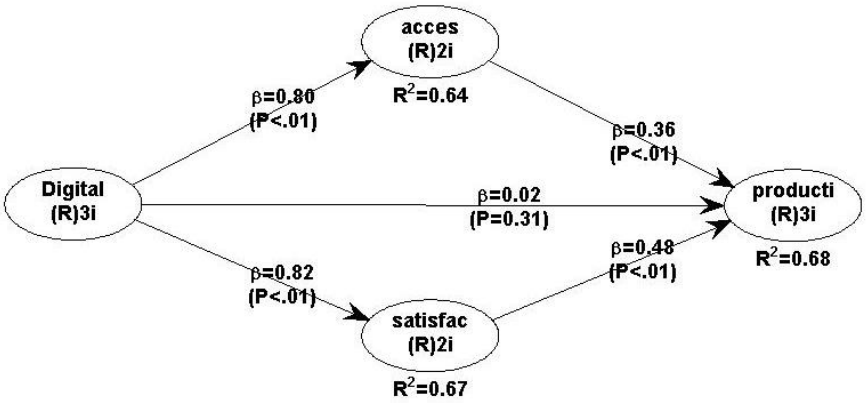

Figure 1. SEM-WarpPLS Model Analysis Results
Source: Processed Primary Data (2024).

The results of the model fit test (model fit and quality indices) indicate that the model and overall data alignment are satisfactory, as presented in Table 5.

Table 5. Model Fit Test Results (Model Fit and Quality Indices)

No.	Model fit and quality indices	Criteria fit	Analysis Results	Remarks
1.	Average path coefficient (APC)	p-value<0,05	(APC)=0.498, P<0.001	Meets model fit requirements
2.	Average R-squared (ARS)	p-value<0,05	(ARS)=0.665, P<0.001	Meets model fit requirements
3.	Average adjusted R-squared (AARS)	p-value<0,05	(AARS)=0.664, P<0.001	Meets model fit requirements
4.	Average block VIF (AVIF)	Acceptabe if ≤ 5, idealy ≤3,3	(AVIF)=3.697	Ideal
5.	Average full collinearity VIF (AFVIF)	Acceptabe if ≤ 5, idealy ≤3,3	(AFVIF)=3.801	Ideal
6.	Tenenhaus GoF (GoF)	Small ≥0,1 ; medium ≥0,25; large ≥0,36.	(GoF)=0.737	Large
7.	Sympson's paradox ratio (SPR)	Acceptabe if ≥0,7, idealy = 1	(SPR)=1.000	Ideal
8.	R-squared contribution ratio (RSCR)	Acceptabe if ≥0,9, idealy = 1	(RSCR)=1.000	Ideal

No.	Model fit and quality indices	Criteria fit	Analysis Results	Remarks
9.	Statistical suppression ratio (SSR)	Acceptabe if ≥0,7	(SSR)=1.000	Accepted
10.	Nonlinear bivariate causality direction ratio (NLBCDR)	Acceptabe if ≥0,7	(NLBCDR)=1.000	Accepted

Source: Processed Primary Data (2024).

Inner Model Results of WarpPLS 7.0 Analysis

Direct Effects Path Coefficients Analysis

Hypothesis testing used T-tests for each direct effect. According to Hair et al. (2020), a positive path coefficient means the independent variable positively affects the dependent variable, while a negative path coefficient indicates a negative effect. A p-value over 0.05 means the independent variable does not significantly impact the dependent variable. See Table 4 for complete results.

Table 6. Results of Inner Model Hypothesis Testing (Path Coefficients)

No.	Relationship Between Variables Exogenous ⟶ Endogenous		Path coefficient	*P-Value*	Remarks
1.	Digitalization (X1)	Productivity (Y)	0.023	0.308	Not Significant
2.	Digitalization (X1)	Satisfaction (X2)	0.816	<0.001	Significant
3.	Digitalization (X1)	Accessibility (X3)	0.803	<0.001	Significant
4.	Satisfaction (X2)	Productivity (Y)	0.483	<0.001	Significant
5.	Accessibility (X3)	Productivity (Y)	0.364	<0.001	Significant

Source: Processed Primary Data (2024).

Based on the results of the structural path analysis, H1 is rejected because the digitalisation of subsidised fertiliser management (X1) does not have a significant direct effect on rice productivity (Y1) with a path coefficient of 0.023 (p=0.308). This indicates that digital technology alone is not sufficient to increase productivity without mediating factors that support its adoption and optimal utilisation by farmers. Conversely, H2 and H3 are accepted with high path coefficients (0.816 and 0.803; p<0.001), confirming that digitalisation effectively increases farmer satisfaction and technology accessibility, in line with the findings of Sharma et al. (2021) which show that digital systems in agricultural input distribution enhance farmer satisfaction through transparency and ease of access.

H4 and H5 are also accepted with path coefficients of 0.483 and 0.364 (p<0.001), proving that farmer satisfaction and technology accessibility play important mediating roles in transforming the benefits of digitalisation into real productivity improvements, supporting the research of Kumar & Singh (2022) which emphasises the importance of mediating factors in the adoption of agricultural technology to achieve optimal productivity outcomes.

Results of Indirect Effects Analysis (Indirect Effects for Paths with 2 Segments)

Table 7. Results of Indirect Effects Analysis (Indirect Effects for Paths with 2 Segments)

Exogenous Variable	Mediating Variable	Endogenous Variable	Coefficient	*P-Value*	Remarks
Digitalization of subsidized fertilizer distribution	Satisfaction, Accessibility	Rice Farmer Productivity	0.686	<0.001	Significant

Source: Processed Primary Data (2024).

Based on the results of the mediation effect analysis in Table 7, H6 and H7 are accepted because the indirect path coefficient of digitalisation (X1) on productivity (Y) through the mediation of farmer satisfaction (X2) and technology accessibility (X3) of 0.686 (p<0.001) shows a very significant and substantial effect. This proves that although digitalisation does not directly affect productivity, through the enhancement of farmer satisfaction and technology accessibility, digitalisation is capable of having a significant positive impact on rice productivity. These findings align with the Technology Acceptance Model (TAM) developed by Davis (1989) and reinforced by the research of Venkatesh et al. (2020) in the context of digital agriculture, which explains that successful technology adoption requires mediation of factors such as user satisfaction and ease of access to technology to achieve the desired outcomes. The high mediation coefficient value (0.686) indicates that the strategy of digitising subsidised fertiliser distribution will be more effective if focused on improving farmer satisfaction through responsive services and enhancing technology accessibility through digital literacy training, as recommended by Klerkx & Rose (2020) in their study on the digital transformation of food systems. The total effects analysis, representing the combined direct and indirect path coefficients from the SEM analysis, reveals the following contributions: digitalization (X1) impacts rice farmer productivity (Y) by 50.268%,

satisfaction (X2) by 66.586%, and technology accessibility (X3) by 64.481%. Additionally, satisfaction (X2) contributes 23.329% to rice farmer productivity (Y), while technology accessibility (X3) adds 13.25% to productivity (Y).

Digitalization Variable (X1)

Research findings indicate that although the digitalisation of subsidised fertiliser distribution has no significant direct effect on rice farmers' productivity, productivity is still influenced by various complex, interacting factors. This is in line with the findings of Nakano et al. (2018) which emphasise that agricultural productivity is influenced by multiple factors including education, training, experience, access to resources, government policies, and socio-economic conditions. The characteristics of the respondents in this study indicate that the majority of farmers have at least a high school education (48.3%) and benefit from non-formal training, which supports the findings of Ayinde et al. (2020) that the education level of farmers is positively correlated with the adoption of agricultural technology.

Although manual and digital distribution processes coexist, SEM-PLS analysis shows that productivity significantly increases through the mediation of farmer satisfaction and technology accessibility with a contribution of 50.628%. These findings support the Technology Acceptance Model developed by Venkatesh et al. (2012), where successful technology adoption requires the mediation of user satisfaction and ease of technology access. Farmers' satisfaction arises from the improvement in service quality and trust facilitated by the digitalisation system, as explained by Kumar & Dixit (2019) that the digitalisation of public services enhances satisfaction through transparency and process efficiency.

The digitalisation system has proven to streamline the registration and purchase process of subsidised fertilisers through the integration of the eRDKK and i-Pubers platforms. Farmers registered in local groups can easily redeem fertilisers at kiosks using their Identity Cards, with all transactions documented digitally to facilitate validation and monitoring. This is in line with the research by Mittal & Mehar (2016), which shows that the digitalisation of agricultural supply chains reduces transaction costs and enhances traceability. The Simluhtan application also

contributes to maintaining system integrity with real-time verification capabilities to reject invalid identities during registration, supporting the findings of Wolfert et al. (2017) on the importance of data integrity in smart farming systems.

The digital system has proven to be efficient because it accelerates service delivery and allows farmers to save time and operational costs. The i-Pubers platform helps maintain accurate records and minimise the misuse of subsidised fertilisers, in line with Aker's (2011) research which shows that digital technology in government subsidy programs can reduce leakage and improve targeting accuracy. Trust plays an important role in mediating the effect of the digital fertiliser system on productivity through increased transparency in data management, supporting Luhmann's (1979) findings and reinforced by Gefen et al. (2003) that trust is a critical factor in the adoption of information technology, especially in the context of public services involving government subsidies.

Satisfaction Variable (X2)

Digitalization of subsidized fertilizer management improves the accuracy of fertilizer application data (eRDKK). Farmers and groups must provide accurate details like identity, land area, and commodity types. The integrated Simluhtan application helps filter identity accuracy connected to Dukcapil, blocking farmers with more than 2 hectares from entering eRDKK. This helps ensure valid land tracking.

Digitalization allows for complete digital tracking of all transactions. Information on requested fertilizer quotas is clearly recorded, minimizing the chance of misuse as kiosks need to document distributions. Farmers registered in eRDKK only need to show their Identity Card (KTP) for redemption; this rule does not apply to those not recorded. The SEM-PLS analysis shows a significant influence of digitalization on farmer satisfaction (66.586%).

The SEM-PLS results show that satisfaction directly affects rice farmers' productivity at 23.329%. Satisfaction stems from service quality and trust in fertilizer purchases. Farmers who perceive they receive quality fertilizer in the right amounts and at the right time feel more satisfied and are motivated to improve their farming (Painneon et al., 2022). This aligns with Sipayung et al. (2021), which

states that satisfaction with the distribution process influences farmers' decisions to use subsidized fertilizers. Farmers' satisfaction also depends on the efficiency of distribution, which should be straightforward, quick, and responsive to their needs (Effendi et al., 2021). In Malang, farmers trust the distribution system and appreciate the seamless, effective, transparent, and responsive services.

Technology Accessibility Variable (X3)

As part of the digitalization of subsidized fertilizer management in Malang Regency, kiosks use smartphones for transactions and stock reporting. The i-Pubers application, designed by the Ministry of Agriculture, is user-friendly, making it accessible to both kiosks and farmers. Using smartphones doesn't require complex technology; farmers can simply sign on the device's screen. There is a good telecommunication infrastructure across subsidized fertilizer kiosks in Malang Regency, with 229 kiosks serving 375 villages.

The state of the roads between sub-districts and villages has improved, making access to fertilizers easier for farmers and groups. The SEM-PLS analysis shows a significant positive influence of digitalization on technology accessibility (64.481%).

The direct effect of technology accessibility on rice farmers' productivity is positive and significant at 13.25%. This effect still needs enhancement. Changes in subsidized fertilizer distributions make it important for agricultural extension workers to creatively and intelligently share information and technology with farmers (Srimenganti et al., 2022). They play a key role as motivators and facilitators, increasing the frequency of farmer group meetings to improve awareness about productivity. With non-formal education, like agricultural training, farmers can improve their understanding and skills regarding agricultural innovations (Fitrianingsih, 2023).

CONCLUSION

In summary, the research findings indicate that digitalization has an insignificant direct effect on rice farmers' productivity, but it significantly influences farmer satisfaction and technology accessibility. Additionally, both

farmer satisfaction and technology accessibility have significant direct effects on productivity, with farmer satisfaction and technology accessibility also serving as significant mediators in the relationship between digitalization and productivity.

Based on the findings of this research, the following recommendations can be made: To enhance the effectiveness of the digitalization of subsidized fertilizer distribution systems, it is essential to optimize the role of agricultural extension workers in disseminating information, increase farmer group involvement, and hold more frequent meetings among these groups. Additionally, the government should appoint dedicated support personnel for subsidized fertilizers, recognize the efforts of farmer groups in eRDKK preparation, and encourage them to produce more accurate documents. Furthermore, future research is necessary to explore the economic impacts of digitalization on farmers and distribution kiosks , as well as to assess crop productivity related to restrictions on subsidized fertilizer commodities.

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